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SUPPLEMENT TO "THE ELECTRICIAN," NOVEMBER 2, 1894.

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July 20th, 1894 ... ...A Large Sheet "Practical Wiring Chart."
August 10th, 1894 ... ...Steel Plate Portrait of the Late Dr. Heinrich Hertz

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THE ELECTRICIAN:

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NOTES.

Although many of the electrical exhibits at the Royal Society Conversazione on Wednesday last were not new to those who industriously attend the meetings of scientific societies, they were of very considerable interest. A number of experiments with polyphase currents were shown by Prof. S. P. Thompson, including several which were not shown at his recent Royal Institution discourse. Mr. W. W. Beaumont showed his vibro-motors and reaction balance devices, and in the same room Dr. Alexander Muirhead showed his new form of siphon recorder and curb transmitter, in connection with an artificial cable of the same capacity and conductor resistance as that which is to be laid across the Atlantic in July next. The capacity is 800 microfarads, and the resistance is 3,350 B.A. ohms. A speed of 50 words per minute is attained. Mr. Wimshurst brought models of swivels designed to connect the moorings of lightships with the shore. Each shackle contains a coil of insulated wire, and the pin of the swivel acts as a magnetic core. Mr. Crompton showed some thoroughly practical electrically-heated soldering bits, taking from 40 to 80 watts on a 100-volt circuit. Close by, Sir David Salomons had a brilliant show of very pretty vacuum tubes, showing striæ and other phenomena, which may some day prove to be of scientific interest. The Rev. F. J. Smith exhibited some ergometers, one of which was applicable as an electric governor. A Moissan furnace, Roberts-Austen pyrometer, Callendar and Griffith thermometer, and Mr. Wilde's magnetarium were among the other electrical objects.

Perhaps the most novel exhibit was that of the new harmonic analyser with a glass sphere, described at a recent meeting of the Physical Society by Prof. Henrici. The instrument, exquisitely constructed by Herr Coradi, of Zürich, is probably the most accurate and perfect integrating machine that has been made. The parts are so few, and compared with other harmonic analysers, the mechanical action is so simple, that not only its mode of working, but the result of its analysis of a curve, can be followed by sheer common sense. The operation of algebraical harmonic analysis cannot be so followed by one mathematician in a hundred. It is almost entirely blind handling of the symbols according to certain rules. To some minds this work is simply impossible, but we do not believe that this need prevent a thoroughly clear appreciation of differential and integral calculus, and of harmonic analysis. There is no algebra whatever about Prof. Henrici's machine. There is nothing but wheels, wires, rollers, a glass sphere, and several graduated scales. We look forward to the day when students who are quite unable to do the algebraical work will be allowed to study these subjects from watching the action of such machines as these. At present they are regarded as the climax of the orthodox algebraical methods, but even so fail to interest some kinds of mathematicians. Regarded from that point of view, their use is extremely limited. As educational machines they will, in proper hands, open the eyes of mechanically or geometrically-minded students to the truths of the calculus, which will perhaps still remain for them an algebraical mystery, but something more than an algebraical trick.

The past month has been a decidedly unfortunate one for electricity supply companies. On the 19th ult., Mr. Justice Kekewich decided that the City of London Electric Lighting Company ought to be mulcted for the nuisance caused by their Bankside works, although refusing to grant an injunction on the ground of the public inconvenience likely to arise from such a step. Last week Mr. Justice Stirling, in the action Wise *v.* Metropolitan Electric Supply Company, went a step further; not only were damages awarded, but an injunction was granted, though its operation was suspended for three months to give the Company time to complete their devices for overcoming the vibration trouble. The law of nuisance may, indeed, be a nuisance of a law; but as far as it relates to statutory electric lighting concerns, at any rate, lawyers are agreed that it is as plain as the proverbial pikestaff. Electric light undertakers, it appears, are authorised and impliedly required to erect generating stations *somewhere*, but not anywhere in particular; the erection and operation of a station on any site selected must not cause a nuisance at present or in future to those dwelling near. The plainness of the liability may be cold comfort to those who have rendered themselves liable; but, as an offset, there is the evident desire of the judges not to interfere more than absolutely necessary with the business of electricity supply, and as to the prevention of vibration in the future, it may be confidently asserted that the resources of civilisation have not as yet been exhausted.

In this week's issue we give in full the judgment in the important and interesting action brought against the Commercial Cable Company by Messrs. Muirhead in connection with the payment of royalties for using their American duplex

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patent, No. 234,490, of 1880, which the Company alleged had lapsed by reason of the expiry of an English patent of 1876, which it was argued was an anticipation of the American one. As we have already stated, the sum involved was a large one, amounting to something like £45,000, and the elucidation of the technical points at issue required the services of Lord KELVIN, Sir FREDERICK BRAMWELL, Dr. JOHN HOPKINSON, Prof. SILVANUS THOMPSON, Dr. BOTTOMLEY, Sir HENRY MANCE, Mr. SWINBURNE, and many others, the Court being engaged in hearing the case for no less than seven days.

MR. JUSTICE KENNEDY, it will be seen, has decided against the contention of the Commercial Company that the English patent was an anticipation of the American one, and the Company's endeavour to avoid payment is therefore temporarily at all events unsuccessful. The whole case turned on the question as to whether Fig. 2 of the English patent of 1876 (see *The Electrician*, March 9th) showed substantially the same arrangement as that depicted in Fig. 3 of the American patent of 1880; whether the *continuous* adjustment of resistance was an advantage in duplex working; whether there was any point in keeping the sum of the resistances of the bridge arm constant; whether a cable man looking at Fig. 2 of 1876 would have been led to make the particular arrangement depicted in Fig. 3 of 1880. To us it seems impossible that any amount of looking at Fig. 2 of 1876 would, at any rate in 1876, have resulted in Fig. 3 of 1880, and Mr. Justice KENNEDY was of the same way of thinking. The name of MUIRHEAD is ineffaceably connected with submarine duplexing, and by the upholding of this patent substantial justice has been done.

THE electrolytic effects of traction currents are discussed in an unusually clear and instructive manner in a paper just read before the American Institute of Electrical Engineers, and reproduced in our present issue. The author, Mr. ISAIAH H. FARNHAM, of the New England Telephone and Telegraph Company, is a prophet in his own land, having been the first to connect in an indubitable manner sundry peculiar corrosion phenomena on the lead-covered cables of his Company with the leakage currents from the electric tramway system of the West End Company of Boston. Thanks in no small measure to the Board of Trade Regulations recently promulgated, we are not likely to witness in England anything approaching the state of things chronicled by Mr. FARNHAM in the first portion of his Paper; nevertheless it is instructive as showing what might have happened had there been an electric traction "boom" in this country, and no authority empowered to insist on the negative pole being put to earth, and the water mains being effectively connected to it. In this respect, indeed, Mr. FARNHAM goes beyond Board of Trade requirements. He does not rely merely on connection at the power-house, but urges that conductors should be run out to all pipes situated within what he calls "the danger territory," *i.e.*, the area within which the pipes become positive to earth. The advantages of the negative-pole-to-earth arrangement and of this additional precaution are strikingly shown in the three maps giving the electrical condition of underground Boston, firstly, with positive pole to earth and no effective connection to water and other pipes; secondly, with negative pole to earth; thirdly, with negative pole to earth, plus auxiliary conductors.

THE experiments made and facts adduced by Mr. FARNHAM, which appear to point to the possibility of serious electrolysis where there is only a minute difference of potential between pipe and earth, and to the existence of considerable electrical resistance at the joints of water pipes, require, as the daily papers say, "to be received with all reserve." The "non-conducting screen," which at one time found no little favour in high quarters, does not seem to have successfully resisted electrolytic contagion at Boston, telephone cables "painted with asphalt, taped, painted again, and finally covered again with a heavy braiding also saturated with asphalt," being badly corroded.

THE advent of May brings, among other annual institutions, the time-honoured "May exams." of the Science and Art Department, and thousands of young people, whom newspapers delight to call "embryo electricians," are preparing themselves in various ways to "sit for magnetism and electricity." Of these various ways there are two which are worthy of especial condemnation; they are, grinding and cramming. Indeed, so much are these recognised as specifics for a "pass" that the science student has long been heard to sing the paraphrase doggerel: "March grinds or April crams will get you through the May exams." Three classes of people are to blame for this melancholy state of affairs. Firstly, the Examining Department is to blame for perpetuating an antiquated, not to say fossilised, syllabus of examination, with its ridiculously unscientific division under the three heads of "magnetism, frictional electricity, and voltaic electricity," and its perpetuation in almost unvarying form of a host of "stock questions." Secondly, the instructors are at fault; and by instructors we mean both oral teachers and the authors and publishers of cram-books. During April and the early part of May the rush for printed "back papers," and pamphlets giving typical answers to selected stock questions, is simply phenomenal; while, in the vast majority of cases, the teacher devotes the last few lectures to a vigorous grinding up of his class in these back papers. Thirdly, the so-called student is to blame for prostituting his studies to a mere certificate, and for aiming at a tangible show of knowledge, in the shape of a piece of cardboard, instead of trying to fill his mind with well arranged useful knowledge that he can be sure of throughout his life.

Blake v. Pulver Transmitters.—The Christiania Telephone Company is adopting the Pulver microphone in place of the Blake. No less than 615 of the latter were replaced last year.

Cable Interruptions:

	Date of Interruption.
Cayenne-Paramaribo	Oct. 25th, 1893.
Bissao-Bolama	Nov. 24th ,,
Brest-St. Pierre (P.Q. Co.)	Mar. 29th, 1894.

Berlin Overhead Railway.—The scheme has received the consent of the German Emperor, and the work is to be begun immediately. The double line is to have a three-minute service.

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The Board of Trade Electric Traction Regulations.—The electric traction regulations recently issued by the Board of Trade are described in a French contemporary as protective clauses submitted to the Minister of Commerce by a special committee appointed by the House of Commons.

Extension of the Liverpool Overhead Railway.—An extension of the Liverpool electrical overhead railway to Seaforth was inaugurated on Monday, more than a thousand passengers being booked up to noon. This extension makes the overhead railway six miles long.

Institution of Electrical Engineers.—The annual conversazione of the Institution will take place on Thursday, May 31st, and will be held, as before, in the galleries of the Royal Institute of Painters in Water Colours. The cards of invitation will be issued towards the end of this week.

Institution of Civil Engineers.—It was announced at the meeting of this Institution on Tuesday last, that Mr. James Swinburne had been transferred to the class of member. It was further announced that Mr. David Cook had been elected to the class of member; also that Mr. J. E. Baron had been elected as associate-member.

Interurban Telephony in France.—The Chambers of Commerce concerned have decided to repeat their offer to advance the sum of £3,680 to the State on the condition that a third telephone trunk line, to be devoted exclusively to main-line communications, be erected between Paris and Havre.

Glasgow and West of Scotland Technical College.—The Edinburgh University Court, at their last meeting, decided to recognise the day lectures and laboratory courses given by Prof. Andrew Jamieson at the Glasgow and West of Scotland Technical College as qualifying *pro tanto* for their degree of B.Sc., in engineering.

New Lamps for Old.—Messrs. Fleischhacker and Möhrle, of Pasing, near Munich, have introduced a method of repairing worn-out or blackened glow lamps, which is said to be perfectly successful. The saving on the price of new lamps is from 30 to 40 per cent., even at the present excessively low prices ruling in Germany.

Another Electro-Chemical Journal.—In addition to the *Electro-Chemische Zeitschrift*, referred to last week, we learn that the first number of still another journal of this kind has just seen the light. The new journal is called *Die Zeitschrift für Electrotechnik und Electrochemie*, and is edited by Herr Arthur Wilke, of Hanover, and Dr. W. Borchers, of Duisberg. The publishers are Messrs. W. Knapp, of Halle.

Electrical Exhibition at Derby.—An electrical exhibition will be opened at the Mechanics' Institute, Derby, on the 14th inst. by the Mayor. Demonstrations will be given in electrical cooking, heating, &c. In connection with the opening, Sir Frederick Bramwell will lecture on the subject of electricity. The electrical power in connection with the exhibition will be supplied from the borough electric lighting station.

Proposed Underground Railway in Budapest.—The municipal engineering department of Budapest has sanctioned the construction of an underground electric railway from the Gisela Platz under the Andrassy-strasse to the Stadt Wäldchen. The proposed capital is about £300,000. When this project is realised Budapest will be the first town to follow the example of London in the utilisation of this method of traffic.

Electric Traction at Barmen.—A somewhat unusual step has just been taken by the municipal authorities of Barmen. It appears that in the concession granted to the Elberfeld-Barmen Horse Tramways Company, a proviso was made that the Company should adopt any improvement which might offer itself in connection with tramways. The municipal authorities have therefore just decided that the Company must convert the tramways into electric lines.

Royal Institution.—At the annual meeting of this Institution on Tuesday, May 1st, the annual report of the Committee of Visitors for the year 1893, was read and adopted. The real and funded property now amounts to above £102,000. Sixty-two new members were elected in 1893. The books and pamphlets presented in 1893 amounted to about 250 volumes, making, with 584 volumes (including periodicals bound) purchased by the managers, a total of 834 volumes added to the library in the year.

The Varley Testimonial.—We have received a lengthy communication from Mr. S. A. Varley expressing his deep obligation to the members of the testimonial committee for having so gracefully recognised his services to applied science in the circular they issued on the formation of the committee, and returning his sincere thanks to all those who have subscribed to the testimonial fund. As Mr. Varley's letter will no doubt appear in full in the columns of our contemporaries, our inability to find room for it this week will not prevent it being made known.

Aldin v. Latimer Clark, Muirhead and Co.—On Wednesday Mr. Justice Stirling gave another decision adversely affecting an electric light undertaking. This was in the action brought by Mr. Aldin, timber merchant, of Richmond, against Latimer Clark, Muirhead and Co., for endangering his timber-yard and preventing free access of air to it by the erection and working of a central lighting station. The judge decided that injury had been done, but not sufficient to warrant an injunction, and ordered an inquiry as to damages. A fuller report of this action will appear in our next issue.

A Society of Electro-Chemistry in Germany.—The application of electricity to chemistry has made such progress in Germany that the formation of a German electro-chemical society is but a natural consequence. A meeting of the leading electro chemists of Germany was held at Cassel a few days ago, when the formation of such a society, with head-quarters at Berlin, was decided upon. At the meeting a council was elected, and this includes such well-known names as Ostwald, Wilke, Classen, Kraut, Bottinger, Vogel, Rathenau, &c. The object of the society is in the advancement of both the theory and practice of electro-chemistry. The first annual meeting is to be held in Berlin in October next.

Obituary.—The death is announced, at the age of 64, of Dr. Karl Eduard Zetzsche, the well-known Continental telegraph engineer. In 1856 Dr. Zetzsche took employment in the Austrian Telegraph Service. In 1858 he went to Chemnitz, where he became teacher of mathematics and mechanics at the Royal Technical High School, and in 1876 he accepted the chair of Professor of Telegraphy at the Polytechnic School in Dresden. In 1880 he went to Berlin, and became editor of the *Electrotechnische Zeitschrift* (1880-1886) and telegraph engineer to the German Postal Service (1880-1887). Dr. Zetzsche published several books on geometry, trigonometry, and telegraphy, most of them having had several editions.

Epping Forest and Walthamstow Electric Railway.—This Bill came on Wednesday before a Committee of the House of Commons, presided over by Sir J. Kennaway, and after considering the proposals of the promoters for running workmen's trains at fares of a penny for three miles, as against a penny for the whole distance, which the London County Council ask, they deferred their decision upon this point. Yesterday, the Committee decided that the Company should run workmen's trains till eight in the morning, the fare being one penny for a distance of nine miles, the Board of Trade to judge as to sufficiency of accommodation. The promoters intimated that in consequence of these onerous terms they might possibly withdraw the Bill.

Budapest.—The electric lighting works erected in Budapest by the Elektrizitäts Aktiengsellschaft, formerly Schuckert and Co., notwithstanding the competition of a supply station erected by Messrs. Ganz and Co., have been a pronounced success. The station originally planned was intended to supply 12,000 lights; but after scarcely nine months working nearly 17,000 lamps have been connected to the mains, and there is a possibility of another 37,000 being added. The result of this is that it has been decided to raise the capital of the Company from three million to five million crowns, and to carry out immediate extensions involving an expenditure of £50,000. The extension works are to be carried out by the original contractors on the same system, viz, the alternate-current-continuous-current-accumulator system.

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The Post Office and the Telephones.—In the House of Commons on Monday last Sir J. Fergusson asked the Postmaster-General whether the agreement with the National Telephone Company had been completed or had made further progress? Mr. Arnold Morley stated that considerable progress had been made with the agreement, and within the last few weeks the points of difference between the Telephone Company and the Post Office had been brought within such narrow compass that he was led to believe that it might be possible to lay the agreement on the table of the House very shortly. Mr. Labouchere asked whether the agreement had not been delayed for nearly two years, and whether the effect was not to give the Telephone Company practically a monopoly as against the municipalities who wished to improve the telephone service of their towns? The Postmaster-General did not think the position of the municipalities had been prejudiced.

Telegraphy and the Recent Religious Riots in India.—The India Office has laid before Parliament a number of reports from officers in Burma, Bombay, and certain districts of the North-Western Provinces and Oude relating to the recent conflicts between Hindus and Mahomedans. Amongst the causes of the greater frequency of these conflicts in recent years the Government of India mention the greater frequency of communication and the interchange of news by post and telegraph between different parts of the country, so that the news of a riot is known all over India, and controversies arise and hostility is engendered even in districts where harmony has hitherto prevailed between the two religions, and the example set in some distant towns may thus be followed in a dozen other places where the people, but for the suggestion afforded by the example and the manner in which it is discussed, would have continued to live in mutual amity.

Telephonic Communication in Germany.—A new telephone line has just been completed and put in operation between Bingen and Mannheim. A long-distance line is also to be established to give communication between Munich, Leipzig, Berlin, and Hamburg. Some new regulations have just been issued by the German Postal authorities regarding the use of the public telephone call-offices, which are not calculated to foster or encourage the use of such means of communication. Hitherto it has only been necessary to pay the ordinary fee to an attendant on entering the telephone box; but the new regulations provide that a form must be filled up giving the office and number of the person with whom it is desired to hold communication, and also at the foot the name of the person making the call, then a postage stamp has to be purchased and affixed to the form. The form has then to be checked by the clerk, and an entry in a book made before the applicant is allowed to enter the telephone box. One advantage of the public telephone call-office system has been the despatch by which one could obtain communication, which advantage will be materially reduced under the new arrangement.

Popular Engineering Literature.—"Since the advent of several popular professional magazines, and the growth of the demands for popular scientific and engineering writing, there has been a vast amount of pseudo-scientific rubbish unloaded on the unsuspecting public," says the *Electrical World*. "As the average reader of these articles is unable to comprehend the real scientific principles at stake, it is therefore thought necessary to select the merely striking and curious points for their delectation. These are then enlarged upon to an alarming extent, and all sorts of speculations added, until the impression is left upon the minds of the readers that scientists and engineers must be a poor lot indeed to be unable to realise some of the promises thus glibly held out by these writers—who, by the way, are almost always unknown in the scientific or professional circles they purport to represent. It is this class who have made a shibboleth of the phrase 'Electricity is yet in its infancy,' who picture the modern ocean ship propelled by electricity crossing the ocean in a day, and who, after harping upon the use of electricity for trunk railways, have recently substituted electric air navigation as being less tame. One of their favourite themes is the appalling inefficiency of the steam-engine. Elaborate calculations are made to show that the steam-engine is a woefully inefficient machine, and the implication conveyed that steam engineers are a sorry lot not to apply a remedy. While it is true that from a thermodynamic standpoint the steam-engine is inefficient, this follows from a law of nature and not through the neglect of man. Another subject that has a great attraction for these gentlemen is the generation of electricity from water power. The energy of water, they argue, unlike that of coal, is free of cost, and the efficiency of the turbine is eight to ten times as great as that of the steam-engine. With these data to start with they revel in predictions; all domestic operations are to be carried on by electricity, and the farmer would sow, harvest, market and even assist the chemical growth of crops by electricity, and man would become a mere presser of electric buttons."

The Manufacture of Briquette Fuel.—At the meeting of the Institution of Civil Engineers on Tuesday, May 1st, a Paper was read on "The Manufacture of Briquette Fuel," by Mr. William Colquhoun. The Paper contained a description of the various English and Continental methods of agglomerating slack coal, which had now become an important and increasing industry, and opened up an outlet for large quantities of small coal hitherto lost on the pit-bank or in the workings. Various agglomerating agents were detailed and their local advantages discussed; the characteristics of good pitch derived from coal-tar rendered that agent, however, in every way the most suitable. By the use of from 8 to 9 per cent. of pitch, slack coal might be agglomerated into a form eminently suitable for storage purposes, waterproof, incapable of deterioration on exposure, of cohesion greater than the large coal from which it was derived, and, finally, having calorific qualities nearly equal to large coal. In support of the latter contention, the author cited the results of three experiments with English briquettes which gave 8·41lb., 8·77lb. and 8·99lb. respectively, as the weight of water evaporated from and at 212°F. per pound of fuel. The average evaporative power of several of the best Welsh steam-coals was 9·33lb. Careful experiments made by Mr. Marié on the Paris, Lyons, and Mediterranean Railway gave as corresponding figures for three descriptions of French briquettes, 8·88lb., 9·15lb. and 8·68lb. respectively. The mechanical preparation of the coal used in briquette manufacture, received more attention on the Continent than in this country, particularly in regard to the washing and subsequent drying of the slack. These operations were necessary in order to render the poorer coals serviceable for the manufacture. The draining and drying appliances in use were described, particularly those of Jacoby, of the Molière Collieries, and of Biétrix, the latter being described in detail and instances given of the working cost. The coal and pitch were intimately intermixed by two methods, known respectively as the melted- and dry-pitch processes, the pitch by the former being melted (sometimes with additions of common tar) prior to its addition to the coal, and by the latter being ground up with the coal in a dry state. Several examples were given of the procedure in each case. In both instances the mixture of coal and pitch was subjected to the action of heat until each particle of coal was covered with a film of melted pitch and so rendered fit for compression into blocks. In this state the mixture or paste contained from 3 to 5 per cent. of water in order to facilitate the sliding of the particles of coal one on the other during compression. The machines for compressing the paste were roughly divided into three classes, irrespective of the nature of the power employed. These classes were: First, single-compression machines, illustrated by detailed descriptions of the Mazeline, Stevens, and Dupuy presses; secondly, machines compressing on both sides of the briquette, such as those of Middleton, Biétrix, and Veillon; thirdly, machines acting by the tangential pressure of rolls, like that of Fouquemberg, and those of the sausage-machine type such as the Bourriez press. Briquettes hot from the press had an inconsiderable cohesion, and had to be treated with care in stacking and loading, and arrangements made to keep down the cost of labour. Costs were given of making briquettes in works in England, in the North of France, and in Belgium. Instances were cited of the suitability of the same process for the agglomeration of charcoal-dust, sawdust, coke-breeze, friable iron-ores, and cement. An appendix gave the annual production of briquettes in various countries.

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MEASURING COEFFICIENTS OF INDUCTION.

BY ALEXANDER RUSSELL, M.A.

The following methods of measuring coefficients of self and mutual induction are very convenient in practice, as they do not necessitate a rearrangement of the apparatus when measuring the two coefficients. The first method requires a condenser, in addition to the ordinary apparatus for measuring resistance, and is capable of giving very accurate results. The second method is not quite so accurate, as we make the assumption that the alternating currents follow the harmonic law; still, as this method only requires an ordinary voltmeter and ammeter suitable for use with alternating currents, it is often very useful. For example, with a Cardew voltmeter and a Siemens dynamometer, and using the current supplied by the

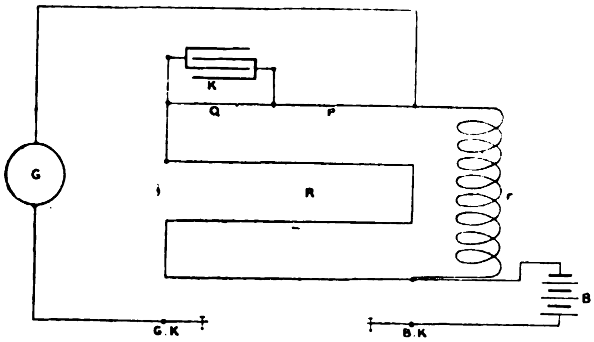

Fig. 1.—Diagram of Connections for Measuring Coefficients of Induction.

London Electric Supply Corporation, the results obtained for the coefficients of self-induction of various coils experimented on were well within 2 per cent. of their real value.

1. The apparatus required for the first method is a Wheatstone's Bridge, a mirror galvanometer, and a condenser (preferably a sub-divided one). This method can be employed when the apparatus is fitted up permanently for measuring resistance without disarranging the connections.

In Fig. 1, a Post Office box is shown, r is the inductive coil whose coefficient is to be measured, G the galvanometer, Q, P, and R the resistances of the various arms of the bridge, and K a condenser (unconnected at first).

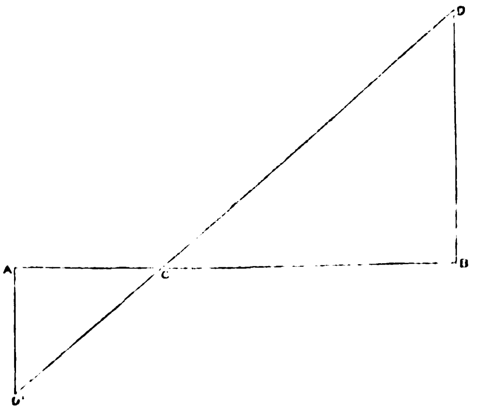

Fig. 2.

Measure the resistance of the coil r in the ordinary way, putting down the battery key before the galvanometer key, when there is a balance

$$r = \frac{P}{Q} R.$$

Now, if we put down the galvanometer key, and then the battery key, there will be a sudden throw or "kick" of the galvanometer needle, causing the spot of light to give a momentary swing to one side, and then coming back to zero. If we raise the battery key, keeping the galvanometer key down, there will be an equal kick in the reverse direction. These effects are due to the self-induction of the coil r upsetting the balance until the current in r attains its steady value, the E.M.F. of self-induction being only brought into play when the current is growing or diminishing.

Now, if we shunt the resistance Q with the condenser K, and perform the same operations as before, the kick will be much smaller, or may even be in the reverse direction.

Suppose that when K is K_1 we get a kick of d_1 divisions to the right, and that when K is K_2 we get a kick of d_2 divisions to the left. Then, to find the value of K that will annul the kick, make (Fig. 2) the line A B equal to $K_2 - K_1$ in any convenient scale. Draw A D_1, B D_2 at right angles to A B, and make A $D_1 = d_1$ and B $D_2 = d_2$. Let $D_1 D_2$ cut A B in C. Then, when $K = K_1 + A C$ there will be no kick when we put the galvanometer key down before the battery key. When this is the case, we can show that if L be the coefficient of self-induction of the coil r, then

$$L = K Q r \times 10^{-6} \text{ henrys},$$

where K is in microfarads and Q and r in ohms.

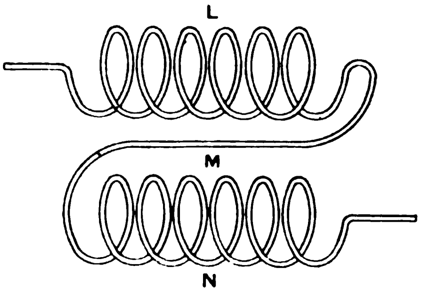

Fig. 3.—Effective Self Induction = L + N + 2 M.

We can also employ this method to measure the coefficient of mutual induction between two coils. Let L and N be the coefficients of self-induction of the two coils, and M the required coefficient of mutual induction. Then, if we connect the two coils in series, as in Fig. 3, the mutual inductive E.M.F. on each coil acts in the same way as the self-inductive E.M.F.

Hence, if L′ be the coefficient of self-induction of the two coils connected in this way, and measured as above, we obviously have

$$L' = L + N + 2 M.$$

Similarly, if L″ be the coefficient of self-induction of the two coils connected, as in Fig. 4,

$$L'' = L + N - 2 M.$$

Therefore $$M = \tfrac{1}{4} (L' - L'').$$

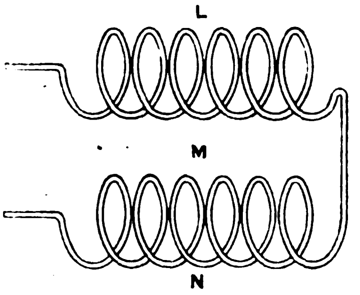

Fig. 4.—Effective Self Induction = L + N - 2 M.

Hence the apparatus set up as in Fig. 1 can be used for measuring resistance, self-induction, and mutual induction.

It is sometimes useful to connect the two coils in parallel, and then to measure the apparent coefficient of self-induction. If we find L_1 and L_2, as formerly, then in this case,

$$\left. \begin{aligned} L_1 &= L \left(\frac{S}{R+S} \right)^2 + N \left(\frac{R}{R+S} \right)^2 + 2 M \frac{S R}{(S+R)^2} \\ L_2 &= L \left(\frac{S}{R+S} \right)^2 + N \left(\frac{R}{R+S} \right)^2 - 2 M \frac{S R}{(S+R)^2} \end{aligned} \right\} \quad (1)$$

Hence $M = \frac{(S+R)^2}{4 S R} (L_1 - L_2)$; where R and S are the resistance of the two coils respectively.

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Putting $M = 0$ in formulæ (1), we get the case when the mutual induction can be neglected,

$$L_3 = L\left(\frac{S}{R+S}\right)^2 + N\left(\frac{R}{R+S}\right)^2.$$

Putting, in addition, $N = 0$, we find that shunting an inductive coil R by a non-inductive coil S, diminishes its effective coefficient of self-induction in the ratio of S^2 to $(R+S)^2$—a well-known result.

Those who are acquainted with the theory of alternating currents can prove the formulæ (1) from the general algebraical expression for the equivalent self-induction of a branched circuit by putting the frequency = 0.

This method gives the correct values for the coefficients, even when the coils are wound on brass cores, or if there are any closed circuits near them.

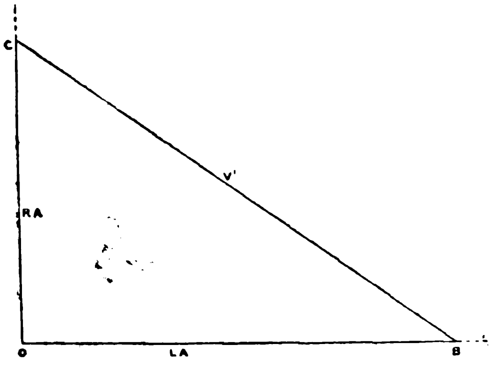

Fig. 5.

2. The method with alternating currents is as follows:— Place the coil in an alternating-current circuit. Let the current through it be A amperes, and let the potential difference between its terminals be V' volts. When placed in a direct current circuit, let the potential difference be V when the current is A. Then the following construction to find L can be proved at once from the formula for impedance. Draw (Fig. 5) O C and O D at right angles to one another. Make O C = V, with centre C and radius = V' describe a circle, cutting O D in B. Then the length of O B divided by $2\pi n A$ where n is the frequency gives the magnitude of L in henrys.

Again, for mutual induction, let the coils be connected as in Figs. 3 and 4. Let V' be the potential difference between the terminals in the first case, and V'' be the potential

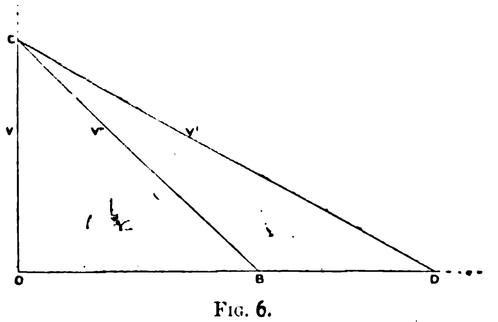

Fig. 6.

$OC = V = RA.$ $OB = 2\pi n L''A.$ $OD = 2\pi n L'A.$ $BD = 8\pi n MA.$

difference in the second case when the same current A is flowing through it, and let V be the potential difference with a direct current A. Then, using the same construction as before, make C D = V' and d C B = V'' (Fig. 6). The length of B D divided by $8\pi n A$ will give the coefficient of mutual induction between the coils.

This method fails to measure the coefficient of mutual induction between two coils, when this coefficient is very small compared to the sum of the coefficients of self-induction. For example, in a Siemens' wattmeter, which measures up to 2,400 watts, the coefficient of self-induction of the volt coil was greater than half a henry, while the coefficient of mutual induction between the coils was only 20 microhenrys, when the pointer of the ampere coil was at zero. It also fails if there are any closed circuits or masses of non-magnetic metal near the coils, a consideration which does not affect the first method.

Although coefficients of self and mutual induction can be measured easily practically, it is very difficult to calculate them from the geometrical dimensions of the coils. In fact, it is only in a very limited number of cases that they can be found, and even in these cases the length of the formulæ are prohibitive to all but the most expert calculators. As a rule also, the formulæ given for them in pocket-books (when correct) are only rough approximations, and unless we know exactly where the approximation comes in, it is never safe to use them.

MAGNETIC QUALITIES OF IRON.*

BY J. A. EWING, F.R.S., AND MISS HELEN G. KLAASSEN.

(Continued from page 715, Vol. XXXII.)

Fig. 25 gives the curves drawn by the magnetic curve tracer in a series of tests of a pair of bars built up of soft thin sheet iron. Four cycles are shown, the magnetising current having had as extreme values three, two, one and one-half amperes

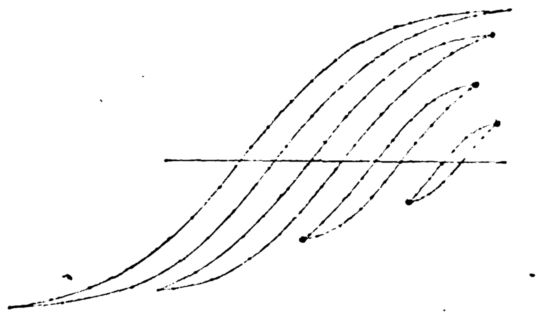

Fig. 25.—Cycle Magnetisation of Soft Iron, shown by the Magnetic Curve Tracer.

respectively. The zero was shifted a little before each cycle to separate the curves. Here the changes of current took place slowly, a pause being made at each of the marked points to allow the position of the reflected spot of light to be noted. The curves are sheared over to the right

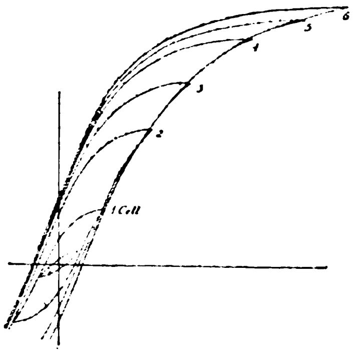

Fig. 26.—Cyclic Magnetisation of Soft Iron, shown by the Magnetic Curve Tracer.

in consequence of the gap in the magnetic circuit under test. The areas of these curves, which are not affected by this shearing, when plotted in relation to B are found to lie on a smooth curve of the type drawn in Fig. 21.

Fig. 26 is another test of the same class, made with a different curve tracer and with other iron. Here the successive cycles are shown in their natural relation to one another, without change of zero, and it will be seen that they show well a feature which was referred to in the ballistic tests, namely the projection of the extremities of each cyclic curve over the rising limb of the cycle next above it. Many other examples of curve-tracer tests might be cited as confirming this observation.

* Abstract of Paper read before the Royal Society.

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Fig. 27 is closely related to Fig. 26. It shows a group of curves taken in immediate succession to the group of Fig. 26, the iron, the instrument, and the condition of the experiment being in every way the same, except that in Fig. 27 the cycles

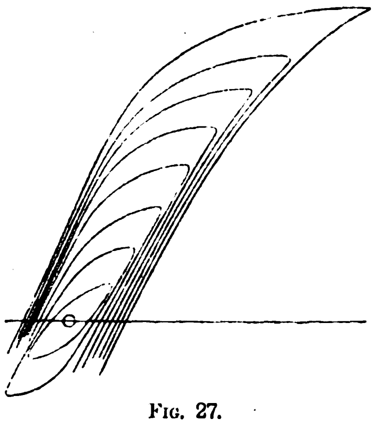

FIG. 27.

were gone through comparatively fast—at the rate of 3½ cycles per second—whereas in Fig. 26 the process was quite slow. The rounded corners and increased wideness of these curves should be noticed. Their increased area shows that more work

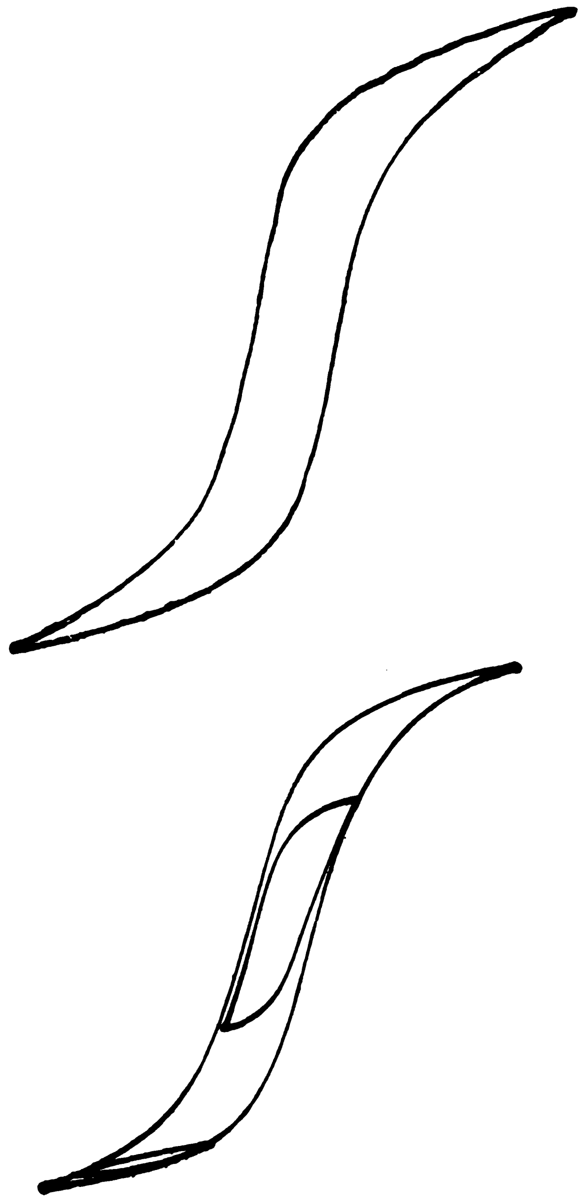

FIG. 28.

is here being done on the iron, the effect probably—at least in great part—of Foucault currents. The main portion of the magnetic circuit consisted, in this instance, of well laminated metal, but thick solid pole pieces were used

The curves of Fig. 27 were recorded by marking with a pencil the luminous line described upon the screen in the periodic repetition of each cycle. In Fig. 28, where the results of a group of tests with a different instrument are shown, the curves were automatically recorded by allowing the spot of light to fall on a sensitive plate.* In all except the last figure in this group each cycle was gone through in about half a second—the commutator being driven uniformly by means of a small electric motor—and the exposure lasted during some 20 to 30 cycles. The curves, therefore, give good evidence of

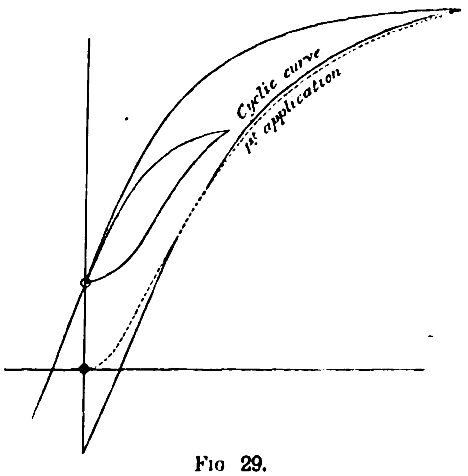

FIG. 29.

the constancy with which the movement repeats itself. In the last figure in the group of Fig. 28 the commutator was slowly turned by hand, and two minor loops were superposed on the main cycle.

Fig. 29 is another test made at the same time, and on the same metal as the tests of Figs. 26 and 27. It shows a small loop superposed on a main cycle, and also a curve (drawn in broken line), which is the magnetisation curve starting from zero, taken after the metal had been reduced to neutrality by the process commonly known as "demagnetising by reversals" —namely, by numerous reversals of a gradually diminishing magnetic force. Here is found a feature which was first

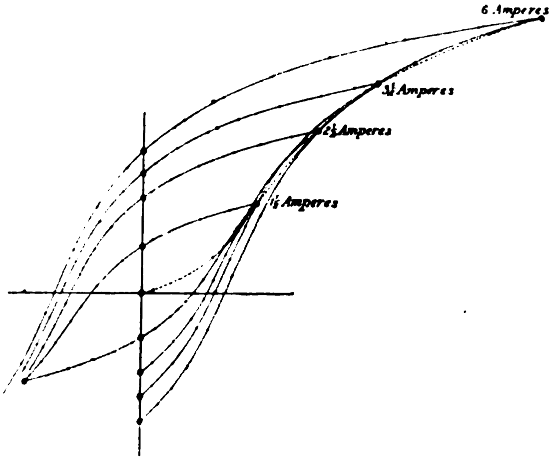

FIG. 30.—Cyclic Magnetisation of Soft Iron, shown by the Magnetic Curve Tracer.

remarked, we believe, by Dr. John Hopkinson, namely, that in magnetising from the neutral state the curve crosses the rising limb of the cyclic curve. The same feature has been looked for, and always found, in many other curve-tracer tests.

This crossing is in agreement with the fact already noticed, that the extremity of one cyclic curve projects beyond the rising limb of a higher cycle. For, after a piece has been put through the process of "demagnetising by reversals," the magnetising curve starting from zero, passes, as nearly as we can

* We are indebted to Mr. A. G. Dew Smith for these photographic recor

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judge, through the projecting extremities of the cycles. Hence it lies outside of the upper part of the rising limb of any cyclic curve.

Fig. 30 gives a further illustration of these remarks. It shows a magnetic curve-tracer test of moderately hard steel, the dotted curve being obtained by magnetising from zero, after the process of demagnetising by reversals had been performed. This line will be seen to pass through the extreme points of the several cyclic curves, which thus overlap one another in the manner already described.

Fig. 31 is a study in superposed magnetisations in soft iron. Here the magnetic curve tracer was arranged with two independent magnetising coils upon the magnetic circuit under examination. One of these was used to apply a cyclic variation of magnetic force, while the other was used to apply a steady force of greater or less intensity, on which the cyclic force could be superposed. For brevity, we may distinguish the two circuits as P and Q. In the first place, after the iron had been demagnetised by reversals, the current in Q was applied, and was reversed repeatedly between equal positive and negative values, there being, at the time, no current in P. This gave the usual cyclic curve *a b* (Fig. 31), from which it will be seen that the magnetising force then applied by Q was comparatively small. Then (the piece having been again demagnetised) a current was set up in P, which brought the magnetism up to a value represented by the point *c* in the figure. This current in P being now kept constant,

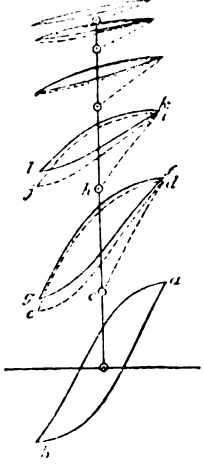

FIG. 31.

the current in Q was applied. This gave the line *c d*; then the current in Q was reversed, giving the dotted line *d e*, and re-reversed. Finally, after several reversals of the current in Q, the process of reversal gave the closed figure shown by the full line *f g f*. Next (the current in Q having been stopped), the steady current in P was increased to a value which brought the magnetism up to *h*. Then the application and reversal of Q's current gave the lines, *h i*, *i j*, *j k*, the cycle finally settling down after several reversals into the form shown by the full lines *k l k*. The same description applies to each of the loops which are seen higher in the diagram. The highest ones lie in what is often called the region of saturation. Throughout all these successive operations the current in Q, whose reversal formed the loops, had the same extreme value. The experiment shows how, as might be expected, the reversals of a given magnetising current produce less and less magnetic change as the total magnetism is increased. It also illustrates one of the minor consequences of magnetic hysteresis, namely, that a period force, applied in addition to a constant force, does not immediately produce cyclic effects; it is only after several repetitions of the reversal that the curves become closed. During the interval of "accommodation" (to use the term which has been applied in other instances where the same feature occurs in the phenomena of magnetisation) the mean value of the magnetism is rising, as a consequence, one may say, of the molecular shaking which is involved in the process of reversal.

(To be continued.)

COST OF ELECTRICAL ENERGY.*

BY R. E. CROMPTON, M.INST.C.E., VICE-PRESIDENT.

(Continued from page 727, Vol. XXXII.)†

FUEL AND WATER.—DIVS. 1 AND 2.—THE EFFECT OF THE EFFICIENCY OF STEAM ENGINES ON DYNAMOS OR ALTERNATORS.

Now that so many supply works have been running for several years, and that the works accounts have been annually published in the full detail demanded by the Board of Trade requirements, so that the actual cost of fuel, water, stores, labour and salaries, and actual output of energy delivered, are recorded, and are known to everyone who interests himself in these matters, it might be thought an easy matter to draw some useful conclusions from these published figures, so as to throw light on the comparative efficiency of the various systems and types of plant used in these supply works; but I regret to be obliged to confess that the drawing up of such comparative tables is not an easy matter. I have examined the published accounts of 23 important and representative electric supply works, in order to compare for this part of the Paper the cost of the fuel. From these I have prepared Table VI., which relates solely to fuel and water used. I must mention that in preparing this and the other Tables I at first relied on the published accounts for the information as to fuel, stores, labour, and salaries; but, as I found that several serious mistakes existed in the published analysis of such accounts, I in every case have taken the precaution of sending the figures to the engineer of each works, in order that he might satisfy himself of their correctness, and in most cases the engineers of these works have very kindly supplemented this figure by the other data required to bring this cost of fuel to a common basis for purposes of comparison.

The best method of comparing the comparative efficiency of the generating plant would be by comparing the weight of water evaporated per unit generated; but, as I have already pointed out when discussing the boiler question, this water measurement has been very rarely carried out, so that I am obliged to fall back upon the only certain measurement—that is, the weight of fuel used. I have written to all the engineers of the works named in these Tables, and have in some cases received full information, in others partial information, and in a few cases have been refused all supplementary information. In the cases where the information has been partially, or where it has been entirely withheld, I have been obliged myself to fill in the blanks by calculating them from the published costs and known calorific values of the fuel used. I have done this after having made careful inquiry in each case; and whenever there has been a doubt as to quantity price, or calorific value, I have endeavoured in each case rather to favour that particular works. At any rate, any errors that may exist in these calculated figures cannot be large enough to affect the result which I now bring before you.

In addition to the accounts of the 23 works examined, I have also examined the accounts of 10 foreign works; but I find their information is too incomplete and too difficult to bring to a basis of comparison with our English works, and I do not complicate my Table by adding them in.

Of the 23 English works examined, 10—viz., those at Bournemouth, Chelmsford, City of London, Eastbourne, House-to-House (London), Metropolitan, Newcastle and District, Newcastle-on-Tyne, Leeds, and Exeter—distribute the bulk of their output on the converted alternating system. Two works—viz., those at Chelsea and Oxford—distribute on the converted continuous system. Eleven works—viz., Birmingham, Bradford, Brighton, Charing Cross and Strand, Hove, Kensington, Knightsbridge, Liverpool, Preston, St. James and Pall Mall, and Westminster—distribute on the direct system.

* Paper read before the Institution of Electrical Engineers, April 26th.

† During the reading of the Paper the author made the following additions to the portions published in our last issue:—

After the words, "not a necessity," p. 726, left-hand column, line 6 from bottom, interpolate:—"Since this was written we have been almost continually making experiments, and we find it is undoubtedly true that by exercising very great care and watchfulness you can get as high an efficiency out of a Lancashire boiler as out of any other, but it must not be fired heavily. The great care means that you have to pay higher wages to the stokers, and any mistake on the part of the stokers affects the efficiency of the boiler, which might not be the case with a multitubular boiler. That is the real use of the economisers—they cover the errors and mistakes of the stokers."

On p. 727, at end of paragraph commencing "Referring to Table III. . . ." interpolate:—"Since writing this I have made repeated trials, with the result that on test trials that 5·2 evaporation can be brought up to 8lb., and can be maintained so long as the test apparatus is in position and you can advise the stokers what to do, but as soon as it is removed it falls down again. There should be some means of knowing what the composition of the escaping gases really is, for without some knowledge of the kind some very large errors are still made."

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TABLE VI.—*Comparison of Fuel Used.*

Works.	Distinguishing letter.	Cost of fuel per unit sold.	B. Th. U. in fuel used per watt hour.	Efficiency of distribution.	B. Th. U. per watt hour generated.	Description of plant.
Converted Alternating System.				%		
Newcastle & District	A	0·8	310	70	218	Steam turbine.
Leeds	B	1·23	300	66	200	Alternators, rope-driven.
Bournemouth	C	1·81	232	69	160	" "
House-to-House	D	1·93	265	66	175	" "
Newcastle-on-Tyne	E	0·64	262	66	173	" "
Metropolitan	F	1·8	232	66	153	(1892) Mixed system
Eastbourne	G	1·42	180	60·8	109	Alternators, rope-driven.
Exeter	H	1·35	135	66	89	" "
Average of B, C,	D, E,	& F	245	...	161	
Mixed System.						
City of London	I	1·24	172	82	141	Mxd. system, driving
Chelmsford	J	0·96	146	76	112	" "
Average of I & J	...	...	159	...	126	
Converted Continuous.						
Chelsea	K	1·11	142	62	88	Dynamos, driven direct.
Oxford	L	0·70	88·5	62	56	Dynamos, rope-drvn.
Average of K & L	...	...	115	..	72	
Direct System.						
Preston	M	1·65	315	80	255	Dynamos, driven direct by double-acting engines.
Liverpool	N	0·95	186	75	143	Dynamos, driven direct by single-acting engines.
Birmingham	O	0·88	183	75	140	" "
Charing Cross and Strand	P	1·13	147	90	132	" "
Hove	Q	1·26	147	82	120	" "
St. James and Pall Mall	R	0·95	126	90	114	" "
Bradford	S	0·66	119	88·7	110	" "
Brighton	T	0·904	117	80	94	" "
Kensington	U	0·87	116	86·5	100	" "
Westminster	V	0·78	104	88	92	" "
Knightsbridge	W	0·632	84	91·5	78	" "
Average of N to W	...	...	133	...	112	
Ideal Works	...	0·27	36·25	90	32·6	

In Table VI. I have grouped these 23 works into these three systems of distribution, and have arranged them in each group in order, always heading the list by the works that uses the largest quantity of fuel. It is curious to remark that this system of grouping also divides them very fairly into the two great divisions of

1. Rope- or belt-driven plant.
2. Direct-driven plant.

In the first group I have averaged the fluel consumption in thermal units per watt-hour, omitting from the average the first-named works, as the conditions of working are somewhat abnormal; and, similarly, in the last group I have averaged the fuel consumption for the whole, with the sole exception of the first-named works—*i.e.*, Preston—the conditions in this case being also abnormal. These averages show that the consumption of fuel per unit sold in the first group is about 94 per cent. greater than in the direct group; but as this difference is made up very considerably by the difference in efficiency of distribution, I have calculated the actual fuel consumption at the terminals of the dynamo by the efficiency of distribution of the two systems, which I regret to say is in several cases an assumed figure, as in several cases it appears to be actually unknown to the works' engineers themselves.

The Table shows that, whereas the efficiency of distribution of the converted alternating systems is apparently somewhat under 66 per cent., with the direct systems (excluding the two-wire systems) it is about 86 per cent. The fuel used per unit generated in the converted alternating systems appears to be 43 per cent. higher than that used by the direct systems. In making these calculations I have carefully avoided considering those where a mixed system of distribution is used. The Table also shows that the fuel average of the works where the alternators or dynamos are rope-driven is about 46 per cent. higher than where the dynamos are direct-driven by high-speed engines; and I think that the information that the Table gives on this point is of the utmost importance, as it shows in a marked degree the economical advantages of high-speed direct-driven steam dynamos over slow-speed engines, driving dynamos, or alternators by ropes or belts.*

Eight years ago I stood almost alone when I recommended that the 1,200-H.P. load of the Vienna central station should be divided amongst eight steam dynamos coupled direct to high-speed engines, as at that time most engineers still believed that high economy in the use of steam could only be obtained by putting down long-stroke, slow-speed engines, such as are commonly used in cotton mills, and driving from these engines the dynamos by means of ropes or belts. This superstition was founded on the belief that steam could only be economically used in large engines of this type, which obtained their high piston speed by long strokes and few revolutions per minute; but it did not take long to show that the great variations of load in an electric supply works causes these huge engines to run for many hours at a very small fraction of their load, making them very uneconomical, so that the subdivision of their load between several smaller engines became necessary.

Mr. Willans, in his first and historic paper on steam-engine economy read before the Institution of Civil Engineers, was the first to strike a blow at the erroneous belief that economy could only be obtained from long-stroke slowly revolving engines, by showing that as the enemy to economy, particularly in the smaller engines, is cylinder condensation, the true way to reduce this is not by mere piston speed, as was the current belief, but by reducing the time during which the cylinder surfaces are exposed to the cooling action of the exhaust or of the condenser previous to each fresh steam admission—in other words, by using rapidly revolving short-stroke engines instead of slowly revolving long-stroke ones. Once this was understood, it followed that the high-speed engine making many revolutions, and therefore best suited for coupling direct to our dynamos, is also theoretically the most economical in use of steam. That this is also true in practice is shown by the long series of experiments carried out by Mr. Willans, and the figures that I am now putting before you. The advantages of direct driving are obviously not confined to the Willans, or, indeed, to any single-acting, type of engine; in fact, we have now a considerable choice of high-speed engines, all of which can be coupled direct to dynamos, and which use their steam economically. There is one advantage common to all direct-driven steam dynamos, *i.e.*, their high efficiency in $\frac{\text{E.H.P.}}{\text{I.H.P.}}$. This efficiency, which has been gradually creeping up from 80 per cent., which was the efficiency we obtained from the Vienna steam dynamos in 1886, to the very high figure of 88 per cent., which has recently been obtained by a Willans-Siemens combination, has been much commented upon, and has in some quarters met with actual disbelief; but all who know how accurately the tests bave been

* I should here state that the preparation of Table VI. has been the principal cause why this Paper has been delayed to such a late period of the session. The figures as printed in the proofs that you have in your hands have been altered several times, as additional information has been forwarded to me by the various engineers in charge. Even now I find that several mistakes and omissions exist. Some of them have been corrected on the the large Table on the wall, but those in your hand need correction as follows:—The averages of the first group include all the works mentioned with the exception of the Metropolitan and Exeter; the Metropolitan being for the year 1892, and the Exeter accounts being based on an estimated and not actually measured output. Again, the efficiency of distribution of the Chelsea Company, hence the calculation per unit generated ought to have been omitted. The figure given is that that would be obtained if the efficiency of distribution was the same as at Oxford. The Oxford figures came in at such a late period that I was unable to mention them in the body of the Paper. The results are very encouraging; in fact, I think they are too good to be true, especially when we come to consider the corresponding use of stores in Table VII. I have received a communication from Mr. Hunter, representing the Newcastle and District Company, in which he begs that I will make it clear that of the steam turbines used during the past year only one was condensing. He also demurs to the figures I have given of the B.T.U. per watt, as he says the calorific value of the coal used at Newcastle was only 7,250 instead of 11,300, the figures assumed by me. In explanation of my calculations, I may say that I used the figure 11,300 as furnished to me by Mr. Jackson, of the Newcastle-on-Tyne Company; but I believe that even this figure is too low, and that good Newcastle slack, such as any commercial man would purchase for steam raising purposes at Newcastle, has a value not less than 13,000. I use identically the same slack for my Chelmsford works, and pay for it a price that is not higher than is now paid by either of the Newcastle Companies, and I find on actual test that it has a calorific value of 14,000, so that I cannot accept Mr. Hunter's explanation that the high fuel consumption at Newcastle is due to the inferior quality of the coal used. I have also received a communication from the St. James and Pall Mall Company, altering the figures given in Table VI., which were the 1892 figures; the alteration is, however, entered on the Table on the wall. I must also say that I have not made any selection in the accounts entered in this Table. I have taken all the accounts that were ready at the time I prepared the Table, and those that are omitted were omitted solely at the request of the engineers in charge, on the ground that the only figures available, those of 1892, did not represent the present state of affairs,

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carried out at Thames Ditton, and who have themselves made independent check tests, know also that such an efficiency can be obtained without difficulty—in fact, that efficiencies in excess of 86 per cent. can now be guaranteed at full loads, and 80 per cent. at half loads.

The case is far different with rope or belt-driven sets. In most cases it is difficult to obtain an efficiency of 78 per cent. at full load and 70 per cent. at half load when the engines are fitted with the ordinary unbalanced slide valve, or 80 per cent. at full load and 73 per cent. at half load when the engines have Corliss or balance valves. I must, however, note that Mr. Parker, in his Paper—read before the Institution of Civil Engineers—on the Liverpool Overhead Railway, gives us the satisfactory results obtained from slow-running horizontal engines driving dynamos by ropes; but, although I do not challenge Mr. Parker's ultimate figures, yet I think that without doubt he has made a mistake in his calculated efficiency—that is to say, $\frac{\text{E.H.P.}}{\text{I.H.P.}}$. I think that it would be difficult for me—or, in fact, for anyone who has paid much attention to the losses due to the friction of steam engines, and particularly of condensing engines, and to the losses occasioned by rope-driving—to accept Mr. Parker's figures. No one has made more careful experiments on the friction of such engines than Messrs. Sulzer, of Winterthur, and Messrs. Carels Frères, of Ghent, who make the same type of engines. I have been informed by the latter that an engine efficiency of 91 per cent. is only rarely obtained; generally the efficiency is somewhat lower. Mr. Parker states that the electrical efficiency of his dynamos is 97·7 per cent., which is an extremely high figure. If we take the commercial dynamo efficiency at 96 per cent., which is an outside figure when we consider the side strains on the bearings caused by the rope-driving, and if we suppose that the loss due to the rope-driving is only 2 per cent., which I believe is less than has ever been noticed, it is just possible, with a 91 per cent. engine, a 2 per cent. rope loss, and a 96 per cent. dynamo, to get 85·6 per cent. efficiency.

Although I do not believe that such an efficiency, and correspondingly small consumption of steam per electrical horse-power at full and half loads, can be obtained in practice by engines driving dynamos by ropes, yet it is so often attained by direct-driven sets that at least one maker can now guarantee figures very closely approaching the ideal figures I have given of 18½lb. of steam per unit at full load and 21½lb. at half load. Yet in the cases of direct driving such high efficiency is easily accounted for. In the first place, the engines are fitted with piston valves, which are the most perfect form of balanced valves; hence the internal friction of the Willans or Chandler engines, running as they do with all their parts thoroughly bathed in oil, must be probably lower than that of any other type of engine. Moreover, with direct driving there is no side strain whatever on the dynamo bearings; and even the downward pressure on these bearings can be partially eased by so placing the armature core in relation to the bore of the magnets that a certain amount of lift is given to the core at the time that the magnets are excited. Under such conditions it will be seen that the engine and dynamo mechanical friction can be reduced to a minimum—in fact, to a point very far below what is possible when any form of rope or belt driving is used. The figures that I now give show that the best results yet obtained have been with Willans engines driving direct-current dynamos; and I believe this is mainly due to the great reduction of friction which I have just mentioned, and which tells heavily in favour of this class of steam dynamo when it is only partially loaded. Hence we find that, whereas the combined efficiency of a Willans combination is as high as 80 per cent. at outputs as low as two-thirds full load, the combined efficiency at two-thirds load of a slide-valve engine driving a dynamo by belts or ropes rarely exceeds 70 per cent.; and unfortunately, however much we may desire to keep the load-factor of the engine about 66 per cent., or two-thirds, yet under existing circumstances it is a matter of difficulty to do so even in works where accumulators are used, and in works where there are no accumulators with all converted systems the average engine load-factor appears to be far below this.

As you no doubt expect me to express an opinion as to the cause of the wide differences in economies of fuel shown in these comparative tables, I must point out that even, if we exclude the difference in distribution efficiency by making the allowances that I have done, there still remains three sources of loss—one already dealt with under the heading of the boilers, and the second due to the engines, dynamos, or alternators, and the third to losses which have been called by Kennedy "obscure works losses." Now I think the main cause of the difference in engine and dynamo losses lies in the fact that in the works under consideration the engines have been driven at widely differing load-factors; and, as whenever the engine load-factor is low the use of steam is correspondingly high, I think that this question of engine load-factor is of supreme importance. As I have shown above, a low engine load-factor tells more against belt or rope-driving sets than against direct-driving ones; but in neither case has the subject received the attention that it deserves. Every facility should be given for the men in charge of the steam dynamos to ascertain for themselves at any time at what load-factor they are driving their plant, and if this were done more frequently I am sure that great improvements would result. One reason why at present the men in the supply stations know so little about this question is, that in most cases it is only looked into as a sort of holy mystery by the engineering staff, and at long intervals of time; whereas I feel strongly a book ought to be kept in every works, and the men in charge should always enter up the load-factor of each engine during the hours the stop valve is open; and in order that this may be done with a minimum of labour, I have devised and used in our Chelmsford works a system which I will here describe for the benefit of those who care to adopt it.

The diagram* before you has its base line marked off in percentages of the load of the engine; and the same line is, in addition, marked with the steam-chest pressures, corresponding to these different percentages of load. This steam-chest pressure can be noted by a carefully calibrated gauge fixed on the steam-chest of the engine, the calibration being carried out as each set of indicator diagrams and electric load readings are taken; the result being that the man in charge of the engine can see at a glance from these steam gauges what ought to be the indicated and corresponding electrical horse-power that his engine is giving, and from the same diagram he is able to calculate the consumption of pounds of steam per hour.

Opposite to each gauge pressure is entered the theoretical consumption of steam per horse-power per hour at the standard speed, ascertained from Mr. Willans's table. Thus, if the man in charge enters up these steam pressures of all the running engines every quarter of an hour, it is easy to prepare an accurate report on the engine load-factor of the day, and thus compare the calculated with the actual steam used during the run; so that men who habitually underwork their engines can be thus noted and reprimanded.

Of course I know from experience how much more difficult it is to work engines driving alternators at a high load-factor than is the case with continuous-current steam dynamos. This is partly caused by the comparative difficulty and complication involved in parallelising alternators, compared with the ease of throwing continuous dynamos in and out of parallel on a storage system. In the latter case the enginemen have only one order to observe, viz., to keep their engines as fully loaded as possible on a rising load, not to start an additional set until the sets previously running are considerably overloaded, and on a falling load to shut down the sets at the earliest possible moment, even if it leaves the remaining sets somewhat overloaded for some time. Unless such orders are given and carried out to the letter, so that engine load-factors exceeding 70 per cent. on the average are obtained, it is useless to expect to reduce the consumption of steam below 50lb. per unit generated.

The other causes of waste of steam in electric supply works are those which Prof. Kennedy, in his lecture at the Royal Institution, speaks of as "losses about which we engineers feel very sore, and which sometimes try our temper and our patience greatly, and are not recognised as having any kind of respectable existence." These are those connected with leaks from boiler fittings and steam pipes, with condensation losses in the steam pipes, and due to the wasteful use of steam by all present known means of boiler feed.

These losses have been ignored by engineers, and have never received the attention they deserve; but, as they continue throughout the 24 hours, they amount to a very considerable percentage of the steam evaporated by the boilers, and of course tell most during the summer months, or in fact, in any works where the load-factor is low. Engineers who have been most successful in dealing with these difficulties, and have minimised these losses to the greatest extent, are those who previous to entering electrical works have received a practical engine-room training, either as sea-going engineers, or in engine-rooms of a similar class where fuel economy has been persistently studied. I believe the best remedy for the pipe condensation losses will lie in the direction of superheating the steam after it leaves the boilers. If we could superheat the steam so as not only to have no pipe condensation at all, but to deliver the steam to the engine cylinders at a temperature 8 or 10 per cent. above the corresponding temperature for saturated steam, I believe that we should at once save nearly 10 per cent. of the steam that we now have to evaporate in our boilers. It is very easy to talk of superheating steam. In the days of low-pressure steam at 15lb. pressure such superheating was a reasonably easy matter; but the case is widely different when the high-pressure steam leaves the boiler at a temperature of 375deg., as is now the case. Any further superheating is very much in the nature of passing this steam through pipes at a temperature which nearly amounts to red heat, so that it is little wonder that not

* We regret that we have not been able to obtain copies of the diagrams illustrating the Papers. [Ed. E.]

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many engineers have cared about tackling such a difficult and risky problem; but it is quite certain that this problem will be tackled, and I have recently heard that it has been satisfactorily dealt with by Messrs. McPhail and Simpson, the superheater consisting of a large number of bent tubes made of thick lap-welded iron, each tube being only about 1in. diameter. The bent portions of these tubes are so placed that they are exposed to the hot gases when they first pass through the flues of the boiler, such as the space at the end of a Lancashire or of an "Economic" boiler; in the case of the Babcock boiler it would be more difficult to find a place for them. It is evident that whoever attempts to deal with this problem of working out a satisfactory superheater will have a great many difficulties to deal with. The superheater must, as I have said, be placed so as to be exposed to the high-temperature gases, and yet it must be accessible for ready replacing of the tubes and for repairs. Moreover, it must be easily put in and out of circuit, so that a failure of one of the tubes should not in any way cripple the steam supply of the works. These requirements are in a sense contradictory, but I have no doubt, now so many minds are directed to this problem, it will be successfully dealt with.

Another point which is receiving the attention of all of us is the extended application of condensing plant.

In situations where condensing water is available this problem presents no difficulty, but in a large number of cases condensing water is not available; and of late years—in fact, dating from the time of my 1891 Paper—a number of proposals have been made to introduce what are called evaporative or surface condensers, which may be described as consisting of a very extended surface of tubes through which the steam passes, the tubes being cooled externally partly by an air-fan blast, and partly by a limited supply of water trickling on to the outside of them. Of course, so long as the amount of water used is equal to the feed water used, there would be no advantage in using such a condenser, other than that the steam consumption may possibly be economised, especially at times of light load, so that the steam that is required to pass through the condenser would be proportionately reduced; but Mr. Ledward and several other gentlemen who have paid attention to this subject are confident that they will be able to eventually reduce the cooling water required to two-thirds of that of the ordinary feed water; and if this is the case, it will result in a very great advantage, not only in removing the nuisance—which some people insist is a real nuisance—of the steam issuing from the chimneys of the various supply works, but the difficulties with the boilers will be also greatly diminished. But it must be recollected that this use of condensing water entails the working out of several very difficult problems connected with the thorough filtering out of the oil contained in the exhaust steam before it is allowed to re-enter the boilers. The united opinion of nearly all boiler engineers and inspectors is to the effect that if the water contains the smallest percentage of carbonate of lime the entry of even minute quantities of oil into the boiler is likely to have disastrous effects. The oils forms with the carbonate of lime a covering to the flues and tubes of a highly non-conducting nature, which allows the iron or steel plates or tubes to be greatly overheated, and great damage is thus done; so that most boiler insurance companies absolutely forbid the returning of condensed water to the boiler unless it has previously passed through a purifying apparatus which absolutely frees it from the oil.

I have briefly mentioned how very considerably the wasteful nature of the steam pumps that are at present available for boiler feed pumps affects the total economy of the works. For some time past at Chelmsford I have attempted to deal with this difficulty by supplying my boilers with feed pumps electrically driven; and although these electrically driven feed pumps are by no means as efficient as I hope to make them in the future, yet in their present state their use shows a marked economy over the Worthington or other direct-acting pumps that were previously employed. The electrically driven pumps use the energy from the main switchboard, which is generated in an economical manner; whereas the direct-driven pumps are driven not so much by steam as by water condensed in their steam pipes. I have over and over again called the attention of pump makers to the great want there is of a more economical steam pump than is at present in the market; but there appears to be a difficulty in dealing with the question, I believe chiefly owing to the intermittent way in which these feed pumps are worked, so that between periods of working their supply steam pipes get comparatively cooled.

I have spoken of the difficulty I have met with in obtaining trustworthy figures as regards water consumption. This is mainly due to the fact that a thoroughly trustworthy water meter is not an easy article to meet with. In order that such a water meter may accurately record the water fed into the boiler, it ought to be placed between the feed water heater and the boiler, so that any leakages that may occur at the pumps themselves, or in the lines of pipes, or in the feed water heater itself, may not affect the question of boiler evaporation. This necessarily means that such a water meter must pass hot water. For several years past I have been using Schönheyder's meter in this position, with fairly satisfactory results, but in its present state it leaves much to be desired. The pins wear to such an extent that in our Chelmsford case we find it necessary to take the meter out and replace the pins and recalibrate it once every three or four months. The calibration of such a meter is not a difficult matter if the feed water in any part of its course passes through a rectangular tank, the cubic contents of which can be readily measured, and the water contained marked for each inch of height.

(To be concluded.)

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(TO-DAY) FRIDAY, May 4th.

LONDON CHAMBER OF COMMERCE.

2:30 p.m. Meeting of the Electrical Trade Section at Botolph House, Eastcheap, to consider the Locomotive Acts in relation to the Traction industry.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Students' Meeting at 28, Victoria-street. Paper to be read: "A Description of the Electrical Type-Printing Instruments as used by the Exchange Telegraph Company," by F. Digby Latimer.

SATURDAY, May 5th.

ROYAL INSTITUTION.

3 p.m. Tyndall Lecture: "Colour Vision," by Capt. Abney, F.R.S.

MONDAY, May 7th.

ROYAL INSTITUTION.

5 p.m. General Monthly Meeting.

SOCIETY OF ARTS.

8 p.m. Cantor Lecture: "Typewriting Machines," by H. C. Jenkins.

TUESDAY, May 8th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "Rubies," by Prof. J. W. Judd, F.R.S.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. The following Paper will be further discussed: "The Manufacture of Briquette Fuel," by W. Colquhoun, Assoc.M.Inst.C.E. After which the following Papers will be read: (1) "Recent Types of Ferry Steamers," by Andrew Brown, M.I.C.E. (2) "The Birkenhead Ferry Boats 'Wirral' and 'Mersey,'" by William Carson, M.Inst.C.E.

WEDNESDAY, May 9th.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. The following Paper will be read: "Telegraph and Trade Routes in Persia," by Col. Wells.

THURSDAY, May 10th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "The Solid and Liquid States of Matter," by Prof. Dewar, F.R.S.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary Meeting. Continuation of discussion on "The Cost of Electrical Energy," by R. E. Crompton, M.Inst.C.E.

FRIDAY, May 11th.

PHYSICAL SOCIETY.

5 p.m. The following Papers will be read:—(1) "Electromagnetic Induction in Plane Cylindrical and Spherical Current Sheets," by G. H. Bryan, M.A. (2) "Dielectrics," by R. Appleyard.

SATURDAY, May 12th.

ROYAL INSTITUTION.

3 p.m. Tyndall Lecture: "Colour Vision," by Capt. Abney, F.R.S.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

Electric Light and Power Stations in Germany.—In Germany use has already been made of electric light stations for the purpose of supplying power to electric tramways. At Hamburg the consumption of the tramway already amounts to one-quarter of the total output of the station, and at Aix-la-Chapelle it has been decided to run the proposed tramways by means of current supplied from the electric lighting station.

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The Electrician.

(The Oldest Electrical Journal, 1861—1878.)

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Last week's number of "THE ELECTRICIAN" completed Vol. XXXII. With this week's issue is published (Gratis) the Index to that Volume.

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PATENT AGENTS.

This is an age of hysterics. In literature, in art, in politics, in business, and even in science, screaming is the fashion. The vulgar form of attracting attention is mere screaming on the part of the author, artist, demagogue, or prospectus writer or company wrecker; the more approved mode is the production of something calculated to make others scream. Pure science is tolerably free from this evil, but on its fringe we have anti-vivisectors, anti-vaccinators and anti-4πists who amply make up for any shortcomings elsewhere. Science and business may be said to meet at the Patent Office, and it seems impossible for some people to approach the patent question in a temperate fashion. As in other social problems, when "rights" are under discussion, common sense is too often found to be at variance with political ethics. Inventors, it is claimed, have a positive right to the fruits of their creative ingenuity, and when the Government, in exchange for a very valuable consideration, exacts anything more than a mere nominal registration fee, there are cries about the "taxation of invention." There is much to be said against the general principle of patents; but experience has shown that, on the whole, some such artificial bargain as that which the State now offers to inventors is useful, in so far that it encourages them to develop their schemes, of which a small fraction may eventually prove to be useful to the community. The popularising of the patent system by the Acts of 1883 and 1888, by which fees were largely reduced, and under which applications could be made to the Patent Office through any post-office in the kingdom, had the effect of largely increasing the applications; but the abandonments rose in even higher proportion, and at once exceeded the patents granted in former years. Re-

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formers were not satisfied, and the highly-coloured complaints about the taxation of invention and the hardships of patentees were soon renewed. In 1892 large concessions were made by the further reduction and simplification of the maintenance fees.

Again the cry is raised that "the inventor is being robbed." This time it is not the State directly, but the patent agents who are being howled at. The cause is to be found in two Bills now before Parliament. These two Bills, professing to aim at the proper registration of duly qualified patent agents, differ widely; but the whole difference, though one of grave importance, is to be found in the introduction of one little word of three letters. It is hardly credible that a Bill backed by such names as R. C. H. Gibbs, Sir Reginald Hanson, W. F. D. Smith, H. Kimber, Dr. Farquharson, A. Birrell, and last, but by no means least, by Sir Albert Rollit, should propose that no unregistered person shall be entitled to *act* as a patent agent, under a penalty of a fine not exceeding twenty pounds for a first offence, or to imprisonment for a term not exceeding six months for a subsequent offence. The Bill is promoted by a new body calling itself the Society of Patent Agents, and, besides inviting incorporation and registration of its present members, it seeks powers of government and of future addition to its numbers by sundry bye-laws. These bye-laws contemplate pure autonomy, and their only redeeming feature is, they are not to come into effect until they have been submitted to and allowed by the Board of Trade. But the Bill, in proposing to punish any unregistered person who assists another to draw up a specification, is so absurd that it really deserves no further attention.

The other Bill is introduced under the auspices of the Chartered Institute of Patent Agents, a body which has been not only officially recognised, but has been entrusted since 1889 with important duties, by the Board of Trade. It clearly states in its memorandum that its object "is not to create a monopoly, but to regulate the profession of patent agents in a manner similar to that in which other professions, such as those of solicitors, veterinary surgeons, and dentists are regulated." It "protects the public from deception by the unauthorised assumption of the title of patent agent." It forbids any person other than a registered patent agent using the title of patent agent under a penalty not exceeding twenty pounds, and we are glad to observe that it forbids also the use "on his place of business or elsewhere, the words patent office," a practice which ought long ago to have been stopped in all cases. The promoters, naturally jealous of their royal charter, ask for protection of the title "chartered." They have already adopted a system of tests of professional qualification, and their Bill schedules certain examinations, and the whole object of the Institute is to protect the public and prevent the "fleecing of inventors."

These Bills have raised a silly and indiscriminating outcry against patent agents as a class. There are, of course, many black sheep—utterly unqualified, as well as dishonest, men—among them. The temptations to which weak-minded patent agents are liable were well set out in *Engineering* last week, and it is difficult to imagine what possible inducement there can be, unless in a small town, for an inventor to go to one of these men. There are, we believe, no less than 46 Fellows of the Chartered Institute in London, and 26 in the provinces. London is unduly favoured in this as in other respects; and in the matter of patenting, the non-Londoner is at a considerable disadvantage, for he is often unable to consult a good patent agent or to examine published specifications without making a considerable journey. A large number of patentees employ no agents, and no doubt many engineers who have seen three or four specifications put through by a good agent are capable of turning out fairly good home-made ones. If they apply for two or three a year and drop three out of four at the end of the fourth year they certainly save a few pounds and perhaps gain some experience. But anyone with an invention which really promises to be a valuable matter will do well to discuss it with a good patent agent. The employment of a patent agent may be compared to the employment of a doctor or of a solicitor. For mild ailments, or for simple agreements or wills, an intelligent amateur treatment may be sufficient; intelligence, of course, implying an acquaintance with elementary principles. The amount of care and attention bestowed, to say nothing of valuable advice in drafting, as well as practical suggestions given as to the carrying out of the invention, is probably cheaper for the money than any professional services of the solicitor or of consulting engineer. It is rather flattering to an inventor to think that the agent has practically passed his draft specification with hardly an alteration. This alone is worth half the fee, and the feeling of security that two such wise heads have agreed on the settlement of the momentous document is worth the other half.

It is a great pity that the excitement, the circulars, the petitions, and general fuss about the robbing of inventors that is now being made should be directed against both of these Bills. We have little fear of the result. After encouraging and facilitating in so many ways the application for patents by the public, and after thus throwing open the Patent Office to them, it is hardly conceivable that the Board of Trade should forbid inventors to apply except through a patent agent. This it is not asked to do, although it is, of course, quite impracticable to prevent advice either in connection with the invention itself, or with the drafting of a specification being given either for fee or no fee, by a consulting engineer or by a friend of the inventor. We so highly esteem, on the other hand, the services of experienced patent agents, that we welcome any measure which will strengthen their position, and, if possible, sweep away the disreputable speculators and sharks who so disgrace this honourable profession, and are the real causes of the agitation concerning the "robbing of inventors." This can always be prevented if only inventors will take the trouble to enquire into the professional status and qualifications of any patent agent they may think of employing.

PROF. A. B. W. KENNEDY'S PRESIDENTIAL ADDRESS TO THE INSTITUTION OF MECHANICAL ENGINEERS.

(Continued from page 718, Vol. XXXII.)

I pass now to the last and largest section of my subject, the question of public electric lighting from the point of view of the mechanical engineer. From the side of the public, that is, of the users of electric light, the essential points are simple, viz., that the light should not visibly flicker, that it should not be below the declared pressure nor very much above it, that it should be available at all hours, and of course most of all that it should never go out! But any notions one might have that in consequence of the simplicity of this final result the means of attaining it would also be simple, are very speedily dispelled by a consideration of the facts. It is, alas! not sufficient to provide a shed, a boiler, a decently-governed engine and a dynamo or alternator, and many and sad have been the disappointments in consequence. The fact is, that although the final result to be attained is always the same, and is always extremely simple and straightforward, the conditions under which that result has to be obtained are always varying, and are not only extremely complex in any one place, but are also different altogether in each different place. To members of this Institution, however, I need not point out that

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this is not any cause for grumbling—the more difficult and complicated the problem the more chance there is for the engineer in working out its solution.

I will consider first those variations which are entirely beyond the control of the engineer, *i.e.*, the variations of load, and afterwards those which are within his power, *i.e.*, variations in the working of the station. To those of you who have practically to do with these matters the variations I have to speak of are absurdly familiar; but to others—probably the majority—they are still sufficiently unfamiliar to be of some little interest. I have, therefore, prepared diagrams which may illustrate them.

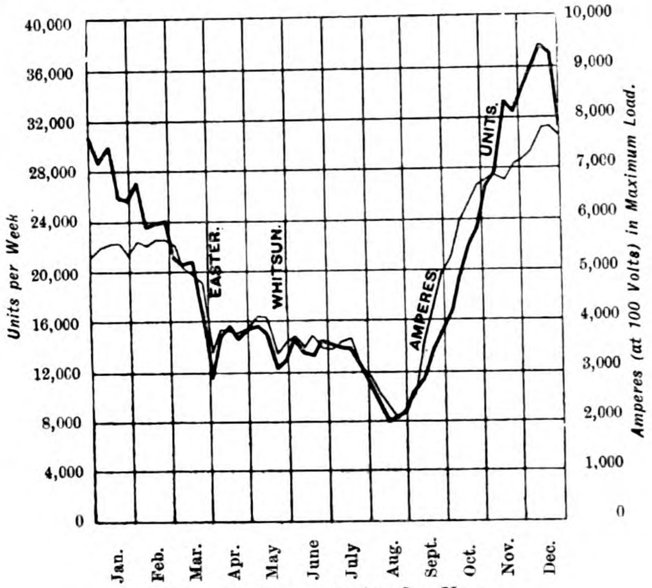

Fig. 1.—Output during One Year.

Diagram 1* shows the variations of output of a lighting station during a whole year. Each vertical division stands for one week. Irregularities are due to particularly foggy weeks or to weeks in which public holidays occur, such as Easter and Whitsuntide. For the rest the curve follows pretty obviously the changes in daylight, except that the minimum occurs, not in the very middle of the summer, but during August, in consequence of the large number of private houses which are shut up at that time while the days are still too long to require the use of any artificial light in shops which close at 7 o'clock.

Diagram 2 shows the variations within a week, each vertical division standing for one day. Here, of course, the chief variation is that which occurs on Saturday and Sunday.

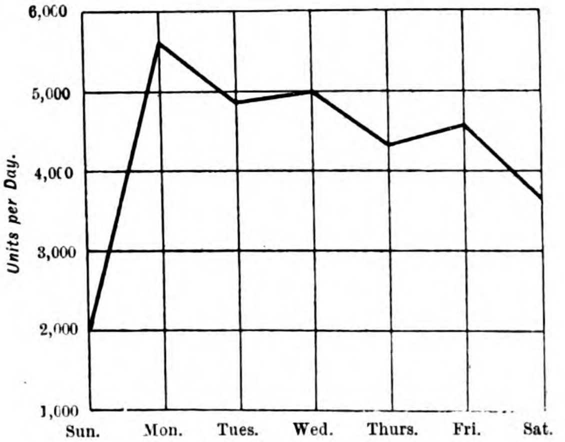

Fig. 2.—Output during One Week.

Diagram 3 shows the variations occurring within one day, the vertical divisions each standing for one hour. In this diagram three days are actually shown, one in December, one in August, and one in June, and it will be noticed that the three are very different. In winter there is practically always a double maximum, one occurring about breakfast time or in the forenoon, after which the load falls off in the middle of the day and reaches its full maximum towards evening. In the summer time the morning load disappears altogether, and there is only one maximum, which occurs much later than it does in winter. In fact I have noticed that in London at any rate the average time up to which people use light is fully an hour later in the summer than it is in the winter, a somewhat interesting fact in sociology. In August the "peak" of the diagram becomes a minimum, the private houses using no light because they are closed, the shops because the days are still too long.

The thick line on Diagram 1 shows in rather an interesting fashion that the maximum load and the minimum output by no means vary together. The maximum load is much more constant than the maximum output, and does not vary nearly so fast or so much.

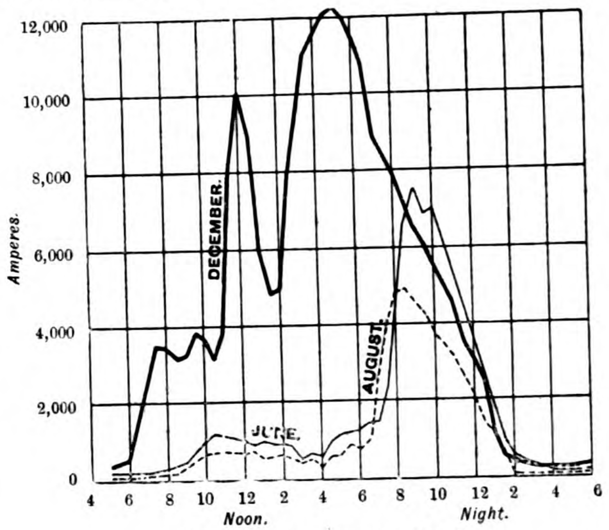

Fig. 3.—Load Curves. London.

The quantity which chiefly varies is the time during which that load lasts, and this time is, of course, dependent on the hours of sunlight, or more particularly on the interval between sunset and closing or bed-time.

Besides the variations shown in these diagrams it is right that I should mention one or two others. A very important class of variations are those which may be said to be due to latitude. In a place as far north as Aberdeen, for instance, there is practically no night for two months in the year, and for a much longer time than this no lighting whatever is used in shops, and hardly any in private houses. On the other hand, the hours of lighting in the winter are proportionately longer than in the south. The effect upon the annual output diagram would be not to alter its area considerably, but to thicken it up in the winter and reduce it very much in the summer. As an illustration of northern loads I have shown in Diagram 4 load curves for a winter and a summer day, taken at a little station which was running in Glasgow supplying offices some two years ago.

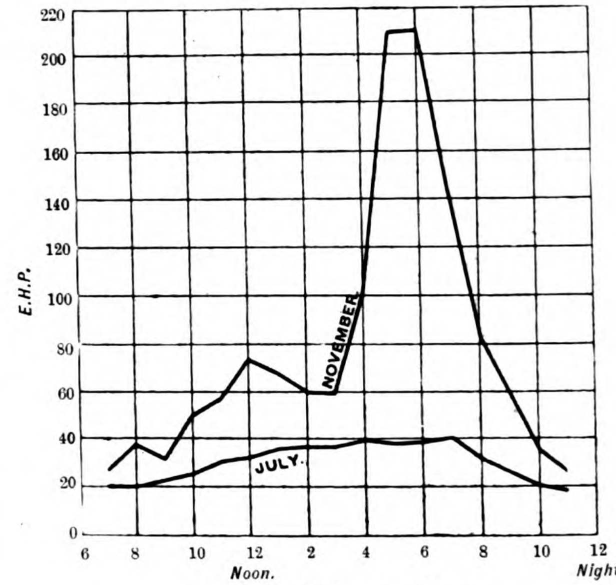

Fig. 4.—Load Curves. Glasgow.

One set of variations which puzzles and troubles the engineer very much is the varying amount of light thought necessary by

* This diagram corresponds to the output at the Davies-street Station of the Westminster Electric Supply Corporation during 1893. The great excess in the last quarter over the first quarter is to a considerable extent due to the larger number of lamps which were on circuit towards the end than at the beginning of the year. The great drop in the last week of all is due to the fact that that week included Christmas Day and Boxing Day as well as a Saturday and Sunday.

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people in different parts of the country. No doubt this depends to a considerable extent upon the nature of the premises in which the light is used, but even this is hardly sufficient to explain the whole of it. In a purely residential district in London, for instance, the average energy used per annum is only about 12 units per lamp wired. In a mixed district like that of the Westminster Company it is about 16 units per lamp wired. In a very rich district containing many clubs, like that of the St. James' Company, one is not surprised to find that it amounts to 22 units per lamp wired. But one is on the whole surprised to find that in Newcastle it should be as much as 25 units, and in Leeds 27. It is no doubt with less surprise that one notices that the consumption of 38 units per lamp per annum which existed in Exeter when current was paid for by contract and not by meter, was exactly halved as soon as consumers were made to pay for the amount which they really used.

There is one set of variations which, unlike all those which have been mentioned above, is to a certain extent under the control of the engineer. I mean the variations on the two sides of a circuit which is arranged upon a three-wire system. Here, of course, the engineer, in the first instance, endeavours to connect about the same number of lamps wired on each side of his system, and to see that the balance is approximately right, not only over the whole system but over each small section of it. In spite of all the care that may be used in this matter, however, I have found that a three-wire system may be very often greatly out of balance for a few minutes at a time owing to causes entirely beyond the engineer's control. Rapid changes in this respect occur chiefly within the 15 or 20 minutes during which load is coming on most rapidly in the afternoon. In a station when the load was increasing from 2,000 up to 8,000 amperes, I have frequently seen that in the course of 10 minutes first the positive and then the negative side would have 400 or 500 amperes more than the other. By the use of a balancing machine which can be transferred by a single switch from one side to the other the case, of course, can be met as it arises, but it is sometimes a little surprising that the changes should be so large and so rapid.

I have endeavoured to indicate to you some of the great number of variations in conditions, in spite of which the engineer has to obtain a uniform result. All these variations, even the last, are practically altogether beyond his control. Some of them occur with considerable regularity and can be foreseen, others are most irregular and come without any warning whatever. But all of them affect very greatly both the method and the cost of production. The method first, because the efficiency and regularity of supply must be considered before the matter of economy. Any method of supply which was inevitably liable to breakdowns and interruptions would be wholly condemned on that ground alone, even if it happened to be of the very highest economy. But given any one of the many methods of supply which are equally good as to result to the consumer, then that method must mainly be judged by its economy under the particular conditions in which it has to work. It will of course be borne in mind that the cost of power production in this case is not a mere 3 or 4 per cent. as in the case of a factory. It is 50 or 60 or 70 per cent. of the whole expenses, the balance being expenses of management and distribution, along with interest, depreciation and other charges connected with capital.

As to the effect, then, of the uncontrollable variations on system or economy, the first thing which I have to point out is that their madness is not entirely without method. There are some points which are as certain as it is that all Members of Parliament will not be on one side, in spite of the fact that such a thing is in imagination conceivable! Two of these are of special importance. First of all, there will never be more than certain proportions of all the lamps which are wired alight at once, either at times of maximum or of minimum load. The maximum maximum on the circuit of the Westminster Company is about 35 per cent., on that of the St. James Company I believe over 60 per cent., of the House-to-House Company about 35 per cent. In Glasgow, where at present the light is solely in the region of offices and shops, the proportion is as high as 56 per cent. You will see that these proportions depend largely upon the nature of the places where the light is used. This proportion, which, of course, can be only an estimate in any particular place until the experiment is made, fixes for the engineer the maximum number of lamps wired for which a given horse-power will supply current.

The maximum minimum is an almost equally important quantity, and in most places the engineer has to do with two such maxima, one for the day hours and another for the night. In a purely residential district the night load will always be very small and the day load will be practically nil. In the City of London the day load, in consequence of the number of dark places to be lit, is considerable, the night load extremely small. In a mixed district like that of the Westminster Company, the day loads, in the middle of summer, is not greatly more than the night load. It is to be noted, however, that the night load is practically the same all the year round, while the day load, even apart from fogs or exceptional weather, necessarily varies very much. The maximum maximum, also, as we have seen, varies much at different times during the year, although it never exceeds a certain amount. It is also worth noticing that in general the night load on a central station will increase but slowly with the growth of the station. The first consumers who take the light are most often those who are most in need of it, who require it for dark corridors and long hours. Later on thousands of lamps may come on to a circuit in shops, offices, and in ordinary private houses, without a single one of them being used after midnight. In an average district the day load increases faster than the night load, because out of any large number of shops and offices some are sure to have dark places requiring current in the daytime. But neither night nor day loads increase nearly as fast as the maximum evening load, which—a certain normal condition having once been reached—will increase exactly in proportion to the lamps wired. In an alternating current station where very numerous isolated transformers are used, the night load increases nearly proportionately to the day load because of the increase of magnetising current.

The determination of the sizes of units to be used in any station depends essentially on the probable values, absolute and proportionate, of the loads I have mentioned. It is now a commonplace, although a few years since no one seems to have thought of it, that the machinery in a station should be so subdivided that under all sets of conditions which remain steady for a few hours at a time it should be possible to have such machinery as is running, running more or less nearly fully loaded; only in this way can much economy be hoped for. It must not be taken, however, that this is a mere question of arithmetic, which can readily be settled offhand. In every case—it is to be hoped—the output of a station will be much greater ten years hence than it is to-day. The engineer has not uncommonly to consider somewhat difficult *pros* and *cons* when he is called upon to provide machinery which shall be of such a type that it can allow dividends to be earned during the years of growth and yet remain still suitable in the time of maturity.

It is further to be remembered that this question of the choice of size of unit is also quite modified in the cases where condensing plant is used instead of non-condensing. The reason for this I will not discuss here; I had a good deal to say about them in a recent discussion at the Institution of Civil Engineers. A good condensing engine uses nearly the same steam per indicated horse-power-hour at any load above half output. The increased consumption per estimated horse-power-hour is therefore proportionately much less than in the case of non-condensing engines, and the economical importance of fully loading the machines is correspondingly minimised in stations where condensing plant is employed.

The question of size of unit leads naturally to that of the necessary magnitude of reserve in any case. I think this is a simple matter, but no doubt it is sometimes wrongly treated. To make the reserve a fixed proportion to the total plant for instance, is a method which can only possibly come right by a fluke. I will not argue for the necessity of a reserve—that appears to me to be beyond any argument. The reserve is required for two purposes—to provide against breakdown of plant and to provide against accidental increase of load on special occasions. It is in the primary conditions of the case that the light absolutely must never go out, even if a machine wholly breaks down at the time of full load. From this it follows as a mere matter of arithmetic that the minimum of reserve must be a unit equal in size to the largest unit in the station, so as to be capable of taking its place if it breaks down. I should have thought that it went without saying that a machine of 100 H.P. could not be a reserve in a station where other machines were of 200 H.P., had it not been that I have seen it often so said. If an engineer considers that the winter, when the full load is liable to come on at any moment, is a suitable time for overhauling his plant, it is obvious that the reserve must be at least double the minimum which I have mentioned. Indeed most engineers would prefer to have two strings to their bow, and not to know that the breakdown of one machine would absolutely use up the reserve they wanted to keep in case of specially heavy load coming on, as long as it (the breakdown) lasted. This, however, is a question of degree, of caution, and some would say also of nervousness.

(*To be continued.*)

Electromagnetic Synchronism.—An elaborate and exhaustive Paper on "La Synchronisation Electromagnetique" is published in the *Bulletin de la Société Internationale des Electriciens* for April. It is from the pen of M. Cornu, and deals with the subject with that completness and careful analysis which is characteristic of M. Cornu's work. Commencing with the discussion of geometrical and mechanical analogues, such as the pendulum, the theory of electromagnetic synchronism is evolved, and the principal theorems in connection therewith are discussed.

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DESTRUCTIVE EFFECT OF ELECTRICAL CURRENTS ON SUBTERRANEAN METAL PIPES.*

BY ISAIAH H. FARNHAM.

For the past year or more there have been read before water, gas, and electrical engineering societies all over this country, Papers on the subject of electrolytic corrosion of water pipes, gas pipes, and lead cables. In fact, a meeting of such societies is incomplete to-day without some discussion on this subject. It was, therefore, with hesitation and misgivings that I considered the written invitation from the officers of the Institute to prepare a Paper on the "Electrolytic Effect of Currents on Subterranean Gas and Water Pipes."

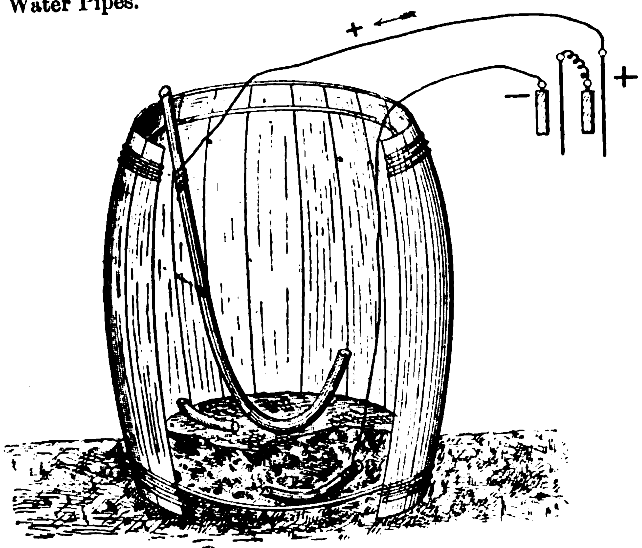

Fig. 1.

Early in the summer of 1891 some lead-covered telephone cable removed from wooden ducts in Boston showed some very marked yet local spots of corrosion. The cause of the corrosion was generally attributed to acetic acid contained in the wooden conduit, which had, years before, caused corrosion on a few cables in certain sections of the city. In the case just mentioned the corrosion was so severe, and located in spots only, that it led me to attribute the cause to electrolytic action from the railway currents, and a letter was written to my company to that effect. A few months later the repaired and raised from the ground, and found 1·5 to 2 volts difference of potential, the cable being positive to the earth. A barrel of earth (*see* Fig. 1) was procured from an excavation in the street, a metal plate placed beneath the earth in the barrel, and two short pieces of lead cable placed side by side on top of the earth. The plate in the bottom of the barrel was then connected to the negative side of a storage battery giving 4 volts potential, and one piece of the cable lying on the earth, was connected with the positive pole of the storage battery. The second piece of cable in the barrel was left without electrical connections. The earth was then saturated with water, and the circuit was closed, allowing the current to pass from battery to cable, to earth, to plate, and to battery, for seven consecutive days. The pieces of cable were

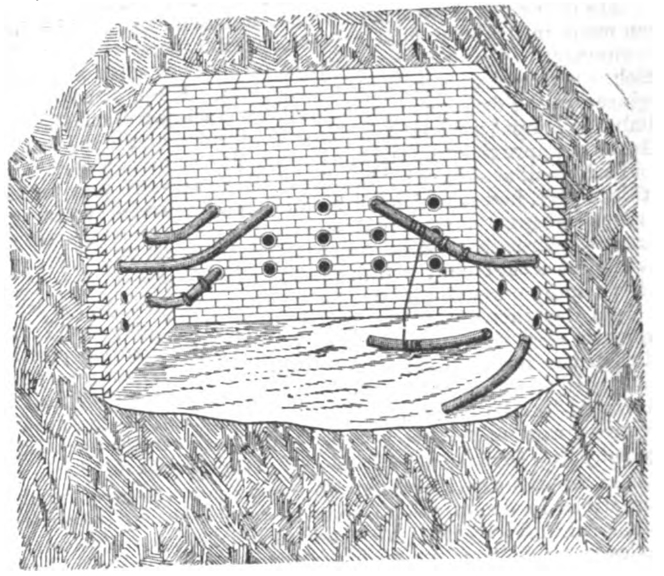

Fig. 2.

then removed and the piece which had been connected with the battery was badly pitted, closely resembling the cable which had been destroyed, while the second piece of cable showed no corrosion whatever, proving conclusively that a current such as was found in the manhole, was sufficient to cause the damage that had been found, and that the corrosion was not, in the case of the experiment at least, due to any acid or salts in the earth. In addition to the experiment just mentioned, we placed in the bottom of manhole chamber No. 76, two short pieces of cable, one of which

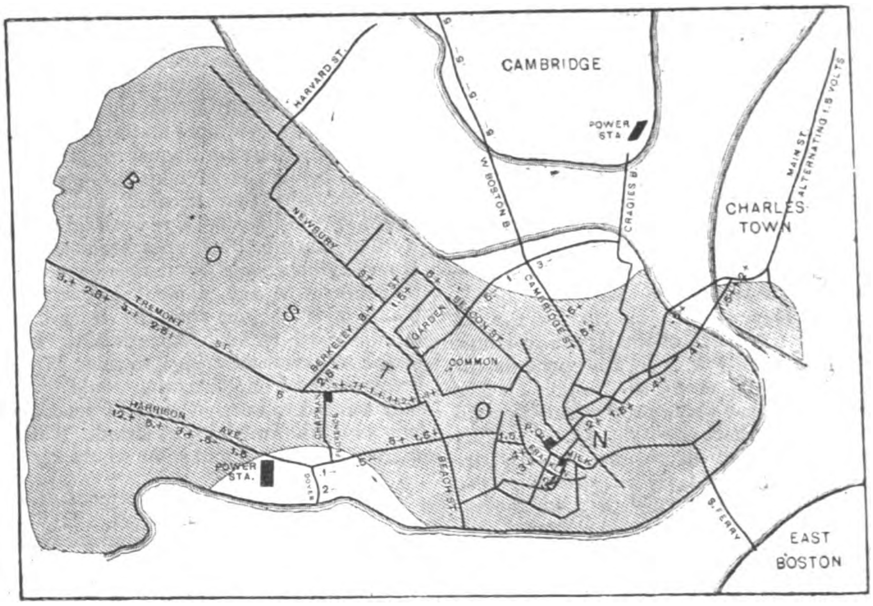

Fig. 3.—Showing where corrosion was going on when first brought to notice.

lead covering of a cable (No. 208), resting upon the ground in manhole chamber No. 76, located at the corner of Berkeley and Newbury streets, was found eaten entirely through at the point of contact with the earth. I then felt certain the cable had been destroyed by the action of the current. With Mr. W. I. Towne, my assistant, I proceeded to prove the theory. We took measurements between the cable and the earth, the cable having been we connected by a wire to cable No. 208, which had been damaged by electrolysis. (It should be understood that the damaged cable had been repaired, and removed from the bottom of the chamber). Fig. 2 shows the arrangement of this experiment. At the end of six weeks, the pieces of cable were removed and examined. The one which had been connected with cable No. 208, was deeply pitted*, while the other piece was free from corrosion, and these

* Abstract of a Paper read before the American Institute of Electrical Engineers.

* The plumbers of Omaha, Neb. apply the name of "small-pox pipe" to that pitted by electrolysis.

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experiments, with several others of minor importance, satisfied all who were interested, that electrolytic action was destroying cables, and probably gas and water pipes.

It next became necessary to prove to the electrician of the railway company, that the current causing electrolysis was from the railway system, and not from a leak in the Edison or some other electric lighting system. Measurements were made between the cables in all manholes and the earth near the cables, for voltage and direction of current. It was found that within a radius of about 2,000ft. from the Albany-street power-house, cables were negative to the earth, ranging from zero to 2 volts, and that outside of this neutral line, they were positive to the earth from zero to 12

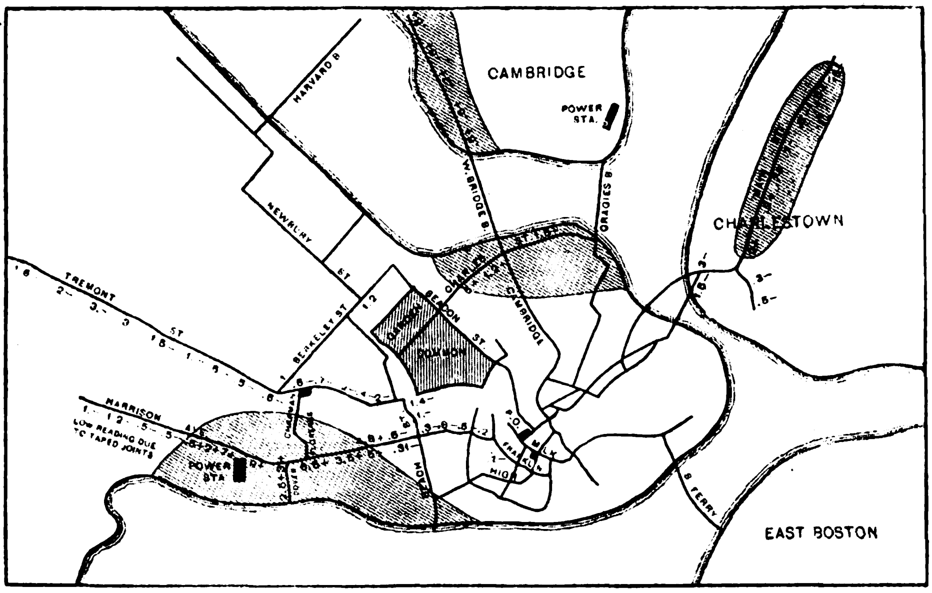

FIG. 7.—Condition after current was reversed by West End Company.

volts. This condition prevailed until a point was reached near the East Cambridge power-house, when they again passed a neutral line and became more and more negative as that power-house was approached. The same conditions were found as the Allston railway power-house was approached. On obtaining sufficient data, maps were drawn, showing voltage between cables and earth throughout all sections of the city. This is shown in map (Fig. 3). In addition to the figures placed beside the several routes of cable conduits, showing the direction of current and its pressure, we

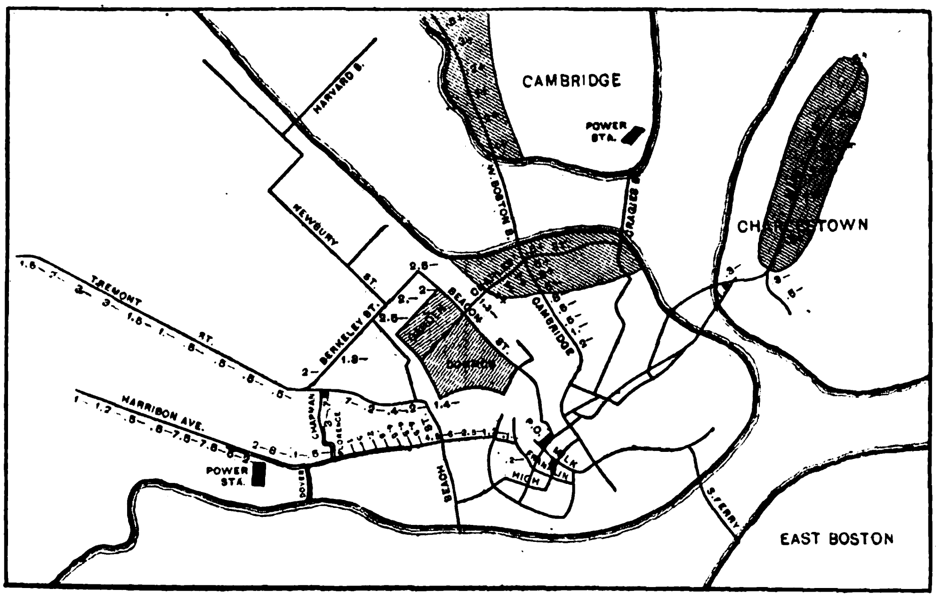

FIG. 8.—Condition, Jan. 4th, after connecting West End ground wire to cables near Power Station.

have shaded, such portion of the map where at that time we found the cables positive to the earth. We may call the shaded portion of the map the danger territory. These potential measurements, though taken for other purposes, incidentally furnished all the proof needed to convince one that the railway power was the source of the troublesome currents.

At the time the map was made, and previously, the railway was operating with the negative pole of the dynamo to the trolley, the positive side being to the rails.

Having outlined our early experience in running down this new trouble, we will next mention some of the proposed and applied remedies. Several conferences were held for the purpose of suggesting and discussing means for preventing the destruction of the cables, at which the officers and experts of both the railway and telephone companies were present, and it should be said, that the railway company in Boston has shown a disposition to adopt any promising plan for overcoming the evil, save, perhaps, the abandonment of the rails and earth as a part of the circuit.

First: It was proposed to remove all cables from the wet bottom and sides of the so-called manholes. It was found very difficult to place and retain cables free from the wet sides, and even could this have been accomplished, the action at the mouth of the ducts, and within them would still have continued. They were, however, all removed from the bottom of the manholes.

Second: It was suggested that the cables might be connected to ground plates in the manholes, and so transfer the electrolytic action to these plates, and thus save the cables. This experiment was tried on an extended scale, but though many ground plates having a surface of several square feet each, were connected with the cables over a large portion of the city, it was found that voltmeter readings taken between the cables and a point on the earth a short distance removed from the ground plate in any manhole, gave nearly the same pressure as before the ground plates were connected. In some cases, the voltage between the cables and the earth was reduced 25 per cent.; in many others, no noticeable reduction was made. The ground plates were constructed from pieces of old lead cable, 6 to 10ft. in length and embedded in the wet earth at the bottom of the manholes. It was evident from this

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test, that ordinary ground plates would not prove of material advantage for protecting the cables.

Third: Prof. Elihu Thomson suggested, among other possible remedies, the placing of motor generators at different points along the railway line, wherever the cables and pipes are found to be in danger, the motor generators to be operated by the railway power current; the secondary current developed by these generators to be utilised to lower the potential in the cables and pipes to zero, with respect to the surrounding earth or rails. The suggestion included means for automatically starting and stopping the generators, as cables might become positive or negative to the rails. The motor generators would, so to speak, pump the current out of the cables and force it into the rails whenever the potential of the former should rise above zero. Fig. 4 illustrates this suggestion. This plan has not yet been put into operation so far as I am aware.

Fourth: Insulating the cables and pipes from the earth was proposed. As some of the worst cases of corrosion of cables by electrolysis occurred where they were painted with asphalt, taped, painted again, and finally covered again with a heavy braiding also

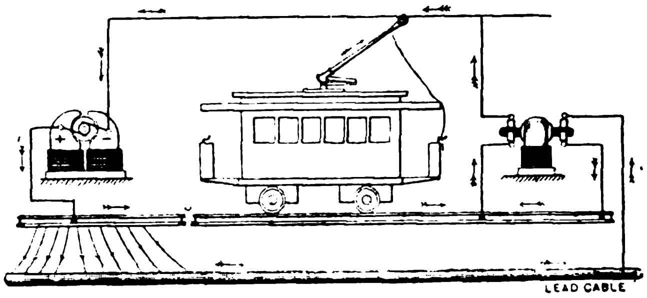

Fig. 4.

saturated with asphalt, it was apparent that to insulate cables sufficiently to protect them would be difficult and expensive, if indeed practically possible. I show specimens of corrosion of cables which had been treated with asphalt, tape and braiding. To protect water and gas pipes by a sufficient insulating jacket was seen at once to be impracticable.

Fifth: Breaking the metallic continuity of the cable sheath and pipes was proposed. From the fact that severe action is frequently found in comparatively isolated spots, where cables and pipes cross each other or pass near or across the rails, it follows that any system of breaking the metallic continuity, would have to be studied with reference to the entire complicated system of pipes, cables and rails ramifying through the streets of a city. There would also be a difference of potential between the several sections of cable or pipe, severed metallically, tending to cause electrolysis at one end of each section, as illustrated in Fig. 5. In case of water pipes, treated in this manner, the action might be expected on the interior as well as on the exterior.

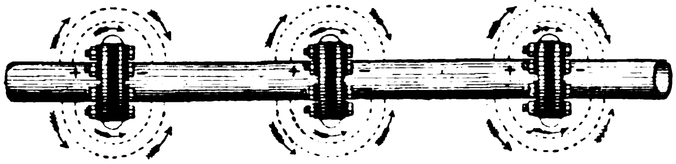

Fig. 5.

There appears to be some evidence of such an action as this in gas and water pipes where the electrical continuity is partially broken by leaded joints. Fig. 6 shows an iron service pipe from the Cambridge gas system. It will be noticed that the action is most severe at points immediately on either side of the coupling. The reason the corrosion appears on both sides of the coupling in this case is not clear; it may be due to reversal of current on the railway system. We have observed other specimens similar to this, which may tend to show that for currents of low pressure, the resistance of joints materially affects the results. I will again refer to this question in connection with potential differences in water mains.

Sixth: My assistant, Mr. Towne, suggested that the railway current might be so frequently alternated as possibly to prevent serious action on the pipes and cables. It seemed possible to reverse it once each 24 hours, at a given time in the night when the load is comparatively light. To do this in a large system involving several power stations would require either a loss of current for a few minutes in order to guard against one station reversing before some other had opened or reversed its current, or would require some electrical system connecting the several stations together, and operating the reversing apparatus simultaneously. We concluded it would be very difficult, if indeed at all practicable, to reverse such heavy currents during regular traffic. We then made a reversing experiment, giving 24 hour periods between each alternation, but found at the end of two weeks, to our sorrow, that the plates subjected to the action of the current were seriously electrolysed. It seemed useless to pursue this line of work further at that time.

Seventh: At about this stage in the study of the problem, Mr. Fred. S. Pearson, then engineer of the West End Street Railway Company, made two suggestions which, though separate in themselves, and presented at different dates, yet carried out in conjunction have proved exceedingly helpful in overcoming the difficulty, at least so far as relates to telephone cables. It occurred to Mr. Pearson, first, that if the railway current should be reversed so that the positive pole would be connected with the trolley, the danger of electrolysis would be removed from the greater and more scattered

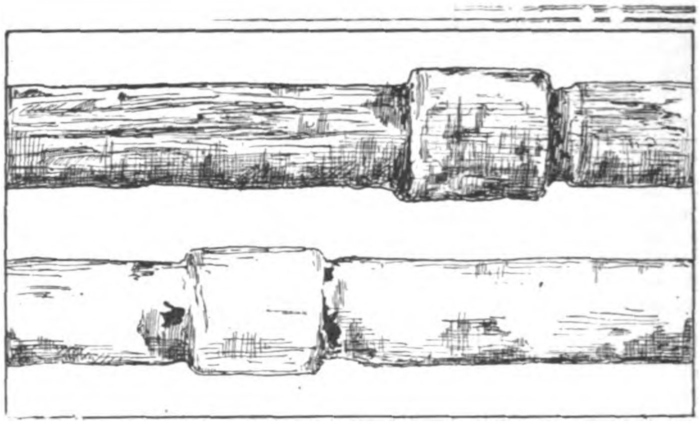

Fig. 6

portions of the city, and be brought near the power stations, where it possibly could be more easily dealt with. This reversal was made, and the expected potential changes between cables and earth followed. Fig. 7 is a map of Boston, showing the condition after the reversal of current. The shaded or dangerous portions in this map correspond to the white or safe districts in the map, shown in the first of this Paper (Fig. 3), the only variation being that, by the reversal, the neutral or zero line was thrown out a little further from the Albany-street power-house than it was located before. It was also noted that the cables near the power-house which had been from one to two volts negative to earth before the change of current, were now one to nine volts positive to earth, that is, they were raised higher above zero than they had been below zero prior to the reversal.

Mr. Pearson next suggested the plan of running out large copper conductors from the negative side of the dynamo, and extending them through the dangerous district, connecting them at frequent intervals to the cables. On the principle involved in Prof. Thom-

Fig. 9

son's motor generators, this low resistance conductor connected directly to the dynamo, was to pump the current from the cables and so prevent its passage into or through the moist earth. Some of us were sceptical as to the completeness of this proposed remedy. It seemed possible that even with a such a good return conductor, some of the current might still pass into and through the earth. Voltage measurements, however, at once dispelled the doubts, for we found that the cables measuring nine volts positive to earth, gave a reading of 22 positive to the return conductor; that is, the return wire as relating to the cables, was at all points, more negative than the earth (if we may be allowed the expression). The return conductors were made up of a large number of No. 18 copper wires formed into cables about one inch in diameter, known as conductors of 500,000 circular mils. These conductors were extended in each direction from Albany-street power-house entirely through this dangerous district, its longest section being about 4,300ft. The cables in every manhole within the district were connected by several No. 12 copper wires to the return conductor and soldered. On first connecting the cables to the return conductor, which took place on December 24, 1892, the current was sufficient to melt several strands of No. 12 wire. A measurement for current flowing in the main return conductor which was used for relieving the cables only, gave about 500 amperes.

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The map, Fig. 8, illustrates the condition after the installation of the return conductor at the Albany-street station. The danger patch which existed in that locality is now removed, and the cables are all negative to earth. The remaining danger patches were corrected by taking similar means of reaching the East Cambridge power-house. In treating this latter case, many measurements were made to determine whether or not the railway return wires put up to take the current in a measure from the tracks would answer for a return for the cables, instead of using a special return conductor, as had been employed at the Albany-street district. It was found that they would not answer, since the potential of these track return wires varied constantly and was frequently above that of the earth.

The cables on the Boston side of the draw of West Boston bridge, proved to be positive to both the rail and the water, while on the other side of the narrow draw the opposite condition existed, showing at once that it was unsafe to assume any neutral lines or potential difference without making measurements to determine the absolute facts.

So far, this Paper has dealt particularly with the subject of protection of lead-covered cables. It might be inferred that water and gas pipes can be treated in precisely the same manner with the same results, or as water pipes have a much greater sectional area of metal, it might be presumed that simply a connection of such pipes to the dynamo at the power station would be sufficient to bring their potential down to zero throughout the dangerous district. The facts so far coming to our notice would materially modify such inferences, and therefore should find a place here. That iron pipes are as truly subjected to the corrosion as lead need not be stated to the members of this society, but for the benefit of city officials and others who may read the Paper, it should be plainly stated that they are quite as readily destroyed by electrolysis. Fig. 9 is from a photograph of an iron gas pipe taken from Brooklyn, N.Y. The City Engineer of Milwaukee, Mr. G. H. Benzenberg, has kindly sent me a photograph of a 6in. iron water main, badly corroded. It is the best specimen of cast-iron pipe I

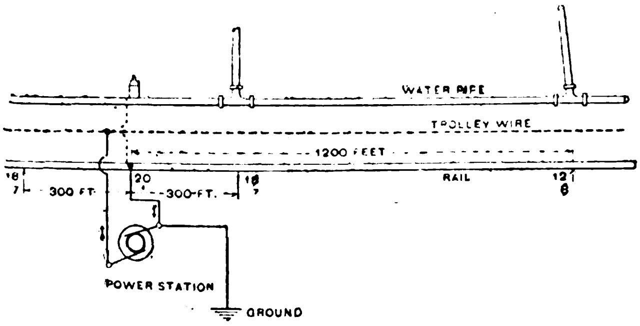

Fig 10.

have been able to obtain, although not the most serious case of corrosion. Mr. Benzenberg writes that the trouble in that city was chiefly noticed upon the six-inch water main extending 100ft. on each side of a point opposite the railway power station. Services entering this main were also destroyed, and all were renewed three times during the past two years. He states further, and I quote his own words, "at other points where power houses were established thereafter, the mains were immediately connected by extra heavy copper wires with the generator; we have had no trouble with them so far." Mr. O. H. Tripp, engineer at Rockland, Me., recently furnished me with a specimen of wrought-iron pipe destroyed in five months; the fact is of special interest as it comes from a city having but a small railway system. In Boston there have been water as well as gas-service pipes corroded through by electrolysis. I have not learned of any mains having burst from this cause. Measurements of water pipes in the city indicate they are still in danger, notwithstanding several thoroughly-made connections with the pipes at the power station; the same is true in Cambridge, Mass. This leads me to call attention to an interesting series of inquiries.

The engineer of the Water Board at Rochester, N.Y., suggested to me a short time ago, while looking into the question of electrolytic action upon the pipes in that city, that possibly there might be sufficient resistance in the joints of the water mains to cause an action upon the lead ring which forms the connection between sections of pipe. He stated that not unfrequently there is found a film of moisture between the pipe and this lead ring, and as the pipes are coated with a preparation of tar or asphalt on both the inner and outer surfaces before they are laid, there might be a poor electrical connection. Without having made any inquiries or tests upon this point, it seems to me probable that the careful caulking which is given these lead rings, would form in some portion of each joint a good electrical connection; that is, one of very low resistance. Recent measurements, however, made in Boston, and others made in Albany, during the latter part of March, this year, convince me that there is a very appreciable resistance in such joints.

Fig. 10 will illustrate the conditions at Albany. We found the negative side of the dynamo to be connected with the rails and with ground plates in old wells; no connection had been made with water or other pipes. Directly in front of the power station the voltmeter indicated a pressure of 20 volts between water pipe (an 8in. cast-iron pipe) and the rail, the pipe being positive. A reading taken about 300ft. in either direction, up or down the street, indicated about 18 volts. At a point 1,200ft. north, the reading was lowered to 12 volts. We then connected the rail side of the dynamo to the street hydrant and took new readings, finding 1 volt at the station, 7 volts at 300ft. distant, the same south, and 8 volts at a point 1,200ft. north. These measurements, with similar indications in Boston, show plainly that there is a very appreciable resistance in the water-main joints. At the same time the measurements give fair evidence that the difference of voltage between any two sections of water pipe is very small. The interested parties at Albany have kindly consented to allow any facts or figures obtained there in reference to this subject to be placed in this Paper. It is proposed at Albany to extend large wires through the dangerous district, one wire for each system of pipes, connecting the pipes to them at frequent intervals.

It is probable that the remedy which has been applied to telephone cables in some cities has been the more positive from the very failure, so far, to thoroughly protect the other systems of pipes against electrolytic action. The cables are connected by a large wire to the dynamo, while water pipes are not so treated. Therefore, the current which enters the water pipes at points outside the danger district passes to the neighbourhood of the power station, and, in leaving them there, raises the potential of the earth about the cables. In other words, the current flows from the water pipes to the ground, and thence to the cables in order to reach the dynamo. Connecting any one system of pipes to the dynamo will, in a measure, protect other systems of pipes, but connecting all systems reduces the certainty or margin of certainty of protection to any one system. When all cables and pipes in the danger district are connected by sufficiently large conductors to drain them, a careful adjustment in resistance in these several conductors may be found necessary in order to insure a balance between the several systems of pipes. It may lead to the necessity of reducing the carrying capacity of the conductor returning to the dynamo from the rails themselves.

The question has already risen, and it doubtless will be repeated here—"How small a difference of potential between pipe and earth will cause electrolytic action?" In reply to this, it may be stated that some of the worst cases of corrosion in Boston have occurred where the difference was but one and one-half volts. Mr. A. T. Wells, of Chicago, in describing to me an examination of some of the first cases in Cincinnati, states that the "difference of potential between the cables and the rail, was never more than one-half, and usually less than one-quarter volt." Such a difference between cable and rail would mean a much less difference between cable and earth, where electrolysis takes place. Mr. John C. Lee, of Boston, has experimentally caused the corrosion on lead and iron by a difference of potential of $\frac{1}{100}$ volt.

These facts certainly indicate that but a very small pressure is necessary to produce the action, and should dispel the numerous statements that well bonded rails or a large amount of rail return wires will alone overcome the trouble. In some cities, where electrolysis is in progress to-day, the return copper nearly equals that of the trolley and feed wire system. We cannot force the current to take one path exclusively when others are open to it.

The facts given above, with others similar, though not enumerated, lead me to these conclusions:

1st. All single trolley railways employing the rails as a portion of the circuit, cause electrolytic action and consequent corrosion of pipes in their immediate vicinity, unless special provision is made to prevent it.

2nd. A fraction of a volt difference of potential between pipes and the damp earth surrounding them is sufficient to induce the action.

3rd. Bonding of rails, or providing a metallic return conductor equal in sectional area and conductivity to the outgoing wires, is insufficient to wholly prevent damage to pipes.

4th. Insulating pipes sufficiently to prevent the trouble is impracticable.

5th. Breaking the metallic continuity of pipes at sufficiently frequent intervals is impracticable.

6th. It is advisable to connect the positive pole of the dynamo to the trolley lines.

7th. A large conductor extending from the grounded side of the dynamo, entirely through the danger territory and connected at every few hundred feet to such pipes as are in danger, will usually ensure their protection.

8th. It is better to use a separate conductor for each set of pipes to be protected.

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9th. Connection only at the power station to water or gas pipes will not ensure their safety.

10th. Connection between the pipes and rail, or rail return wires, outside of the danger district, should be carefully avoided.

11th. Frequent voltage measurements between pipes and earth should be obtained, and such changes in return conductors made, as the measurements indicate.

In closing this somewhat rambling Paper, I can do no better than use words which will remind you of Patrick Henry; "eternal vigilance" will be the "price" of pipes and cables where conditions favourable to electrolysis exist.

LEGAL INTELLIGENCE.

Wise v. Metropolitan Electric Supply Company (Limited).

On Friday morning, April 27th, Mr. BEALE, Q.C., continuing his argument for the defendants, said they had shown that they had exercised such discretion as ought to have been exercised, with their knowledge of the nature of the works, in selecting the site. They put the works on the site of some old stables, and consulted the agent of Lord Portman, as well as the Vestry, and no objection was raised upon the ground that it was not a proper site. They had not shown negligence in choosing the site or in the construction of the works, there had been no disposition to economise at the risk of nuisance, and, in fact, they had done everything they possibly could to prevent a nuisance. It was suggested in the course of cross-examination that they might stop the nuisance by putting up more engines on another site. They were asked whether they had not room for more engines at Paddington, without regard to the area covered from that station. How did they know, if they they did remove to Paddington, that they would not be involved in the same difficulty they were now under, and that other people would not complain in the same way that the plaintiffs in this case were now complaining?

Mr. VERNON SMITH followed on the same side, submitting that it was rather a case for damages for injury to business than for an injunction. Looking to the evidence, he did not think it was proved that the plaintiffs suffered very serious loss in consequence of the noise and vibration; some customers, no doubt, did not return, but most of the plaintiffs had said they still let their rooms to some extent. Therefore, such loss as they had sustained was a matter which could be met by damages, and he asked his lordship to regard the balance of convenience and inconvenience in the case, by giving the plaintiffs their remedy through the award of damages, and not by granting an injunction.

Mr. GRAHAM HASTINGS, Q.C., replied for the plaintiffs. He submitted that they ought to have damages, and they ought to have an injunction. Having read the cases bearing upon the point as to what constituted a nuisance, notably the definition of Lord Selborne in Fleming v. Hyslop, "whatever causes material discomfort and annoyance for the ordinary purposes of life," counsel argued that there was distinct evidence of nuisance, and also of loss of business, and in one case loss of health in consequence. He asked for an injunction, and that it should not be suspended for any long period, in view of the fact that his clients were still sustaining injury from the continuance of the vibration.

JUDGMENT.

Mr. JUSTICE STIRLING, in giving judgment, said this was an action brought by five plaintiffs who were tenants and occupiers of houses in Manchester-street, Manchester-square, against the Metropolitan Electric Supply Company, who had erected works for the supply of electric lighting in the immediate neighbourhood of the plaintiffs' houses, and it was sought to restrain the defendants from carrying on their business in such a way as to cause a nuisance to the plaintiffs by three different modes, namely, vibration, noise, and by causing smoke and smuts. The defences which were put forward by the Company were twofold: first, it was said that they did not carry on their business in such a way as to cause an actionable nuisance to the plaintiffs; and secondly, that even if they did, the remedy of the plaintiffs was by compensation under Section 17 of the Electric Lighting Act, and not by way of injunction and damage in an action of this sort. With reference to the second of these points, he considered it unnecessary for him to go into the subject, because it had so happened that, this case having been commenced last sittings, and there being no time to prosecute it to a termination, in the meantime the same point had been raised upon the same Acts, and practically the same Order before Mr. Justice Kekewich, in a case which he heard at the commencement of these sittings, and which was decided a few days ago. He (Mr. Justice Kekewitch) had considered fully in his judgment the legal question, he had dealt specifically in that judgment with most of the substantial points which were raised by Sir Richard Webster, and if there were a few points which were not touched upon, it did not seem to him that they would have affected the conclusion at which the learned judge arrived. Therefore, it seemed to him that it would not be right that he should enter into the question again, and he should proceed on the basis of the conclusion at which the learned judge arrived on the question of law. He, therefore started with this assumption, that the defendants were not entitled to carry on their works in such a way as to cause a nuisance to their neighbours; and starting from that point there were two points which he had to consider, first of all, whether a nuisance in the legal sense was caused by the works of the defendants, and secondly, if so, what was the remedy of the plaintiffs in respect of it. He had before him the correspondence which had passed between the plaintiffs and the officers of the Company, and he found that so early as January 13, 1890, Mr. Grant, one of the plaintiffs, wrote to the Company complaining of a nuisance by reason of the vibration. Then in February, 1891, Mr. Barrell wrote to Mr. Bailey also complaining of the vibration. Notwithstanding these letters, Mr. Bailey appeared to have been of the opinion that there was nothing in the complaints, and he stated very candidly in the witness-box that it was not until October, 1892, that he began to believe that there was anything in them. Having at last, after constant complaints, come to the conclusion that they had some foundation, he set to work to investigate the subject, and he stated that about that time he reported to his Board, and was instructed to take every possible means to overcome the cause of complaint. The result of Mr. Bailey's inquiries was that he discovered that the works were not situated on absolutely solid ground. It was found that somewhere about from 10 to 12ft. below the floor of the engine-room there was a stratum which was variously described by witnesses as spongy clay or mud, or saponaceous clay. That stratum extended to a depth of 23ft., and it was discovered that at all events when that stratum became charged with water it was of an elastic nature, and that the engines and alternators which were employed in the manufacture of the electrical supply transmitted their vibrations through the solid bed of brickwork and concrete on which they were placed to this lower stratum, and that then they were propagated to the houses of those who were now complaining. The plan which he (Mr. Bailey) suggested, and which was adopted, under the advice of eminent engineers, to remedy this effect, was to place underneath the solid bed of brickwork and concrete columns reaching down to the solid London clay, some 23ft. below the termination of the uppermost stratum, which was supposed to be solid, and on which the brickwork and concrete rested. These were cast-iron columns, filled with concrete, and one was placed between every two engines. The works were completed in November of last year, and it was stated that they cost somewhere about £2,000. But, unfortunately, it had turned out that even this did not put an end to the vibration. The question arose, What was the reason of that? and the answer which was given by the defendants' witnesses (Mr. Bailey, Prof. Kennedy, and Dr. Hopkinson) was, that although what might be termed the vertical vibrations had been stopped by means of those pillars, the horizontal motion was not stopped; that was to say, those pillars, solid though they were, did yield to a certain extent in a horizontal direction, moving, as an inverted pendulum would do, from the bottom of the column, the bottom of the column being fixed, the top gave way to a certain extent, and horizontal vibrations were still transmitted through the stratum of spongy clay. Now the further question arose, Could this be remedied? The witnesses whom he had mentioned agreed that probably it could. All of them very properly admitted that the problem they had to solve was a new one, and they could not speak with absolute certainty on such a question, but if they were correct in the view they had entertained as to the origin of the vibrations which still existed, then they would in all probability be stopped by placing at the top of the columns slanting struts in such a way as to stop that horizontal vibration. A pair of such struts had been placed in position; but they were not absolutely completed or effectively connected with the columns at the present time, but it was said that they would be completed in a short time. It was further proposed, if that were not found sufficient to absolutely stop the vibration, to put in further struts at different points. But the important point to be considered was this, that it was admitted on all hands—defendants' witnesses did not dispute it—that vibration did exist in those houses, and it might be taken as a fair conclusion from the evidence that there was a substantial amount of vibration existing in those houses due to the working of defendants' engines. All the scientific witnesses gave their evidence with the greatest possible fairness—and among them he included Mr. Bailey—and he did not propose to go through that part of the evidence, as to which there was no question. But did this vibration constitute a nuisance? That was the next question he had to decide: and the test to be applied was that suggested by Vice-Chancellor Knight-Bruce in Walter v. Selfe, and by Lord Selborne in the House of Lords, did it cause material discomfort or annoyance for the ordinary purposes of life to those houses, and to the business of lodging-house keepers carried on there? In beginning to consider the evidence upon this point, he would remark that the question was put to Mr. Bailey as to whether he considered these complaints were in any way unfounded, and although he thought some of the statements were slightly coloured and exaggerated he did not seriously dispute the general accuracy of the evidence. His lordship then read portions of his notes of the evidence given by the several plaintiffs, and by their lodgers, remarking that whilst they spoke very forcibly as to the vibration, which was the first ground of complaint put forward, and evidently felt it to be a real grievance, he was not much impressed with the manner in which they gave their evidence as to noise, which seemed to be rather an appendix to the vibration, as sometimes a complaint about air was added to a complaint about light. But as to the vibration, it did seem to him that the witnesses gave their evidence with great moderation, and without any serious exaggeration. It might be that there was a little colour here and there, but substantially the case of the plaintiffs as to the interference with the comfort of the houses as the effect of the vibration was made out. He could not come to the same conclusion as regards either the noise or the smuts, which he did not think was a serious part of the nuisance. He accepted entirely the statement made by Mr. Bailey that during the coal strike they were unable to get the proper and usual coal, and were compelled to burn coal of an inferior quality, which did produce a certain amount of smoke, but there was certainly no case made out for an injunction upon this head, nor did he think there was any case made out as to damages. But that was a small part of the case, and he did not think any serious expense had been incurred in consequence of the mention of noise and smuts. It did seem to him that there was substantial interference with the houses

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and businesses of lodging-house keepers carried on by the plaintiffs, and that that ought to be ground for an injunction, and also an inquiry as to damages. But it was said on behalf of the Company that if an injunction were granted it ought not to be put in immediate operation. He was entirely of that opinion. He thought the Company had been unfortunate. It was not necessary for him in the view he had taken to go into the question of negligence, and he should say nothing upon that, but he certainly thought that since October, 1892, when the attention of the engineer was first seriously directed to the matter, they had done their very best to remove all ground for complaint on the part of the plaintiffs, and if they had not succeeded up to the present time it was not attributable to any negligence on their part, but to the fact that they had had to deal for the first time with a very difficult question. He thought the Company ought to have a fair opportunity of completing the works upon which they were now engaged, and which there was reasonable hope would entirely prevent the nuisance; and they certainly ought to have a reasonable time allowed them for that purpose. Having regard to the difficulty of the subject, he thought it would be a fair thing to suspend the operation of the injunction for three months at least, and that would give them an opportunity of bringing the matter before the Court before the Long Vacation if, unfortunately, the efforts of the engineers did not meet with success. He proposed, therefore, to grant an injunction as regards vibration only, an inquiry as to damages on that subject, and to suspend the operation of the injunction for three months.

Mr. GRAHAM HASTINGS asked for costs on the higher scale, as the questions dealt with were difficult ones.

Mr. JUSTICE STIRLING said the question which the advisers of the defendants had to determine was a difficult one, but he did not think the question before the Court was such as to require costs on the higher scale.

Muirhead v. The Commercial Cable Company.

Judgment was given in this action on Saturday last. A full report of the case will be found in our issues of March 9th and 16th last.

JUDGMENT.

Mr. JUSTICE KENNEDY: This is an action brought by John Muirhead, Alexander Muirhead, and Herbert Arnand Taylor, to recover from the defendants, the Commercial Cable Company, the sum of £3,565. 1s. 6d. under an agreement in writing, dated January 2, 1884. At the date of the agreement the plaintiffs were the holders of certain English, Canadian, French, and American patents for apparatus to be used in duplex telegraphy. The defendant Company were about to lay and work certain submarine telegraphic cables, and the purpose of the agreement was to secure to the Company, in the establishment and working of their cables, the use of the patented apparatus, and of improvements in that apparatus. By the terms of the agreement, in consideration of the payment to the plaintiffs during the continuance of the agreement of certain specified royalties, which were to be calculated and assessed in the manner therein prescribed, and to be paid quarterly, the plaintiffs granted to the defendant Company the use of their patented apparatus with its improvements, in the form and to the extent which is set out in the agreement. The first article is the only part of the document in the precise language of which there is any importance as regards the decision of this action. The article runs thus:—"The inventors grant to the Company the right to apply their said patented duplex apparatus to the above-named cables. This grant is made for the whole period during which the patents shall last. The inventors bind themselves, moreover, at the request of the Company to give them during the continuance of this agreement the benefit of all improvements and modifications which they may discover in the said duplex apparatus, whether they be or be not by letters patent, or otherwise legally protected, but in that case the present contract shall be prolonged for a period equal to the term of any new patents that may be taken out." For the purposes of this case it may be taken that this agreement was until July 1, 1891, carried out by both plaintiffs and defendants. But the quarterly payments which would, if the agreement was still in force, have become due on September 29th and December 25, 1891, have not been paid, and this action was instituted by the plaintiffs to recover them. If the right to them exists, there is now no dispute as to the figures. But the action has pecuniarily an importance which goes far beyond these figures, for if the plaintiffs are entitled to succeed as to these two payments, it follows that they are entitled to similar quarterly payments for several succeeding years also.

The issue which is raised in the action may be stated in a single sentence, and it is this—Was the Patent No. 234,490 granted to the plaintiff, Alexander Muirhead, on November 16, 1880, in the United States of America, a patent which, in the language of that article of the agreement which I have just quoted, "was lasting" after July 1, 1891. The plaintiffs contend that it was. If it was not, the defendants are entitled to judgment in their favour. Simple, however, as the statement of the issue is, the determination of it involves some important questions of law and some important and, in my judgment, more difficult questions of fact of a scientific and highly technical character, the trial of which occupied several days. The controversy arises in the following manner:—The patent to which I have referred was, as I have said, granted by the Patent Office of the United States on Nov. 16, 1880. The grant is expressed to be a grant of letters patent for the term of 17 years from that date. *Primâ facie*, therefore, it would last until Nov. 16, 1897, but being a United States patent, it is governed by the law of the United States. It is part of the statute law of those States that "Every patent granted for an invention which has been previously patented in a foreign country shall be so limited as to expire at the same time with the foreign patent, or, if there be more than one at the same time, with the one having the shortest term, and in no case shall it be in force more than 17 years." This statutory provision is repeated in the 29th of the Rules of Practice of the United States Patent Office (revised September, 1880), which are established under statutory authority by the Commissioner of Patents, subject to the approval of the Secretary of the Interior; and in the 162nd Rule it is further laid down *inter alia* that "Every patent will contain a short title of the invention or discovery, indicating its nature and object, and a grant to the patentee, his heirs and assigns for the term of 17 years of the exclusive right to make, use, and vend the invention or discovery throughout the United States and the territories thereof. But if the invention shall have been previously patented abroad, the term of the patent will expire with the term of the foreign patent." It has been in my view settled by judicial decision in the Courts of the United States, in reference to those provisions, that although a United States patent has not upon its face been limited, but contains an express grant of the patent rights for the full term of 17 years, nevertheless, by operation of law, if the invention has, in fact, been previously patented abroad, and the foreign patent expires before the 17 years term has run out, the United States patent expires at the same time.

It is also, in my judgment, settled law that the United States statutes are not to be construed as invalidating *ab initio* a patent wherein, although it is for an invention previously patented abroad, the grant is not limited as it ought to have been, but runs for the full term of 17 years. The statute is to be construed simply as controlling the effect or duration of the grant. In other words, the grant is a valid grant, but is good only for the shorter term, and expires at the expiration of the foreign patent. It is, in my view, further, the law of the United States, that in such a case as that to which I have just referred, where the grant has wrongly been made for a term exceeding the duration of the earlier foreign patent, it is not necessary, in order to terminate the rights of the patentee, and to prevent the exercise by him of the privileges of the grant after the period to which the grant ought to have been limited, that any judicial proceedings should be taken for the purpose. By operation of law, that is, of the Statute which I have cited, the United States patent is extinguished and expires, notwithstanding the terms of the grant, when the foreign patent expires.

This being the state of the American law as to patents, the defence of the defendants to the plaintiffs' claim in this action is, that the invention for which the United States patent of November, 1880, was granted was, in the words of the Statute which I have cited, an invention "which had been previously patented in a foreign country" (the "foreign patent" in this case was the English patent granted in 1876, No. 2,564), and that the foreign patent expired not later, at any rate, than July 1, 1891; that, consequently, the United States Patent of November 16, 1880, although containing a grant for 17 years from that date, also expired at the same time, and therefore, as after July 1, 1891, there was no patent which was "lasting" within the meaning of the agreement between the parties, the obligation of the defendants to pay royalties then ceased.

In reply to this defence, the plaintiffs raise two sets of contentions, the first of a purely legal character; the second resting partly on law and partly on fact, and based upon the construction of the English and American patents, and the inferences to be drawn from the scientific evidence which was adduced before me to explain the terms and the subject matter of the various patents.

First as to the law. The plaintiffs' points on this head resolve themselves, I think, into four. First, they say that whilst they do not dispute that as between the patentee and a party charged with infringing the patent, the alleged infringer may, according to American law, succeed by proving that the American patent has expired because of the expiration of a prior foreign patent granted for the same invention, although the duration of the American patent has not been limited, as it ought to have been, upon its face, to the duration of the foreign patent, yet that this line of defence is not open to a licensee as against his licensor. The plaintiffs contend that such a defence in truth involves an attack upon the validity of the patent which is expressed to be granted for the full term. I am unable to take this view. It appears to me that all that the defendants seek to do is to do that which is permissible to a licensee as against his licensor, just as it is permissible to a lessee against his lessor, that is, to show that his right, originally good, has expired. The American law does not, upon proof that the invention which has been patented in the United States has been the subject of a prior foreign patent, avoid the grant *ab initio*, but treats the duration of the grant as limited to the life of the foreign patent, just as if that limitation had been originally written into the patent. The term is treated as if it had been expressed from the first, as it ought to have been. But then the plaintiffs in this case lay stress upon the particular terms of this agreement. The obligation upon the defendants is to continue, according to that agreement, "for the whole period during which the patents shall last." Mr. Finlay argued that this means "as long as they last on the face of them without attack," and that the expression is merely another way of suggesting what he called the "face-term" of the patent, that is to say, 17 years. I cannot so interpret the agreement. I read it as meaning the whole period for which the patent lasts as a patent according to the law of the United States. When it lasts no longer as such, it appears to me that defendants' obligation also ceases. I cannot see any estoppel to prevent the defendants showing that the true effect of the patent according to the law of the State which made it, is a grant which, in the circumstances alleged, gives a term of 14 and not of 17 years. There remain two other points of law raised by the plaintiffs' counsel in argument. It is pointed out correctly enough that the law of the United States only applies to the case of an invention patented in the United States where the invention has been previously patented in a foreign country by the American patentee, or by some person with his knowledge or consent. In this case the American patentee is Mr. Alexander Muirhead, and the English patent in question, the patent of 1876, is granted to his brother,

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Mr. John Muirhead, the invention being stated to be "partly a communication from abroad by Alexander Muirhead residing at Aden." The fair inference which the plaintiffs, who called both the Messrs. Muirhead as witnesses, might have rebutted, if in truth it could be rebutted, appears to me to be that the English patent of 1876 was granted for an invention, whatever it was, with Mr. Alexander Muirhead's knowledge and consent; and if that be so, then I think that the American law would apply, if the English patent is found in fact to include the thing which was patented in the United States in 1880. Lastly, I was pressed to hold that I could not, sitting here, find that the United States patent had expired without proof of a decision in a United States Court to that effect, and in the absence of such a decision, the point which the defendants raise as to the expiration of the 1880 patent, ought to be treated as a point not open to them. It was put by the learned counsel for the plaintiffs rather on the ground of convenience He suggested a hardship upon the patentee, on the ground that he could not, when sued in this Court, as he might perhaps have done if sued in the United States, place himself in safety as regards the allegation of identity of the 1876 and 1880 patents by disclaiming part of the latter patent. He also pointed out the possibility and the undesirableness of a conflict of judicial decisions—an American Court holding the patent to be good, whilst the English Court had held differently. It appears to me that I could not properly rule that the defendants' line of defence is inadmissible on any such grounds. The action is brought on the agreement. It is an action properly brought in the English Court. By Article 9 of the agreement it is provided that "These presents are to be read and construed as an English contract and all questions arising thereout shall be determined by a competent English tribunal to the jurisdiction of which the parties hereto bind themselves beforehand to submit." What is the question on the agreement? It is the question whether an American patent was or was not lasting after a certain date. How could I properly refuse to try that question because it involves matters of the law of the United States relating to patents? It seems to me to be clear that I must deal with this as other questions of foreign law are constantly dealt with in the Courts of this country, upon evidence of that law. I may add that in this case, through the good sense of the parties, the materials for forming my judgment as to the foreign law applicable to this case have been put before me in a most satisfactory and convenient form.

Having thus dwelt with the plaintiffs' contentions in point of law, I come to the consideration of that which appears to me to be the most difficult, as it certainly is the most interesting question in the case—the question of fact to which, during the seven days' trial the greater part of the evidence and the arguments of counsel was directed. Are the defendants right in their contention that Muirhead's American patent of 1880, has, in the language of the American Statute, been granted for an invention which had been previously patented in England in 1876? Unless the defendants are right in this, the defence to this action wholly fails, and the plaintiffs are entitled to my judgment. In order to enable me to form my judgment on this issue, which involves considerations of a scientific and highly technical character, I have had adduced before me on each side a great body of most valuable scientific evidence. I have also had (and I desire to make my acknowledgment of it) very great assistance from all the counsel engaged in the case—assistance which included, amongst other things, the neat and excellent model of the duplex apparatus which was, as I was informed, constructed by Mr. Walter, the junior counsel for the defendants.

The American law applicable to this class of case has been placed before me in a collection of judicial decisions. What are the principles by which, acting upon these decisions, I ought to be guided in the consideration of this case? There are three passages, and three passages only, from the selected judgments to which I think it necessary to refer as laying down principles of law which might be held to be applicable to this case. The first of those occurs in the judgment of Mr. Justice Coxe in the case of the Brush Electric Company *v.* Julien Electric Company and others, decided in the Circuit Court, S. D. New York, March 18, 1890. The principle laid down I believe to be identical with the principle upon which an English Court would act in a similar case. "The law does not favour forfeitures. A patent should never be declared invalid because of the expiration of a foreign patent, if there is doubt about the inventions being the same. The burden is upon the defendants, and the doubt should be resolved in favour of the patent." The second passage to which I propose to refer is one to which my attention was directed by the learned counsel for the defendants. It is that which is laid down by Mr. Justice Bradley in Siemens's Administrator *v.* Sellers, in relation to the case of the American patent containing improvements on the earlier patent. He lays down the law in the following terms:—"It is contended by the counsel of the complainants that the American patent contains improvements which are not exhibited in the English patent, but if this were so it would not help the complainants. The principal invention is in both, and if the American patent contains additional improvements, this fact cannot save the patent from the operation of the law, which is invoked if it is subject to that law at all." The third passage to which I shall refer deals with the test of the identity between the subject-matter of the two patents, which is necessary in order to bring into operation the law upon which the defendants rely. I find that the test is, as one might expect, put in various ways in the American cases which have been brought under my notice, but nowhere I think has it been so fully or satisfactorily stated as in the judgment of Judge Coxe, following, as the learned judge says, the judgment of the Supreme Court in two earlier cases, in the action of the Electric Accumulator Company against the Julien Electrical Company. Applying his language to this case, one may find the proper test of identity in the answer to the following questions:—First, is the principal invention of the American patent of 1880 found in the English patent of 1876? Secondly, is the subject matter of the one the same in all essential particulars as that of the other? In other words, will a structure made pursuant to the English patent of 1876 infringe the American patent of 1880? Thirdly, could both the patents have been granted in America? Fourthly, would a person skilled in the art, after reading the description of the invention covered by the English patent of 1876, be able to construct the apparatus described and claimed in the American apparatus of 1880? It appears to me, and I think that counsel in argument put the same view, that these are the principles deducible from the American decisions which are really relevant to the issue in this case, as to the identity of the patents of 1876 and 1880, and I have kept these principles in view in the careful consideration which I have given to the contents of the patents themselves, and to the scientific evidence adduced at the trial in regard to their terms and subject matter. The claim of the 1880 patent is, in my judgment, a claim of the narrowest kind. It is a claim for a particular combination only affecting, as the patentee alleges, new and useful improvements in duplex telegraphy. There is no claim made for any of the structural elements of the combination outside the combination. Admittedly, all those elements taken separately are old. "My invention," says the patentee in his specification, "relates to duplex telegraphs of the class worked on the bridge or differential system. Its object is more especially to reduce the retardation of the signals, and thereby to increase the speed of transmission of submarine telegraph lines, which ends I attain by certain novel combinations and organisations of old instrumentalities set forth in the claims at the end of this specification." The defendants, in order to succeed in their defence, have to establish that this particular combination of old instrumentalities, the working of which, undoubtedly, produces better results than had ever been obtained before, is to be found in the English patent of 1876. In my judgment they have failed to do so. It is unnecessary for me to recapitulate the parts of the combination. They are enumerated, as the patentee says, in the claim at the end of the specification. I need, in order to make the ground of my judgment clear, only to point out that element of the 1880 combination which, whilst the union of all the elements is necessary in order to attain the result, differentiates in my view the invention claimed in the 1880 patent from any combination which is claimed by the patent of 1876. Put shortly, but I hope accurately, the distinction appears to me to consist in the method and means of adjustment, or, as it is called by some of the expert witnesses, the method and means of procuring and maintaining the necessary balance. By the introduction of that method and means, as I understand the evidence, the patentee has been enabled, whilst possessing the necessary facility for getting and maintaining balance, to do that which for speedy (and speedy means successful) working of duplex submarine telegraphy is all important—the elimination, or, at all events, the reduction to the slightest proportions of resistance in the arms of the bridge. I am satisfied by the evidence of Lord Kelvin, Mr. Bottomley, Prof. Thompson, and Dr. Hopkinson that the introduction of the three-terminal rheostat of low resistance placed at the apex of the arms of the bridge, and, therefore, in such a position as not merely to afford an easy and sufficient means of varying the resistance so as to get the ratio which gives a balance, but also to maintain the sum of the resistances of the two bridge arms constant, is a very important part of the 1880 combination. I do not find any combination containing that element in the patent of 1876. The battery, the key, the receiving instrument and its condenser, and, although the language of the specification is on this point somewhat obscure, the use in connection with these, as in the patent of 1880 of the bridge condenser—all these are, I think, to be found in the 1876 patent. But I do not find there any claim for the employment in combination with these elements of the means and method of adjustment which, as I have said, form, in my judgment, an important part of the combination of 1880. On the contrary, I find there, in the 1876 patent, numerous methods of adjustment of a much more clumsy and complicated nature, and a preference expressed in lines 29—31 of the 1876 specification for an arrangement by which the receiving instrument is connected with the opposite poles of the condensers on the bridge side, which would require the maintenance of a high resistance in the two arms of the bridge, and therefore plainly would be incompatible, as I understand the evidence, with the use of a low-resistance rheostat and the elimination of all resistance from the arms of the bridge, as is effected in the 1880 patent.

It is said, on behalf of the defendants, that, as some method of adjusting the resistances is essential, and the adjustment in the bridge arms was a common, though not a necessary, method in 1876, and a rheostat as a ready means of adjustment was known to electricians in 1876, one ought, looking especially at Figs. 1, 2, and 3 of the 1876 patent, to treat the author of that patent as implied, by including in the combinations which he there claims, the use of a rheostat of the kind, and in the position described in the patent of 1880. I cannot help thinking that such a doctrine of implied claim ought in any case to be applied with the greatest possible caution. The danger of its working injustice to inventors is obvious. In this case, if I regard only the points in the specification of 1876 to which I have referred, I certainly cannot apply it. But the argument against such an implication does not, upon the evidence, rest there. I have to consider the fact that the application of duplex telegraphy to long submarine cables was, in 1876, in its infancy, that improvements in this branch of applied science have been obtained, and can be obtained only by experiment, and that when I am asked to find that any practical electrician of ordinary intelligence—I think that, in using this expression, I am understating the argument of Mr. Moulton—would imply in Fig. 2 of the 1876 patent the adjusting method of 1880 as an adjunct of the apparatus. Not only do eminent experts like Lord Kelvin and Sir Frederick Bramwell depose as a matter of opinion, that they could find no grounds for such an implication, but, in fact, the Messrs. Muirhead, who were not only persons of special skill and knowledge, but who were themselves the authors of the invention of 1876, and Mr. Taylor, who has been working with them in developing and improving duplex submarine telegraphy, were during the

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four years from 1876 to 1880 unable to find in the patent of 1876 the combination of 1880, and did not even dream, as Mr. Taylor said, of the possibility of such a combination. "We knew," said the same witness, "that resistance in the arms of the bridge meant so much retardation, so much less speed, and we quite recognised that we wanted to reduce this resistance, but we did not know how, because we did not get a balance with the low resistance we could not get a balance without high resistance."

I have come clearly to the conclusion that the combination patented in the United States was a new invention and was not an invention for which the English patent of 1876 had been granted. Tested as according to the principles enunciated in the American cases it ought to be tested, it seems to me that the allegation of the identity of the patents upon which the defence is based has failed. The patent of 1880 was therefore a lasting patent at the dates fixed by the agreement for the payments claimed in this action; and I therefore give judgment for the plaintiffs on the claim with costs.

A discussion took place as to whether or not the plaintiffs were entitled to interest on the amount at 5 per cent. It was finally decided that the question should be mentioned to his lordship on Monday, counsel in the meantime to agree as to the exact amount of such interest, if payable. Execution was stayed for 21 days to consider the question of an appeal. On Monday, on the case being mentioned, Mr. Justice Kennedy said the question involved a considerable sum of money (£3,566. 1s. 5d.), and he was willing to hear the arguments at any time which counsel might agree upon, either during or after the regular hours for sitting. If, therefore, counsel would agree upon an hour and day and let him know, he would meet them in any way he could. The matter then dropped.

CORRESPONDENCE.

THE LIGHTING OF THE VICTORIA EMBANKMENT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have been watching the suggestions made for the electric lighting of the Embankment, but I do not recollect having seen any reference to a plan which, to my mind, appears the simplest and best, viz., the removal of one in, say, every 12 or 15 of the trees on either side of the roadway and immediately opposite to one another, and the erection in its stead of a handsome standard to carry a five or six-ampere lamp. This would effectively light the roadway, which I take to be of primary importance, and at the same time preserve, or rather improve, the appearance of the Embankment from the bridges at night.—Yours, &c. BENNETT PELL.

Blackheath, April 28, 1894.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

TENDERS INVITED.—The Electric Lighting Committee of the Halifax Corporation invite tenders for the supply and erection of steam pumps, pipes, valves, &c., at the electric lighting works. Particulars can be obtained of Mr. T. P. Wilmshurst, borough electrical engineer, Foundry-street, Halifax, and tenders have to be in to Mr. Keighley Walton, town clerk, by 10 a.m., on Thursday, May 10th.

——— The Brighton Town Council announce in our advertisement columns that they are prepared to receive tenders from persons willing to enter into a contract for the supply of motor-alternators, transformers, meters, &c. Specifications may be obtained from Mr. Francis J. Tillstone, the Town Clerk, to whom tenders must be sent in before 10 a.m. on Wednesday, the 16th inst.

——— The Derby Town Council have accepted tenders for the electric wiring of the Town Hall, the Police Station, the Market Hall, and other public places, the work being shared by Mr. Fletcher, of Burnley, and Messrs. John Davis and Son, of Derby.

TENDERS ACCEPTED.—The Waterloo and City Railway Company (Limited) have received the following tenders for the construction of their line of railway:—

J. Mowlem and Co., London (accepted)	£229,064
Price and Willis	230,835
J. T. Firbank	245,184
W. Scott and Co.	245,555
Pearson and Co.	253,170
Pauling and Elliott	328,114
Perry and Co.	445,829 (!)

The period for completion of contract is, in the case of the successful tender, 2½ years.

TENDERS ACCEPTED.—The Lighting Committee of the Brighton Corporation have received six tenders for the supply and erection of two engines, dynamos, and accessories at the North-road electric lighting works ranging from £6,503 to £5,550, and the tender of Messrs. Crompton and Co. (the lowest sent in) has been recommended for acceptance for the sum of £5,550.

——— The tender of Messrs. Stenner and Co., of Fore-street, Tiverton, has been accepted by Mr. C. D. Harrod for the supply of the plant and apparatus required for the installation of the electric light to his country mansion at Morebath, Devon, at an estimated cost of between £500 and £600.

——— The Worcester Corporation on Tuesday accepted the tender of the Brush Company for laying the necessary mains in certain streets of the city for the amount of £1,861.

——— The Bath City Council have accepted the tender of Messrs. Wyndham and Waters, of Croydon, for the electric wiring of the Municipal Buildings for the sum of £245.

APPOINTMENT.—Mr. Reginald H. T. Drummond, A.M.I.E.E., has been appointed chief electrician at the Madrid station of the Electricity Supply Company for Spain (Limited). Mr. Drummond was formerly at the Bankside station of the City of London Company.

SALE BY AUCTION.—Messrs. Welsby and Bousfield will sell by public auction the whole of the electrical fittings and materials recently used at the Bristol Industrial and Fine Arts Exhibition. The sale takes place on Thursday, May 10, and following days at 12 o'clock. Further particulars are given in our advertisement columns.

——— Messrs. Wheatley Kirk, Price and Goulty issue a preliminary announcement of an important sale of new electrical fittings, plant, &c., which will shortly be sold by public auction.

——— Mr. J. C. Stevens announces in our advertisement columns that he will sell by auction at 38, King-street, Covent Garden, London, W.C., on Wednesday next, at 12:30, a large quantity of electrical apparatus removed from the School of Electrical Engineering, and the stock of the Primary Syndicate.

INSTALLATIONS FOR SALE.—Messrs. Wheatley Kirk, Price and Goulty have for sale cheap several electric light installations, some particulars of which will be found in our advertisement columns.

LIQUIDATION.—Claims against the Trent Gas Engine Company, Limited (in voluntary liquidation), must be sent to Mr. Robert Mellors, King John's-chambers, Nottingham, by May 25th.

——— In the Chancery Division on Wednesday the petition of Mr. A. Dawson and other shareholders for the winding up of the South Staffordshire Tramways Company (Limited) was heard. It was stated that the Company had paid no dividends since 1887, and in April, 1893, a debenture-holders' action was commenced, under which receivers and managers were appointed. The petitioners attributed the condition of the Company to a contract entered into by the Directors with the Electric Construction Company, but it was contended that this contract was very favourable to the tramway company, and, the charges made against the directors having failed, the petition ought to be dismissed. The hearing of the case was not concluded.

DISSOLUTIONS OF PARTNERSHIP.—Mr. J. W. Scott has retired from the firm of Messrs. Girdlestone, Tatham and Co., and the business will be carried on in future by Messrs. J. O. Girdlestone and S. B. Tatham.

——— Messrs. Turvey and Gullette, electrical engineers, 19A, Cowcross-street, London, E.C., have dissolved partnership. Debts will be paid by Mr. W. L. Gullette, who continues the business.

NEW WORKS.—The Hayesmoore Company have opened works for the manufacture of electrical specialities at Union-mews, Union-street, W., the head office remaining at Clapham-road, as hitherto.

MESSRS. W. J. FURSE AND CO.—This Nottingham firm have in hand an installation of the electric light at the new house and museum recently erected by Dr. Mason at Burton-on-Trent, and have just completed orders for putting in the electric light at the leather-dressing works of Messrs. E. Turney and Co. and Messrs. Bayley and Co., of Nottingham. In both cases E.C.C. dynamos and Tangye horizontal steam engines are employed.

MESSRS. ROOTHAAN AND ALEWIJNSE.—This firm have taken into partnership Herr H. Schuurmann, and the business will be carried on in future under the title of Roothaan, Alewijnse and Co. Large show rooms are now opened at the Brussels works.

NATIONAL TELEPHONE COMPANY.—Owing to the ambiguity of a circular issued by this Company, many subscribers to the Metropolitan system were alarmed at the prospect of having their telephone numbers "re-arranged." It would appear, however, that this re-arrangement will only affect about 10 per cent. of the Company's subscribers, which will be a consolation—to those not affected. This alteration is required owing to the necessity that has arisen for concentrating the exchanges, particularly in the E.C. district. Some years ago a number of the smaller E.C. district exchanges were grouped into the East India Avenue Exchange, and it is now proposed to still further concentrate the Company's operations by closing the exchanges at Coleman-street

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and at East India-avenue, and transferring the greater portion of the subscribers into the extensive exchange now nearing completion above the old Hudson Bay Company's premises in Lime-street, E.C., which accounts for a portion of the subscribers' numbers being changed. Here, in a handsome square room, has been installed apparatus at present capable of accommodating 3,000 subscribers, and which is arranged for an ultimate capacity of over 6,500. The interior and exterior arrangements have been entirely designed and carried out by the Company's officials, and the results of the efforts of the staff will be that the Company will possess an exchange which should prove second to none in efficiency, and second to very few in size, either in Europe or America. We think it will be agreed that when the huge outside structure in Lime-street is completed, great credit will be due to those who have designed and carried out a really imposing example of telephone construction work. The outside installation consists of 39 poles 30ft. in height, and 4½in. in diameter at the base. These poles are capable of carrying 30 arms, with 230 wires on each arm. The poles occupy a circular space of considerable extent, and are strongly erected in octagonal form on iron girders. The Company have been fortunate in securing a building for their operations which is probably one o the best-built structures in the City of London—in fact, there are few buildings even there upon which such an immense weight could be with safety erected. The Exchange will have been about twelve months in hand, and is expected to be complete in about a month. The current required for working the new automatic restoring and locking indicators and for the transmitters is produced by a battery installation consisting of 24 cells of 23-plate L-type E.P.S. accumulators, and these are to be charged by a 1-H.P. nominal Tangye gas engine and a 15-volt Œ C.C. dynamo of 60 amperes capacity at 420 revolutions. A special room has been built for the accumulators on the floor below the operating room. It is calculated that at present about 60 operators will be engaged, and the arrangements made provide excellent accommodation for this large staff. Considerable space has been saved by the use of specially designed switchboards, which also effect a great saving of labour for the operators, who are, in addition, to be supplied with specially designed head and breast gear in place of the existing portable telephone and hanging transmitter. These new instruments are manufactured by Messrs. Ericsson and Co., of Stockholm, and have been tested by the Company's officials with, we understand, every success. We are also informed that a new form of transmitter is to be supplied to subscribers at an early date. By a novel arrangement of the leading-in wires and new designs of testing apparatus faults can be readily localised. The new Exchange is to be lighted througout by electricity, about 100 incandescents being required. The heating arrangements are of the simplest and most effective kind, and have been tested with satisfactory results. In addition to the new Lime-street building, an Exchange is to be erected at Holborn, ultimately intended to replace the Chancery-lane and Smithfield Exchanges, and thus further consolidate the Company's metropolitan system. It is anticipated by the Company that the new arrangements, combined with the complete substitution of the metallic-circuit system, will immensely improve the Metropolitan telephone service, at an estimated ultimate outlay of between £100,000 and £150,000.

Woodhouse and Rawson United (Limited).—The creditors and shareholders in this Company, which is now under receivership, have this week received several circulars giving some particulars regarding the position of affairs to date. No. 1 is a circular of the Committee of Inspection; No. 2 a letter from Mr. F. D. Leslie, receiver for the debenture holders; No. 3 a circular from the Epstein Company; No. 4 is described as a "Memorandum of Facts" in connection with the Epstein Company; Nos. 5 and 6 are termed "Testimonials" and "Experts' Reports;" and No. 7 is a form of application, in which the shareholders and creditors of Woodhouse and Rawson United (Limited) are invited to take up £12,000 in Seven per Cent. Mortgage Debenture Stock of the Epstein Electric Accumulator Company (Limited). It would appear that part of the assets in the Woodhouse and Rawson failure consists of a considerable interest in the Epstein Company, which would, it is urged, be considerably increased in value if the sum of £12,000, or thereabouts, can be raised as additional working capital for the Epstein Company. Mr. Leslie, the Receiver and Manager for the debenture holders in Woodhouse and Rawson, applied in January last to sell the Epstein assets, but the trustees for the debenture holders and others strongly opposed the sale, on the ground that the price was inadequate, and the Court refused its consent. The Committee of Inspection appointed at the meetings of creditors and shareholders held in December last are satisfied that the Epstein accumulator is a "serviceable article," and that the proposal to apply a portion of the holding of Woodhouse and Rawson in the Epstein Company to a scheme by which additional working capital will be obtained for the latter is worth the consideration of the creditors and shareholders in the former. In order to increase the value of the Epstein shares, Mr. Leslie has applied to, and obtained permission from, the Court to cancel a contingent debt of £11,000, a portion of the asset referred to, and to offer to those who may apply for the Second Mortgage Debenture Stock now offered a bonus of one fully paid Ordinary share of £1 in the Epstein Company for every £2 of Debenture stock applied for, the balance of 28,150 Ordinary shares and 511 Vendors' shares remaining in Mr. Leslie's hands, awaiting "the expected development of the Epstein Company." Circular No. 3 states that (subject to confirmation) the Directors of the Epstein Company have completed negotiations for the working of the United States and Canadian patents. This communication is dated April 23rd, and the confirmation has to be made within six weeks from that date. Should this arrangement be satisfactorily negotiated, the Epstein Company is to reap a considerable benefit. The application, for this Debenture stock must be sent in by Saturday, the 5th inst. The various circulars bear different dates, commencing with April 10th, and ending with April 23rd. Many of the creditors did not receive the circulars until May 2nd, the original date for the sending in of applications.

A New Cigar Lighter.—In an electrically lighted house matches are comparatively rare, as the smoker finds to his annoyance, and there is a real need for some electrical kindler. An attempt has been made by the General Electric Company to provide something better than the rather clumsy platinum wire in series with a 32-c.p. lamp. In the new device a 32-c.p. lamp is used, but the contact is so brief that the lamp is scarcely rendered hot, and that only for an instant, probably having no effect on the meter. One terminal of the lighter is connected to the lamp and this is connected to a corrugated carbon block, set on a china reservoir containing methylated spirit. A wire covered with asbestos is kept in this reservoir and is attached by a flexible cord to the other terminal. The wire is struck against the carbon block, the circuit is rapidly made and broken, and the spirits are ignited by the sparks. A 16-c.p. lamp on 100 volts is hardly sufficient. In its present form, the device, which will serve for pipes as well as for cigars, is far from ornamental, and needs refilling with spirit from time to time.

"Advertisers' A.B.C."—Mr. T. B. Browne, of Queen Victoria-street, E.C., and Buchanan-street, Glasgow, announces the issue of his well-known "Advertisers' A.B.C. and Advertisement Press Directory" for 1894. In addition to a revised and enlarged list of newspapers and official statements as to their circulation, &c., the book has a Provincial Newspaper Gazetteer containing more than 2,400 towns and places in the United Kingdom with the newspapers published and circulating therein. The price of the book is 10s. 6d., and it can be obtained of all booksellers.

Shipping.—The publishers of the *Handy Shipping Guide*, a weekly periodical well known in shipping quarters, celebrate the seventh year of the *Guide's* existence by the publication of a Supplement, which is to be continued monthly, dealing with matters of interest to the shipping world.

Alleged Libel.—In the action brought by Augustus Fleet, solicitor, of Hatton-garden, London, against the proprietors of the *Pall Mall Gazette*, in connection with the electropathic belt business, the *Pall Mall Gazette* has proved victorious; and Mr. Justice Wright, who tried the case, said he agreed that newspapers had to perform important public functions, and it was impossible for them to do so if the law considered they were under penalty to keep mention of every incidental name out of their remarks. The jury returned a verdict in favour of the *Pall Mall*, and judgment was given accordingly.

Belfast.—The Board of Guardians have been staggered by the amount of the gas bill for the past year, which shows a considerable increase, and have appointed a committee to inquire into the question of lighting generally, and, in particular, as to the cost of an electric lighting installation for the buildings. An expert is to be called in to advise the committee.

Birmingham.—In reference to the Birmingham Electric Light and Power Order (1894), which is being promoted by the Birmingham Electric Supply Company (Limited), the General Purposes Committee of the Corporation have reported that the Draft Order did not appear to them to give sufficient advantages to the public in return for the important concessions sought by the Company, and an objection was therefore lodged, on behalf of the Corporation, with the Board of Trade. This led to negotiations between the parties, and it was ultimately agreed that the price for electric current should be reduced from 10d. to 8d. per unit, and the minimum charge per quarter from £3. 10s. to £3. 6s. 8d., these reductions to apply to current supplied under the existing orders as well as under the new Order. The promoters are to lay mains in all the extended area within two years from the confirmation of the Order, and the clauses of the Board of Trade Model Order with respect to street boxes, supply of current to owners and occupiers and public lamps, &c., are to be inserted. The promoters of the Order have agreed to these condi-

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tions, and the Committee have given the necessary consent to the application.

Bradford.—The Corporation have appointed a deputation to visit Halifax to inspect the electric lighting works there in connection with the refuse destructor.

Bristol.—A Local Government Board inquiry has been held here by Col. Ducat, R.E., to consider an application by the Town Council for sanction to borrow £24,650 for electric lighting purposes. £9,468 represents additional expenditure over and above the original estimate, and it is proposed to expend £15,181 on new works and extensions. It was pointed out by Mr. Preece that the additional expenditure was not due to any error in the original estimate, but to extraordinary difficulties that had occurred in erecting the lighting station buildings. It was his opinion that Bristol has now the best central electric lighting station in the kingdom, so far as the structure is concerned.——The Corporation contemplate extending the electric lighting mains to Clifton and Tyndall's Park for private supply, in addition to other extensions which have been agreed to.

Chelmsford.—There has been some difference of opinion between Messrs. Crompton and Co. and the Town Council as to the purchasing clause in the Provisional Order. The Council endeavoured to insert a clause to the effect that the purchase should be limited to such parts of Messrs. Crompton's undertaking as were used solely for the public and private lighting of the borough, but the Board of Trade declined to agree to this, and, instead, have inserted a clause under which it is stipulated that Messrs. Crompton and Co. shall sell the undertaking authorised by the Provisional Order, with all lands, buildings, materials, and plant used in connection therewith. It was pointed out by the Board of Trade that similar contentions had arisen at Liverpool and Reading, and had, in each case, been settled by the insertion of a clause similar to the above. It was ultimately agreed to leave the final settlement of the matter in the hands of the Board of Trade.

Church Lighting.—Redcliffe Church, Bedminster, is to be lighted throughout by electricity.

City of London.—At the last meeting of the Commission of Sewers, Mr. Ross reporting on the number and cost of the gas lamps displaced by the arc lamps in the main thoroughfares, said that the 479 arc lamps cost £12,454 per annum, whereas the 1,315 displaced gas lamps cost, for lighting and maintenance, £4,631. Mr. McCarthy commented upon the increase, and asked whether the Commission intended to light the side streets by electricity, which he said would cost another £10,000 per year. Mr. Burmester replied that the Streets Committee was considering that point.

Country House Lighting.—Messrs. Drake and Gorham are lighting the Devonshire mansion of Mr. T. B. Bolitho, M.P., with about 120 incandescents. A petroleum engine is to be used, driving an E.C.C. dynamo, to provide current for a battery of 53 D.P. cells.

Darlaston.—The Local Board have decided to consult an electrical engineer, with a view of ascertaining the probable expense of obtaining a Provisional Order.

Derby.—The Local Government Board have sanctioned the borrowing of £5,000 for extensions to the electric lighting of this town, repayable in 20 years. It is intended to supply the light to the two Police Stations and the Market Hall.

Destructive Fire at the Royal Electric Company's Works in Montreal.—While the Earl of Aberdeen was reviewing the fire brigade in the Champ de Mars at Montreal, on Tuesday afternoon, a destructive fire broke out in the Royal Electric Company's Works. Owing to the firemen being in full dress for the parade some delay occurred before they set to work to subdue the flames. Twenty-five dynamos were destroyed, and when the fire was at its height the fly-wheel of the works engine burst, the heavy fragments crashing into the surrounding buildings. There was no loss of life, but many remarkable escapes are reported. The loss of property is estimated at over $100,000.

Dover.—The Dover *Standard* is of opinion that "as a lighting agent there is no doubt that electricity exceeds all others," and "that it is not a heating agent, and as such can never enter into competition with gas." Altogether the views of the Dover *Standard* on electric lighting *versus* gas show a considerable acquaintance with the subject.

Dundee.—On Monday last a deputation, consisting of the whole of the Dundee Council, visited Coatbridge "in the interest of the proposed introduction of the electric light into Dundee."

Edinburgh.—The Lighting Committee of the Town Council have instructed their consulting and resident engineers to prepare and submit a report as to the annual and capital cost of the extension of the electric light to George-street, St. Andrew's-square, Charlotte-square, and the thoroughfares leading from Prince's-street.

Electric Organs.—A new organ with four manuals and pedals, 74 stops, and 3,600 pipes has been erected in the parish church at Ormskirk, near Liverpool, and has been fitted with the Hope-Jones electric appliances.

Electro-Medical Quacks.—These gentlemen are having a bad time all round. It appears that at Nelson, New Zealand, a Prof. Richard, who is described as a medical electrician, is in trouble, and has made tracks to avoid the resentment of the populace.

Electro-Harmonic Society.—The report just issued shows that 35 members have been elected during the past season, against four lost by death, 20 resignations, and 21 struck off the register. The total number of members is 328. The annual general meeting is to be held on Wednesday next at 4.30 p.m., at 28, Victoria-street, S.W. The balance-sheet shows, subject to audit, a surplus balance in hand of £104. 10s. 5d.

Fareham.—A public meeting of the ratepayers was held in the Foresters' Hall, on Thursday last week, to consider the question of entertaining an offer of the Fareham Electric Lighting Company (Limited) to sell their business and undertaking to the Local Board. Mr. J. Blake, the managing director of the Company, spoke at considerable length in favour of the proposed purchase by the Local Board, estimating that the cost of taking over the Company's plant, purchasing duplicate engines, and laying down one mile of mains underground would be £8,000, and calculated that the concern would pay its way after the first year or two. An amendment was proposed to the effect that the Local Board abandon their offer to purchase the plant, several balance-sheets issued by the Company being very severely criticised. On the question being put, the Chairman declared the amendment carried, but Mr. Blake demanded a poll.

Hampstead.—The Electric Lighting Committee of the Vestry have selected Wednesday, the 23rd inst., as the date for laying the foundation stone at the electric supply station.

Huddersfield.—The first annual statement of the Electric Lighting Department of the Corporation shows a deficiency of £2,547 on the revenue account.

Ipswich.—As previously stated, the Town Council have decided to take the necessary steps to obtain a Provisional Order. Mr. Pratt, a member of the Council, in moving the adoption of a motion to this effect, elucidated a carefully prepared scheme for the lighting of the town. He pointed out that in many places the electric light had been introduced, and was not only paying its way, but was realising a fair profit. He advised the selection of the site of the old Vulcan Brewery for the central station, and estimated the sum required for establishing the works at £10,000. After a very lengthy discussion, the motion to take immediate steps in the matter was carried.

London County Council.—At Tuesday's meeting Col. Ford presented a petition from the ratepayers of North Lambeth, calling attention to the Act of Parliament last session providing for the lighting of Waterloo Bridge by electricity, and praying that the Council will no longer delay carrying out the work. The petition was referred to the Highways Committee.

Lynton.—Mr. Benn has transferred his electric lighting works to a company, who propose to obtain greater water power, and by this means make the light more efficient. The Local Board have promised that, upon being satisfied that the additional works are competent to give the better light promised, they will be prepared to extend the lighting contract to the new company for 14 years.

Manchester.—The Gas Committee have presented their report, which announces that owing to the great support accorded the electric light, it has been found necessary to considerably increase the plant.

Mill Lighting.—Messrs. Bennett and Druce have been instructed by Messrs. Tootal, Broadhurst, Lee and Co. (Limited) to re-arrange the electric lighting installation at their extensive mills at Bolton, and to considerably extend the same.

Oswestry.—At the last meeting of the Town Council it was decided to purchase the Provisional Order obtained by the Oswestry Electric Light and Power Company (Limited), for the sum of £350.

Poplar.—The District Board of Works on Tuesday discussed the report by Mr. W. H. Preece on the advisability of adopting the electric light for the district, which we abstracted in our last week's issue. The Board on the whole favourably received the report, and referred it to the Works Committee for consideration.

Portsea Island (Hants).—The Board of Guardians have decided to invite tenders for lighting the Municipal offices by electricity.

South Shields.—At the meeting of the Town Council on Wednesday, a report and estimate prepared by Mr. Joseph A. Jeckell, the Borough Electrical Engineer, was discussed and adopted, and permission granted to apply to the Local Government Board for sanction to borrow £22,000 in accordance with the estimate. A deputation was also appointed to visit several central stations recently erected.

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STIRLING.—The Town Council have received further communications from the Scottish House-to-House Company in reference to the application by that Company for a Provisional Order to light the Stirling district. A letter has also been received from the representatives of the Caledonian Electric Supply Company, in which, after referring to the decision of the Board of Trade in the matter of the Company's Provisional Order, the writer asks whether the Council would be prepared to enter into an arrangement for a joint application by the Company and the Council. As the Council have decided to themselves apply for a Provisional Order, it was agreed to acknowledge the receipt of the letters, and to take no further steps for the present.

THETFORD.—The Town Council, on Tuesday, decided to light St. Peter's clock by electricity at an estimated cost of £8 per year for 16-c.p. lamps.

TOXTETH.—The Board of Guardians are considering the advisability of lighting the workhouse by electricity. It is proposed to employ the 12-H.P. steam engine now at work for laundry purposes during the day to work the electric light installation at night.

WEST HARTLEPOOL.—The Town Council have received an offer from the Electric Construction Company to light the town by electricity. This Company have the contract for running the electric trams in the Hartlepools, and point out to the Council that, as the trams will be run by electricity, the town can be lighted by the same agency at a greatly reduced cost. The Council have decided to obtain further information, and will consider the matter at an early meeting.

WESTON-SUPER-MARE.—It is stated that, in response to the circulars issued by the Local Board inviting support to the electric lighting scheme, No. 1 District, which includes several of the principal business premises, has applied for about 1,000 incandescents; and that, if the Board receives similar support from the other districts, immediate steps will be taken to carry out the Provisional Order.

WINDSOR.—A petition is being signed urging the Town Council to take immediate steps to provide the town with electric light.

WOLVERHAMPTON.—The Corporation have decided to lay the foundation stone of the new electric supply works in the Commercial-road on the 21st inst.

WORTHING.—The Town Clerk has been instructed by the Town Council to make inquiries from the various towns using the electric light for particulars as to cost, &c.

COMPANIES' MEETINGS AND REPORTS.

Brazilian Submarine Telegraph Company (Limited).

The forty-first ordinary general meeting of this Company was held on Wednesday at Winchester House, Sir John Pender, G.C.M.G., M.P. (Chairman), presiding.

The SECRETARY (Mr. Richard Collett) read the notice convening the meeting and the minutes of the previous meeting.

The CHAIRMAN: I will go over in detail some of the points in the report, so that you may have a better knowledge of what we have been doing during the last six months. The receipts for the half-year ended December 31, 1893, were £96,262, against £106,860 in the previous half-year showing a decrease of £10,598. As compared with the income of the corresponding period of 1892, when the receipts were £113,892, the past half-year showed a falling-off of £17,630. The receipts from messages exhibited a decrease of £10,654, while the miscellaneous receipts from interest, rents, and transfer fees, give an increase of £56, resulting in a net decrease, as before stated, of £10,598. The average value of the Brazilian milreis was in the half-years ended December 31, 1893, 10 1/16d.; June 30, 1893, 12¼d.; and December 31, 1892, 13⅝d. This further fall in the exchange value of the Brazilian currency collected accounts, in a large measure, for the decreased receipts from messages. It is to be remembered that on April 1, 1893, a reduction was made in our tariffs, and therefore the first three months of 1893 had the advantage of higher tariffs than those existing at present. The expenditure for the half-year was £24,284, and for the previous half-year £40,580, showing a decrease of £16,296. There is a decrease in cable repairs of £14,607, in working expenses at stations of £1,960—together £16,567; and an increase in London expenses £147, and in other items of expenditure £124, making together £271—or a net decrease of £16,296. The general expenses in London were £2,761, an increase of £147 compared with those of last half-year; but, compared with the corresponding half-year, when they were £2,756, the figures are practically the same, there being a difference of only £5. The working expenses at stations showed a decrease of £1,960, the net result of increases and decreases under many heads, the principal decreases being—salaries of staff £431, agencies £1,068, and electrical expenses and maintenance of land lines £853. There is very little this half-year for a Chairman to put into a speech, but in addition to any special matter, the following subjects will admit of comment. First of all the accounts. These are not the final accounts for the financial year. The usual interim dividends at the rate of 6 per cent. per annum has been paid, and £20,000 has been transferred to reserve. Last half-year we were only able to transfer £7,000, but for the five years previous to 1893 the average amount so transferred half-yearly was £43,500. On December 31st last the reserve fund stood at £668,000, a very satisfactory sum indeed. It is absolutely necessary to provide these large accumulations in order to be able to supply new cables when required. With all our experience up to the present time we cannot tell what the life of a cable really is. We know that if a cable is laid on safe ground that it lasts for a very long time; and, on the other hand, if it is laid in a rocky ground, or anywhere where it is suspended, or where there is friction, we know its life is thereby very much diminished. But the principle upon which we proceed is to go on repairing and renewing and putting in new pieces of cable where necessary each half-year. It is part of our business to keep up our system in as efficient a condition as possible, and that efficiency was maintained to a very great extent by the repairs and the new cable put in when the repairs are effected. There are two cables to be maintained and eventually renewed, and that fact accounts for the large amount we deem it necessary to place to reserve. As you are aware, one of these cables is 20 years old, and therefore it is, at all events, approaching a period of age which causes us to be careful in providing for its renewal. Gentlemen, as you can all detect, I am suffering from a sore throat, and it begins to trouble me just now, when I want my voice, and so I shall be obliged to cut my remarks short on that account. But there are one or two points I think I must refer to. One of these is that the exclusive privilege granted by our concession expires in December with the Brazilian Government. We have had special privileges during the last 20 years, and we are anxious to retain as far as possible those privileges for another 20 years. We are sending out an agent to negotiate with the Government of Brazil, and we are hopeful that if they take the same reasonable view that Governments generally take in dealing with submarine telegraph companies that we shall arrive at a satisfactory arrangement with them, and one which will assure our connection with the Brazilian Government. The Brazilian Government] are undergoing a change, and we hope that when the civil war, now practically terminated, is at an end, that a sound Government will be established, and that with its establishment prosperity will return to their territory. In the returning prosperity we, of course, shall more or less participate. It will be a great satisfaction to us to see the political position of Brazil strengthened, and to know that the Government are disposed to deal with us in a fair and reasonable manner. Judging from our experience of how these things have been dealt with by other Governments, we cherish the hope that the Brazilian Government will treat us with the same liberality that we have received elsewhere. We have secured an interest in a concession obtained by our partners the Western and Brazilian Telegraph Company for the purpose of laying an additional cable between Brazil and Argentina when required. In the event of competition with the American Company which is endeavouring to take as much of the traffic as they can from us, we think it will enable us to meet that competition in a satisfactory way. Of course, we have had to pay for that concession. No concession of the kind is obtained anywhere without payment, but we consider the payment we have made for it is only a fair one, bearing in mind the very great advantages which we shall derive from having the control of that part of the coast. If we had not got it it might have been obtained by what is called the Central and South American system, and then the messages would have been carried by the Galveston route. We have, however, secured the option of laying that cable, but we shall only lay it if we find it is necessary in our interests to do so. If I had my voice at command I would go into further matters, but I think I have given you the outline and heads of our operations during the past half-year. The current half-year will be one of some considerable interest, because, as I have said, our agent is going out to Brazil on important business for us. I hope he will find things proceed pleasantly and satisfactorily; and when, in six months time, I again address you, I may be able to tell you that we have got a new lease, which will be advantageous, not only to the telegraph public generally, but of special advantage to the shareholders of this Company. I beg now to move:—

"*That the report of the Directors and accounts to December 31, 1893, now submitted, be approved and adopted.*"

The Hon. W. ST. JOHN BRODRICK, M.P., seconded the resolution.

Dr. TREWHELLA asked for some information as to the new land lines between Buenos Ayres and Valparaiso. Speaking as an individual shareholder, he thought the Board had shown considerable prudence in securing the option to lay a cable between Rio and Buenos Ayres.

The CHAIRMAN: After delay from unexpected causes the lines of the Pacific and European Telegraph Company between Buenos Ayres and Valparaiso were opened in March last with promising results. We are now enabled, in connection with the West Coast of America Telegraph Company, to deal with traffic to and from Chili, Peru, and Bolivia. In doing this we are competing with what you know as the Galveston route, which, in like manner, competes with us at Buenos Ayres for the East Coast traffic, particularly that of Argentina, and in a lesser degree that of Uruguay. It is our wish to conduct this competition in a friendly spirit and in an honourable and fair manner. The opening of that line is, so far as we can judge, satisfactory. It must be very satisfactory indeed in the future. While this competition is going on we have been under the disadvantage of our opponents having had possession of the ground for about two years, while our cable was being constructed. But we have the hearty co-operation of the Chilian and Argentine Governments in the work we are doing, and I am satisfied with our prospects. I hope I may live to see one system existing, so that communication with Chili and Peru will be upon as sound and good a basis as that of any submarine telegraph company in the world. At the present time we are having competition. There is a company called the South American Company, which has come into Pernambuco at reduced rates. We think we are strong enough to meet any such competition, and at all events we will make it rather

hot work for anyone who attempts to oppose us in that way. We do not presume upon our wealth, but we presume upon our strength, and I think our strength as pioneers of the system is such that we are entitled to support from the Brazilian Government, and we think that with anything like a moderate support from them we shall be able to control to some extent the telegraph system existing to Brazil. We do not want to be arbitrary; we do not want to say or do anything to companies that may think they can compete with us. All I ask them to do is to compete in fair and honourable ways, not to do it by cutting, but by good service, and those who do the service the best are entitled to gain the reward. I hope those who are opposed to us will take the same view, and if they do we shall get on fairly well together.

The resolution was then carried unanimously.

Dr. TREWHELLA, in proposing a vote of thanks to the Chairman and his co-Directors, said he happened to be associated with a great many companies, but he did not recollect one Board in which the shareholders could repose greater confidence in their administrators than in the Board of the Brazilian Submarine Telegraph Company.

Mr. P. A. COARD seconded the proposition, which was agreed to.

The CHAIRMAN, in acknowledging the compliment, said: On behalf of my colleagues and myself I most sincerely thank you. We have only one object in view, and that is to make our Company a successful one, and our hands are strengthened when we have proof of your confidence and co-operation. It is our desire that the shareholders should know as much as is consistent with the interests of the Company, and when I tell you we have nothing whatever to hide, and there is nothing I do not desire you to know, you may be sure we are going on in a very clear and safe way.

The proceedings then terminated.

Phonopore Company (Limited).

The fifth annual general meeting of this Company was held at Winchester House, London, E.C., on Monday last. Mr. Henry Seebohm (the Chairman of the Company) presided.

Mr. CHARLES ISAAC (the Secretary) read the notice calling the meeting, and the report of the Directors was taken as read.

The CHAIRMAN, in moving the adoption of the report and the balance-sheet, said that the late Board, when it took over the management of the Company from the previous Board, did so with a light heart. They thought that all the difficulties had been overcome. They thought they were in an ideal position upon which to build up a prosperous future. They thought they had a large stock of excellent instruments ready for commerce, and ample capital. Members of the late Board, and electrical experts that they consulted, especially Mr. Spagnoletti, took a very sanguine view of its position. They could, therefore, well imagine that in the face of such strong evidence in favour of its perfection it took them a very long time before they were absolutely convinced, as they were now, that what they possessed was little more than a pretty electrical toy. There were great difficulties to be overcome in the practical working of it. They were then, no doubt, in an ideal position, and not in a practical one, and those difficulties were continually developing from day to day, and from week to week correspondence was laid before the Board in one almost uniform result. Everyone was anxious to use the instrument, and everyone when they had tried it were very much pleased with it, but by-and-by they found that the adjustment of it was so delicate that it was more than the average telegraph clerk was capable of grappling with, and the Board had constantly to send out messengers to put instruments right which had somehow gone wrong. There was another obstacle to the success of the instruments owing to the induced currents interfering with the wires, the telephone wires especially, and the Board were obliged, after a year's working, to come to the conclusion that one of two things would have to be done—either to improve the system itself, or else to wind up the Company and throw the whole thing overboard as a failure. It was extremely disappointing to the Board, and as the shareholders might imagine extremely disappointing to the late Chairman of the Company. He (the late Chairman) was absolutely convinced, as all members of the Board were, that the gentlemen who reported on the future of the Phonopore had taken far too sanguine a view of its capabilities, and he naturally felt great disappointment, especially at his age and at his time of life and position, so that he was at last compelled to give in and resign his seat upon the Board. The statements which had been made with regard to the instrument had not been borne out by the results. He had no doubt that all such statements had been made in an absolutely *bonâ fide* manner and in all good faith. He believed that Mr. Langdon-Davies believed every word he uttered, although those statements had not been borne out by facts. He held that it was simply a matter of opinion, and he did not accuse in any way those who made those statements of saying anything which was not true; but there were certain points which were altogether incorrect, and which results had since proved to be so. For instance, that gentleman represented that in the year 1889 the position of the Company was, upon the whole, so satisfactory that there was sufficient profit to pay the whole of the expenditure and to carry forward £266 to the next year. That might have been true, but what he wished to call the attention of the shareholders to was the fact that that profit and more was entirely derived, not from receipts derived from the Phonopore, but from the issue of shares at a premium; and in that year in which the Company was represented to have made £266 profit they absolutely made a loss of £4,721, which was almost precisely the same figure as in 1891. In 1890 the loss was £1,000. In that year the loss was not so great because the Company had not so much money, and they were unable to spend more. In the following years there was but little variation, the loss then amounted to £200, and that loss was owing to the fact that the Company had been carrying on experiments, and had been trying to get the instrument more perfect. He was pleased to say that they had to a very great extent succeeded in doing so. The Board now found that when they sent out instruments they were followed by more orders, and that in itself was a satisfactory matter. People were now taking the instrument, and were grumbling, not at the imperfections of the instrument, but at the price. Most of the railway companies had been hard hit during the past year, and had lost a deal of money owing to the coal strike and other matters, in consequence of which their great desire had been to work upon an extremely economical basis, and therefore did not wish to spend a farthing more than they could possibly help. The Directors hoped that in the future the sales of the instruments would continue to increase, and as they had now constant inquiries being made both at home and abroad, he thought they might look forward to such taking place. The Company had sent out people to instal fresh instruments, and the results of those instruments had been much more satisfactory than they were twelve months ago. The Company had made several important improvements, but they regretted that at the present time they saw no immediate prospects of satisfactory profits. Amongst the improvements which had been made to the instrument were a new receiver and a new Phonopore sounder, and they were now able to work the instrument upon a single needle key, as well as upon the Morse system. Those who were capable of going minutely into the technical part of the matter would see that the Board had placed at the end of the report a circular signed by Mr. S. P. Thompson, which he (the speaker) considered showed that the position of the Company in that respect was ideal. The Directors had tested the instrument, and were now of the opinion that they had got an instrument which would meet the requirements of the market, and they hoped that with that instrument, as alluded to in the circular, the position of the Company would in the future be much better than it was at present. There was one matter to which he wished to allude with regard to the old Phonopore, or, to speak more correctly, the old patents of the Company, which proved a failure with respect to its results, and that was the rate-governor. The old Board bought that patent from Mr. Langdon-Davies for something like £10,000, and they now found there was not one of the instruments which possessed that rate-governor. What they had been able to find was not used as a governor at all, but only as a break: it did not, therefore, need any patent at all, and had been throughout a complete failure. It seemed to him that the old Board had bought a pig in a poke; the arrangement was made upon the specifications of the patent, and so completed. It was difficult to conceive how such a proposal could have been brought forward, and whether they looked at the sublime audacity of the seller, or the credulity of the buyer, it was impossible to understand how such a transaction could have taken place. It was, however, of course, very easy to be wise after the event. When Mr. Langdon-Davies sold the instrument he, no doubt, thought that he was selling an instrument of enormous value, and there was no doubt that the Board were of the same opinion when they purchased it, although it had subsequently turned out to be a failure. The statements which he (the speaker) made on that occasion were made on the authority of those who knew a great deal more about electricity than he did, and he believed that they were all absolutely true. Although the prospects of the Company were much better than they had been lately, yet the shareholders must not fancy that they were going to win in a canter; they had still got a tremendous fence before them, and it was possible that they might come a cropper before they got through. The difficulty which they had to face was that there was no reasonable prospect that the money in hand would hold out until the receipts balanced the expenses. There could be no doubt whatever that in order to keep the Company in a proper position, fresh capital would have to be raised in some form or the other. That would have to be done without doubt before the Company was really on its legs. The shareholders might rest assured that the prospects held out to them some years ago were absolutely pure unmitigated moonshine. He was extremely sorry he could not lay before the shareholders a better report, but he had to the best of his knowledge and belief laid before them the position of the Company. He did not wish, on looking back upon the difficulties through which the Company had passed, and the extremely sanguine views which had been expressed by Mr. C. E. Spagnoletti and others, to exaggerate things at all; and before he moved the adoption of the report he felt it his duty to draw the attention of the shareholders to the fact that, although Mr. Spagnoletti had at one time expressed extremely sanguine views, yet for the present position of the Company they were all indebted to his exertions and to those of his staff, and he hoped that those exertions would not be without fruit if the Company could get through its difficulties. The Chairman concluded by moving the adoption of the report.

Mr. W. HART seconded the motion.

Mr. LANGDON-DAVIES said he rose with regret to move an amendment as last year. On the last occasion he moved a resolution in language of the greatest possible reserve, because he was not so sure of matters as he was to-day. He knew more now than he did then. The effect of that resolution was to suggest that unless the management had radical reforms introduced into it they would soon find themselves in the position described in the first paragraph of the report as follows:—"The explanation is that practical experience unfortunately proved that the instruments required considerable modification to make them marketable, and it was necessary to alter them in nearly every detail; but from the successful working of those which have been recently disposed of, the Board feels satisfied that this, after great delay and cost, has been at length accomplished." That was what the present Board offered to the shareholders as an explanation of the disastrous losses they had suffered. To decide whether or not that was a genuine explanation he had decided to devote his attention. He did not object to Mr. Seebohm as Chairman, and there was no one he would care to replace him with; but he wished to know what technical knowledge that gentleman possessed. As to Mr. Spagnoletti, he desired to make his remarks temperate and inoffensive, but he thought it behoved them to consider whether the position occupied by

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that gentleman as Managing Director in that Company was the right one to be occupied by him. Mr. Spagnoletti had been at work upon improving the Company's instruments. It was stated that that gentleman had been for 37 years the chief of the telegraphic department of the Great Western Railway Company, and for one year the President of the Society of Telegraph-Engineers. He hoped that he had a due regard to the importance of both those positions, but he asked whether that justified him to occupy the position he did in regard to the latest, or one of the very latest, inventions in electrical telegraphy; for the Phonopore involved a new principle of action. He (the speaker) had surrounded it by instruments and parts that obeyed natural law, and it was not understood 37 years ago. He maintained that Mr. Spagnoletti, who had honourably fulfilled his duties to the Great Western Railway Company, had not, he (the speaker) thought, himself advanced with the progress of electrical science. He said that they were informed on former occasions that Mr. Spagnoletti was a man who could sell their instruments.

A SHAREHOLDER: Who said that?

Mr. LANGDON-DAVIES: Sir Mountstuart Grant-Duff said so in perfect good faith. Continuing, he remarked that a test of the original instruments was made on the Great Western Railway between London and Bristol. The test was for about six months, and the instruments were used under the supervision of Mr. Spagnoletti, who approved them upon behalf of the Great Western Railway, wrote to the brokers of this Company in favour of them, and accepted a position for three years to sell them. Two more sets were asked for and fixed for the Great Western Railway. He did not think that this bore out the statement of the report that the instruments were not marketable. Investigations had been made in the laboratory and on the line reports made upon them. He would mention one or two experts who had spoken in favour of them, viz., Lord Kelvin, Sir Frederick Bramwell, Sir A. Clark, and Dr. S. P. Thompson. There were reports from Spain, Paris, and Frankfort, where the Phonopore had stood fire. Mr. Spagnoletti had said that these instruments would not work 500 miles, and he agreed that that was so. He was distinctly told not to make instruments beyond 200 miles. It was not worth while representing that 500 miles was necessary, because it could be done—it was only a question of money. 200 miles was the most common circuit, and the one that would pay them best to make Phonopores for. He would be pleased for a committee of investigation upon his instruments and his work. He challenged them to appoint such a committee. As to his circular, he did not stand alone. He was the representative of forty shareholders, who had studied the matter individually, and had come to the one conclusion he had laid before them that day; forty minds had considered the matter, and they were entitled to consideration. He had plenty of information in regard to finance which he preferred to tell to a committee than to the meeting. He had 6,800 shares, representing the whole of the reward that he received for his invention. He was offered £30,000 cash for those shares, which he refused, giving as his reason that he had determined to stand by the general body of shareholders, and share equally in profits with them. He had stood to that resolution, and he intended to stand by it. He might devote himself to more profitable work, but he wanted to stick by the Company, and help the shareholders to get what they ought. They had elements on that Board that would help that end, and of others that would oppose it. He begged to move the following amendment:—

"*That the consideration of the report and accounts for the year 1893 be deferred to an adjourned meeting to be held within a month, and that a committee of shareholders be appointed to join the Board in considering the report and general condition of the Company's affairs; the Directors and the committee to make a joint report or separate reports as they think fit.*"

What they wanted to do was to reduce the Board to three, to pay that three their fees, and to abolish the office of Managing Director, appointing a business manager in his place.

Mr. PILBURY seconded the amendment, and said, if the instrument was only "a pretty electrical toy," the Board was a farce to remain in office, and to spend money in perfecting it. He had heard Lord Kelvin say, on the other hand, that he was surprised that the instrument which had so much in it had not become better known. He urged the shareholders to see that they got a good return eventually for their money.

Prof. S. THOMPSON said that he had gone out of his way on many occasions to further the interests of the Phonopore. There was the germ, and more than the germ, of a great invention in it. Referring to the old instruments that were sent to Frankfort in 1891 to the electrical exhibition, he gave an address there on the Phonopore, and they had the instrument working from Frankfort to Homburg. The instrument was tried on the right and left banks of the Rhine, and in all cases these instruments had come back upon their hands as requiring too much adjustment. He thought they owed a great debt to Mr. Spagnoletti. As to the rate-governor, he was very much surprised that they acquired it at such a heavy expense, and it would be a surprise to everyone who knew the circumstances from first to last.

Mr. LANGDON-DAVIES said that he thought they had better have a practical business manager who understood telegraphy from a practical point of view, rather than a man who had only been head of a department and seen others work.

Mr. KESKY said that the amendment was equal to a vote of want of confidence in the Board. He would like to know the stake that the Board had in the Company. He (the speaker) thought they would be unwise to pass the amendment upon anonymous information, and to censure the Board thereby.

The CHAIRMAN said the holding of the Board in shares was about one-fourth of the capital of the Company.

Mr. SPAGNOLETTI expressed regret that the discussion had drifted into such uncomfortable matters. He much regretted that they had had such universal complaints as to the old instruments. Complaints came even from the Great Western Railway, and alterations had to be made. From the Midland complaints came from the company, both as to the instruments and that the management had not fulfilled its promises. In every case the complaint was the same. This was last spring. They tried to push the trade abroad—in Vienna, Holland, Germany, and France. Every one had been sent back. There was not a single working installation on the Continent, except one in Bulgaria, which was unsatisfactory. As to France, they were shown at the Exhibition in 1889, but they were all rejected. Since then they had tried the new instruments in Paris, on the Western Railway, between Paris and Rouen, and they had given great satisfaction. They were in hopes of orders at an early date. The instruments were being tried on the State line, the Northern, the Western, the Eastern, the Orleans, and the Paris, Lyons and Mediterranean Railways. The Company would not have to canvass in France, for the Crédit Lyonnais had asked for the agency, and the Prefecture of Police were considering it. In Germany they declined to have anything to do with the thing, and had sent them all back. They had had a letter from the Great Southern and Western of Ireland Railway Company, who declined to give the instrument a trial, because the clerks could not use the key instead of the needle. The Company had now made an instrument which would do as well as the needle. They had ordered 18 trial instruments to be made. The railway companies said that this Company was charging far too high, but he did not think that that was so. As to the rate-governor, they had not got such a thing at work on the whole system. He said that what Mr. Davies claimed as the essential part of his invention in the rate-governor did not exist upon any of their instruments at all. He regretted to be so emphatic, but it was the fact. The plain position was that the instruments would not do that work; they interfered with the telephones too much; complaints came from everyone. The new instruments on the North British were doing well, and the account for them had been paid. The North-Western engineer did not like the instruments, but had been worried into a promise to try them. The regulation had been altered and improved, and the instruments could be put in without adjustment; relays were essential to the instrument.

Mr. LANGDON-DAVIES: Nonsense?

Mr. SPAGNOLETTI: If you take it out of the Phonopore as it now is, it is like taking the mainspring out of a watch.

Mr. KIMBER supported the amendment.

Mr. MOCATTA urged the shareholders to support the present management.

The amendment was put and lost by 11 votes to 25, including the Directors.

The report and accounts were then put and carried by 18 votes (exclusive of the Board) against 10.

The retiring Directors and auditors were re-elected.

The proceedings (which had lasted upwards of two hours) then terminated.

Submarine Cables Trust.

The twenty-third ordinary annual meeting of the certificate holders in this Trust was held yesterday at the offices, Winchester House, Old Broad-street, London, E.C., under the presidency of the Marquis of Tweeddale.

The SECRETARY (Mr. A. Brodrick) read the notice calling the meeting and the minutes of the last meeting, which were approved by the present meeting and signed by the Chairman as correct. The report of the Directors was taken as read.

The CHAIRMAN then said: I am sorry to say that Sir John Pender is not able to be present to-day. He is suffering from what I hope is nothing worse than a severe cold; but it has prevented him from leaving his house. The revenue for the past year amounted to £22,593 as against £23,102 in 1893, or a decrease of £509. This is owing to our having received a smaller dividend for the current year from our investment in the Anglo-American Company. I regret to say that there is no visible improvement in the Atlantic traffic, and I fear that our income from that source is likely to continue to suffer for some time at any rate. The expenses for the year amounted to £1,301, as against £1,627, or a decrease of £326. This is mainly in consequence of the reduction in the number of our trustees, owing to the lamented death of our valued colleague, the late Sir James Anderson. I may mention that the cost of administering the Trust is £698 under the amount provided by the trust deed. Our revenue during the past year has been sufficient to meet two coupons of £3 each, and pay off an additional 5s. of the overdue coupon There still remains a balance of £1. 5s. in arrear, which we hope to pay about the middle of July next. I think I have now referred to all the important matters connected with the Trust. The decrease in income is to be regretted, but although the traffic in the Atlantic is very low at present, we may hope that with the return of business it will improve, in which case our income will be in a more satisfactory condition. With these observations I beg to move:—

"*That the report and accounts of the trustees to April 15, 1894, submitted to this meeting be and the same are hereby received and adopted.*"

Mr. J. DENISON PENDER briefly seconded the resolution, which was unanimously adopted.

On the motion of Mr. Shuter, seconded by Mr. Cunliffe Owen, the auditors—Mr. John G. Griffiths and Mr. John Gane—were re-elected for the ensuing year, at a remuneration of £25 each.

Mr. SHUTER then proposed a vote of thanks to the Chairman and the trustees.

Mr. W. H. BURMAN seconded the motion, which was unanimously adopted.

The CHAIRMAN acknowledged the vote on behalf of his colleagues and himself, and again regretted that the Chairman, Sir John Pender, had been unable to attend the meeting.

The proceedings then terminated

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Norwich Electricity Company (Limited).

The third annual general meeting was held on April 24th, at the offices, Queen-street, Norwich, the Chairman (Mr. F. W. Harmer) presiding.

The CHAIRMAN moved the adoption of the report of the Directors, which contained the following :—" The arrangement which had been made with Messrs. Laurence, Scott and Co. to supply electricity to those who had previously used it, and also to any who might be desirous of doing so until the new machinery was ready to start, has proved a satisfactory one, since it has enabled the Company to commence operations with a sufficient number of customers to earn a profit from the very first day of its working. During the three months ending December 31st last the amount received for current has been £805. 15s. 8d., which will pay the cost of producing it, including salaries, wages, coal, and all other station expenses, the office expenses of the Company for twelve months, and the interest due to the bank, leaving a balance of £237. 9s. 10d., which it is proposed to carry forward. The rapid progress of the Company made it necessary for the Directors to obtain from Messrs. Gurney and Co. a further loan of £5,000, in addition to the £5,000 previously borrowed for the purchase of the Duke-street estate. Since January, however, shares to the amount of about £5,000 have been applied for privately, and the Directors are prepared to allot shares to a further limited amount, as it is clear that considerable extension will be necessary during the present year." The Chairman said the Directors would not have been suprised, nor do they think the shareholders could have complained, if in the establishment of a new enterprise like this the Company had for the first year or so lost money, but so far from this being the case, although it had only been at work for three months, it had not only paid its way from the very beginning, but had even realised a substantial profit for the past year. The Company had certainly made a capital start. The accounts came out better than they had any reason to expect, and they were very hopeful as to the future. They had got the best site in the city for their central station, which was a very important matter. They had adopted the system which they still thought was the right one, and their machinery was all new, and of the most modern and most improved construction. The adoption of the electric lighting in Norwich had gone on far more rapidly than they had expected, in fact, almost faster than they could deal with it; and it was only a question of a short time before the Company arrived at a dividend-paying stage.

The report having been adopted, the retiring Directors, Mr. C. R. Gilman and Mr. R. J. Colman, were re-elected; and Mr. J. Mottram was re-appointed auditor.

West India and Panama Telegraph Company (Ltd).

The following is the report of the Directors for the half-year ended December 31, 1893, to be submitted to the thirty-fourth ordinary general meeting, to be held at Winchester House, London, E.C., on Wednesday next, the 9th inst., at 12 noon :—

The amount to credit of revenue for the six months is £34,265. 6s. 4d. against £38,358. 11s. 9d. for the corresponding half-year of 1892, and the expenses have been £22,602. 8s. 3d. against £25,155. 11s. 5d. for the same period in 1892, leaving a balance of £11,662. 18s. 1d., which, with £4,137. 7s. 4d. brought from last account, makes a total of £15,800. 5s. 5d., with which it is proposed to deal as follows :—

	£	s.	d.
First Preference Shares—			
Dividend, six months to Dec. 31st, 6s. per share ...	10,368	18	0
Second Preference Shares—			
Dividend, six months to Dec. 31st, 6s. per share	1,400	14	0
Ordinary Shares—			
9d. per share (free of income tax)	3,312	0	9
Balance to current half-year's account	718	12	8
	£15,800	5	5

The traffic receipts for the six months show a decrease of £1,965. 4s. 3d. as compared with the correspoding period. It will be remembered that in June, 1891, certain reductions of rates were made in the West Indies. After an experience of two and a-half years it is estimated that these reductions have caused an aggregate loss of £20,863. This discouraging result again appears to show that reductions of rates on this Company's system are not compensated for by any increased use of the telegraph.

The cost of repairs to cables during the half-year amounted to £9,549. 6s. 10d., being £2,464. 0s. 5d. less than that for the corresponding period.

Since the issue of the last report the Company's second repairing steamer "Duchess of Marlborough" has been lying up in London, and up to the present the "Grappler" has dealt satisfactorily with all interruptions in the West Indies.

In accordance with the Articles of Association, Charles William Earle, Esq., retires at this meeting, and offers himself for re-election. The retiring auditor, John George Griffiths, Esq., desires to offer his firm, Messrs. Deloitte, Dever, Griffiths and Co., for election as auditors of the Company.

NEW COMPANIES, STATUTORY RETURNS, &c.

COMPANIES TO BE STRUCK OFF THE REGISTER.—The following concerns will be struck off the Register of Joint-Stock Companies within three months from April 27th, unless some reason be given to the Registrar for the non-filing of the statutory returns:—The Automatic Electrical Corporation (Limited), the Automatic Electric Supply Company (Limited), the British Electric Propulsion and Traction Company (Limited), the Electrical Works Construction and Maintenance Company (Limited), the Electro-Galvanic Machine Company (Limited), the New Electro-Amalgamator Company (Limited), the Portland Electric Light Company (Limited), Thompson's Electrical Fitting and Screw Cutting Company (Limited), the Wolverhampton Electric Light and Power Company (Limited), and Sharp and Co. (Limited).

"HARP" ARC LAMP SYNDICATE (LIMITED).—This Company was registered on May 1st, with a capital of £5,000, in £1 shares, to enter into and carry into effect an agreement which has already been prepared, and is expressed to be made between Wolstan Trubshawe of the one part, and the Company of the other part, to carry on the business of electricians, electrical and mechanical engineers, suppliers of electricity for the purposes of light, heat, motive-power, or otherwise; and manufacturers of and dealers in electrical apparatus and appliances of all kinds, and principally to carry on the business of an electric lamp manufacturing company in all or any of its branches. The subscribers are :—

	Shares.
Arthur Chester, 4, Kingsley-mansions, West Kensington, W...	1
Wolstan Trubshawe, 6, St. Benet-place, E.C.	1
John J. Rathbone, 78, Loftus-place, Shepherd's Bush, W.......	1
David Fowler, 6, East India-avenue, E.C.	1
Francis O. B. Reade, 83, Warwick-road, Earl's Court, S.W. ...	1
Thomas W. Bridgford, 2, Drapers'-gardens, E.C.	1
George F. Garry, 1, Westfield-road, Surbiton, S.W.	1

The first Directors are Arthur Chester, Vyoyar Trubshawe and Francis O. B. Reade.

CITY NOTES.

AFRICAN DIRECT TELEGRAPH COMPANY (LIMITED).—Particulars will be found elsewhere of the drawing of 111 debentures of £100 each of the Four per Cent. Mortgage Debenture Bonds of this Company. These debentures will be paid off at par on July 2nd, and interest will cease from July 1st.

AFRICAN TRANS-CONTINENTAL TELEGRAPH COMPANY (LIMITED).—The Directors of this Company have issued their report, which is to be presented to the meeting to be held on Thursday next. The report states that it was originally proposed to raise a capital of £400,000, but that the Company was ultimately registered with a capital of £140,000 only, this being the estimated cost of constructing the line from Salisbury to Uganda. The report states that subscriptions for a substantial portion of this amount were received, but before proceeding to allotment, the Board obtained from Mr. Cecil Rhodes an agreement to subscribe for the balance at par, and now, when moneys are required, shares are allotted to Mr. Rhodes under this arrangement. The Directors decided to construct the first 400 miles of line between Salisbury and Zomba, in the Nyassaland Protectorate, and 200 miles of material were shipped to Beira for transmission to Salisbury and 200 miles for Zomba. The outbreak of the Matabele war upset the Directors' arrangements, and but little progress has been made with the Salisbury section; but the northern section has been proceeded with, and considerable progress has been made, no opposition but some help having been at first received from the Portuguese. Unfortunately, in February last the Portuguese officials placed obstacles in the way of the Company's works, and, rather than become involved in any conflict, the Company decided to cease operations, and have withdrawn their material for the present. The Directors consider that the action of the Portuguese is a direct infraction of Article II. of the Convention of 1891, under which the Company maintain they have a right to carry on their operations across Portuguese territory. Strong representations have been made to Her Majesty's Government in support of these views.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended April 29th were £901, as against £792 in the corresponding period of 1893, being an increase of £109. The total receipts for the half-year amounted to £15,513, as against £15,360 for the corresponding period of 1893, an increase of £153.

CONSOLIDATED TELEPHONE CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED).—The Directors of this Company have resolved, subject to audit, to recommend to the shareholders, at the approaching general meeting, a dividend at the rate of £2 per cent. per annum, less income-tax, for the year ending March 31st.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the month of April are £3,900, as compared with £3,946 in the corresponding month of last year.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—This Company's estimated traffic receipts for the month of April amounted to £1,742, as against £1,742 in the corresponding period of last year.

EASTERN TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of April, amounted to £56,751, against £56,469 in the corresponding period last year, an increase of £282.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of April, amounted to £38,802, and to £41,713 in the corresponding period of 1893.

LONDON PLATINO-BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The sixteenth annual general meeting of the shareholders of this Company was held at the offices, 19, Great Winchester-street, E.C., on Tuesday last. The total earnings amounted to £24,585. 7s. 3d., as against £23,989. 3s. 10d., an increase of £596. 3s. 5d., compared with the previous year, while the loss on exchange amounted to £16,563. 0s. 9d. The working expenses amounted to £8,606. 19s. 2d., as against £9,297. 9s. 7d., or a decrease of £690. 10s. 5d. Including the amount brought forward from 1892 (£588. 2s. 8d.), the balance to the credit of the revenue account was £16,566. 10s. 9d., from which was deducted £6,000 for debenture interest, leaving, after placing £1,000 to reserve, £9,566. 10s. 9d. The Directors recommended a dividend of £2. 10s. per cent. per annum (5s. per share) for the year, carrying forward £179. 10s. 9d. The Company's lines were reported in good working order. The Directors' report was adopted, and the dividend duly approved and declared. Mr. W. S. Andrews and Lord

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Richard H. Browne were re-elected as Directors, and Messrs. Deloitte, Dever, Griffiths and Co. as Auditors.——It is announced that the offices of the Company will shortly be removed from 19, Great Winchester-street to Blomfield House, London-wall, E.C.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended April 27th (after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited) were £2,825.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, April 25.	Price Wednesday, May 2.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending May 2. Highest	Lowest.
			TELEGRAPHS.			£ s. d.			
£1,134,640	Stock	9/0	Anglo-American	42 44	43 45	5 5 6	Jan., Apr., July, Oct.	43½	43¼
£2,932,680	Stock	18/0	Do. Preferred	80 81	80½ 81½	5 16 7	" "	81½	80¾
£2,932,680	Stock	5/0	Do. Deferred	7¾ 8¼	7¾ 8¼	..	.. ..	..	..
£184,500	100	4%	African Direct Telegraph 4% Deb.(Reg.&Bearer)	101 104	101 104	3 16 11	January and July	..	..
130,000	£10	3/0	Brazilian Submarine	11¾ 12¼	12 12½	5 4 0	Mar., June, Oct., Dec.	12¼	12 1/16
£18,700	£100	5%	Do. 5 per Cent. Bonds	100 103	100 103	4 17 1	January and July	..	–
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	108 112	108 112	4 4 10	June and December	–	–
10,000,000	$100	$1½	Commercial Cable Capital Stock	146 150	146 150	4 13 4	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	12 13	12 13	6 3 1	February and August	–	..
6,000	10	10%	Do. Preference 10 per Cent.	18 19	18 19	5 5 3	" "	..	–
12,931	5	1/7½	Direct Spanish (£4 paid)	2¼ 3	2¾ 3¼	4 16 8	April and October	–	..
6,000	5	10%	Do. Preference 10 per Cent.	8½ 9	8¾ 9¼	5 8 1	" "	..	..
60,710	20	2/0	Direct United States Cable, 1877	9 9¼	9¼ 9¾	6 3 1	Jan., Apr., July, Oct.	9⅜	9 1/16
400,000	10	2/6	Eastern	14¾ 15¼	14¾ 15¼	4 5 11	" "	15½	14⅞
70,000	10	6%	Do. 6 per Cent. Preference	16 16½	16 16½	3 12 9	" "	16½	16
£1,294,100	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	114 117	115 118	3 7 10	May and November	116	116½
£105,900	100	5%	Do. 5 per Cent. Debentures, 1899	107 110	107 110	4 10 11	February & August	..	..
250,000	10	6/6	Eastern Extension xd & bonus	15⅝ 15⅞	15⅝ 15⅝	4 9 7	Jan., Apr., July, Oct.	15⅝	15⅜
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	113 116	114 117	3 8 5	February & August	115¾	115⅝
£62,700	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs 1900	103 106	103 106	4 14 4	January and July	..	..
£108,700	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	103 106	103 106	4 14 4	" "	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	104 107	104 107	3 14 9	February & August	..	..
£200,000	£25	4%	Do. 4% Mauritius Sub. Debs. xd	107% 110%	105% 108%	3 14 1	May and November	..	..
180,227	10	2/6	Globe Telegraph and Trust	8¾ 9	8¾ 9	5 0 0	Jan., Apr., July, Oct.	9	8¾
180,042	10	6%	Do. 6 per Cent. Preference	15¼ 15⅝	15¼ 15⅝	3 18 1	" "	15⅝	15¼
150,000	10	7/2	Great Northern xd	21¾ 22¼	21½ 21¾	3 18 11	Jan., April, and July	21 11/16	21⅝
£200,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	104 107	104 107	4 13 6	March & September	.	
17,000	25	12/6	Indo-European	45 47	45 47	5 6 5	May and November	46½	46½
37,548	10	4/0	London Platino-Brazilian	4 6	4 6	..	" "	..	.
£100,000	100	6%	Do. 6 per Cent Debentures	106 109	106 109	5 10 1	March & September	..	–
£100,000	£100	4%	Pacific European Tel. 4% Guar. Debs. "Red 1942	102 105	102 105	3 16 2	..	..	..
11,839	8	4/0	Reuter's	5½ 6½	5½ 6½	..	April and October	6½	..
8,381	£100 Cert.	35/0	Submarine Cables Trust 6 per Cent.	111 116	111 116	5 3 5	" "	..	..
15,609	10	5/0	West African Telegraph	3 5	3 5	..	January and July	..	–
£249,900	100	5%	Do. 5 per Cent. Debentures	100 103	100 103	4 17 1	March & September	..	..
30,000	10	2/0	West Coast of America	2½ 3	2½ 3		January and July	2⅜	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	103 107	105 109	7 6 10	June and December	–	..
88,321	10	1/0	West India and Panama	1½ 1½	1½ 1½	..	..	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10¼ 10¾	10½ 11	5 9 1	May and November	10⅜	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9 10	9 10	6 0 0	" "	..	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	108 111	109 112	4 9 3	June and December	110	..
64,242	15	4/6	Western and Brazilian	7¼ 7¾	7¼ 7¾	..	May and November	7⅝	7 7/16
33,129	7½	4/6	Do 5 per Cent. Cumulative Preferred	6 6½	6 6½	..	..	..	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	2 2½	2 2½	.	..	2	..
£178,200	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	106 109	106 109	5 10 1	February & August	..	–
£222,700	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	106 109	106 109	*5 10 1	" "	..	–
$1,214,000	$1,000	7%	Western Union 7% 1st Mtge (Building) Bonds xd	113 118	110 115	6 1 9	May and November	..	–
£169,000	£100	6%	Do 6 per Cent. Sterling Bonds	100 104	100 104	5 15 5	March & September	..	–
			TELEPHONES.						
44,000	5	10/0	Chili Telephone (fully paid)	1½ 2½	1½ 2½	..	–	..	–
224,550	10/0	3⅛d.	Consolidated Telephone Const. & Maintenance	1/16 3/16	1/16 3/16	..	May and November	..	–
171,504	£1	6d.	Oriental Telephone and Electric (fully paid)	⅝ ¾	⅝ ¾	..	Yearly	..	–
484,597	5	2/6	National	4⅝ 4¾	4¾ 5	5 0 0	June and December	4⅞	4¾
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	15 16	15 16	3 15 0	" "	..	–
15,000	10	6%	Do 6% Cumulative 2nd Pref. (fully paid)	14½ 15¼	14½ 15½	3 17 5	" "	14 11/16	14½
119,234	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	5⅝ 5⅞	5⅝ 5⅞	4 8 11	..	5 9/16	5⅜
925,017	£100	4½%	Do. Deb. Stk. 4½%	116 118	115 117	3 16 11	January and July	115¾	115
58,000	5	1/0	United River Plate	1½ 2	1½ 2	..	" "	..	–
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	90 100	90 100	5 0 0	" "	–	–
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	.	City of London Electric Lighting (fully paid)	12 13	12 13	–	–	12⅝	12 5/16
20,000	10	6/0	Do. 6 per Cent. Cumulative Pref. (fully paid)	13¼ 13¾	13¼ 13¾	..	–	13¾	13½
19,900	£5	..	Electricity Supply Co. for Spain	..	..	..	–	–	–
£150,000	£5	..	Electricity Supply Company Ordinary	..	..	..	–	–	–
£50,900	£100	5%	Do. 5 per Cent. Debentures, 1900	..	..	..	–	–	–
8,322	£5	..	House to House Electric	..	..	..	–	–	–
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	..	..	–	–	–	–
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..	..	..	January and July	–	–
39,000	£5	1/9	Liverpool Electric Supply (£4 10s. paid)	5¾ 6¼	5¾ 6¼	..	–	–	–
15,000	£5	2/6	Do. (fully paid)	6¼ 6⅝	6¼ 6⅝	..	–	..	–
111,000	5	..	London Electric Supply	½ ¾	½ ¾	.	–	..	–
49,900	£10	5/0	Metropolitan Electric Supply (fully paid) xd	7¼ 7¾	7 7½	3 6 8	..	7½	–
£100,000	Stock	5%	Do. 5% Debs. (Bonds of £10, £20, & £40)	106 109	106 109	4 11 9	June and December	–	–
6,452	£10	..	Notting Hill Electric	4½ 5½	4½ 5½		–	–	–
19,989	£5	4/6	St. James' and Pall Mall	6¾ 7¼	6¾ 7¼	..	–	–	–
20,000	£5	7%	Do. 7 per Cent. Preference	8 8½	8 8½	4 2 4	–	..	..
59,900	5	2/6	Westminster Electric Supply (fully paid)	5¾ 6¼	5¾ 6¼	3 4 0	–	6 3/16	–
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
90,000	8	1/6	Brush Electrical Engineering	2¾ 3	2¾ 3	6 0 0	–	2⅞	..
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	2⅛ 2⅜	2⅛ 2⅜	5 1 1	.	..	–
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	108 111	108 111	4 1 1	March & September	108¾	..
20,000	5	2/6	Crompton and Co., 7 per Cent. Cumulative Pref.	3¼ 3¾	3¼ 3¾	..	January and July	..	..
12,139	5	..	Edison and Swan United	–	–	..		..	–
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	..	..	–	.	–	–
120,000	2	..	Electric Construction	..	½ 1	–	.	–	–
12,845	2	..	Do. 7% Cumulative Pref.	1¼ 1¾	1¼ 1¾	..		–	–
91,195	2	10/0	Elmore's Patent Copper Depositing	½ ¾	½ ¾	..	..	..	–
20,000	5	..	Fowler-Waring Cables (fully paid)	½ 1½	½ 1½	–	.	..	..
50,000	10	15/0	India Rubber, Gutta Percha &c., Works	23 24	23 24	5 4 2	February & August	23⅝	23
£260,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	101 103	102 104	4 6 7	March & September	–	..
11,334	£10	6/4	International Okonite Ordinary	1 2	1 2	–	–	–	..
16,000	£10	..	Do. 8 per Cent. Preference	–	–	–	December and June	–	–
20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	– ⅛	– ⅛	–		–	..
78,949	5	3/6	Swan United (£3. 10s. paid)	2 2½	2 2½	7 0 4	May and November	..	–
87,350	12	36/0	Telegraph Construction and Maintenance	39 41	39 41	5 17 1	March and July	39½	–
£150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	–	–	..	January and July	–	–
37,514	£5	–	Woodhouse and Rawson Ordinary (£3. 15s. paid)	–	–	–	–	–	–
41,098	£5	–	Do. Preference (fully paid)	–	–	–	–	–	–
			RAILWAYS AND TRAMWAYS.						
£630,000	Stock	2%	City and South London Railway	27 32	27 32	1 19 0	May and November	–	–
87,500	£10	1%	Liverpool Overhead Railway	7 7½	7½ 7¾	–	–	–	–

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THE ELECTRICIAN:

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NOTES.

It has been the politic custom hitherto for both electrical and gas engineers to aver that electric lighting would in no way affect the consumption of gas. Some figures recently published by an engineering contemporary would, however, appear to show that in London, at any rate, the large and rapid increase in the use of electricity which has been witnessed within the past two or three years has made a serious inroad into the income of the metropolitan gas companies. According to Field's Analysis, the average rate of increase of the metropolitan gas consumption between 1886 and 1891 was 947 million cubic feet, the increase for 1891 alone being no less than 1,313 millions. In 1892, however, the very year in which the London electricity supply companies first got fairly to work, the consumption of gas only increased by 35½ millions, and last year the curve passed through zero and became negative, the *decrease* amounting to 1,007 million cubic feet. Electricity, of course, is not the only competitor of gas, and the extended use of oil, the advent of an economical burner, and the rise in the price of gas have no doubt had much to do with diminishing the gas consumption per burner connected. But, on the other hand, it must be remembered that London ceases not to grow, some thousands of houses being added to it every twelvemonth, and that the use of gas engines and gas stoves has certainly not fallen off. Again, the brilliant weather of 1893 doubtless had something to say in the matter; but it will be observed that the actual decrease of 1893 followed hard upon a decided decrease in the rate of increase, and that the abnormal meteorological conditions of last year affected electricity as well as gas supply.

At the end of 1893 some 700,000 10-candle 35-watt lamps were connected to the mains of the London companies, and it is interesting to find that this decrease of over 1,000 million cubic feet in the London gas consumption would have been wiped out and converted into a healthy increase, had these electric lights been replaced by an equal number of equivalent gas burners. At the recent meeting of the Metropolitan Electric Supply Company, the district of which is a fairly representative one, it was stated that each lamp connected yielded a revenue of 8s. 9d., and with the Board of Trade unit at 7¼d. this means that each lamp must have been alight some 400 hours. Taking this as an average figure for London we find that these 700,000 10-candle lamps give the portentous total of 2,800 million candle hours. The tests of gas-burners recently published by us clearly show that with average London gas in an average burner 1 cubic foot per hour cannot be expected to give more than two candles. Hence the substitution of gas burners for these 700,000 glow lamps would have augmented last year's gas consumption by some 1,400 million cubic feet; no negligible proportion of the grand total. Moreover, when we consider the numerous large "isolated plants," such as those at the Hotel Metropole, Liverpool-street Station, Paddington, the Imperial Institute, the Palace Theatre, New Scotland Yard, &c., it is tolerably evident that the growth of electric lighting has had a good deal to do with diminishing the increase in the consumption of gas, and converting it, notwithstanding the continued growth of London, into a decided retrogression.

Mr. James Staats Forbes's speeches at the annual gatherings of the unfortunate shareholders of the London Electric Supply Corporation have generally been characterised by that dogged persistency, which we are pleased to consider as a peculiarly English trait, and also by no little originality. We doubt, however, if he has ever been quite so original in his views as on Wednesday last. For the Chairman of a concern which went all the way to Deptford and indulged in all manner of gigantic experiments with the plain and proclaimed intention of underselling all competitors, to complain of the inevitable result of the rate-cutting campaign his Company was the first to start is, indeed, strikingly original. But still more so is the Chairman's preference for the wasteful system of contracts as against the supply of current by meter. It is to be hoped that the London Electric Company will be chastened into living in amity with their meters as well as with their competitors.

In the eleven Papers which formed an intellectual feast for the members of the Iron and Steel Institute, electricity or magnetism is referred to in three only. One of these is remarkable as being, so far as we are aware, the first metallurgical Paper in which a Ewing hysteresis curve is given. The Paper is, however, by Mr. Hadfield, no ordinary metallurgist, and it seems that we have still to wait patiently for other makers of iron and steel to begin to pay attention to the magnetic properties of their manufactures. In a Paper by Prof. J. O. Arnold, it was observed that traces of carbon and sulphur appear even in electrolytically deposited iron. One Paper, that by Mr. D. Selby Bigge, was wholly concerned with electrical matters, and discussed the

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transmission of power to tools in iron and steel industries. He advocates running separate circuits from each motor to the dynamo house, and that each circuit should be provided with an ammeter, under the eye of the man in charge of the engines. The author takes a sanguine view of the economy of electrical driving of factories, and cites some figures of the reduced coal consumption at Middlesbrough. He argues that the remodelling of old works on this system would "effect an enormous saving both in coal consumption, wages, and upkeep."

Mr. Vautin's Paper on the electrolysis of fused salts, a report of which is given elsewhere, is of interest as it marks a more hopeful attempt to grapple with the difficulties of molten electrolytes than has hitherto been made on an industrial footing. Destruction of the vessels and anodes and loss of the metal, which it is sought to obtain, by volatilisation or reunion with the anode product, have been the chief difficulties which the worker in this field has encountered. The use of a basic lining for the electrolytic vessel has much to recommend it, but the anode trouble may prove serious and has perhaps received less careful attention than the question of lining. A carbon anode even if dense and refractory is usually gradually disintegrated when immersed in a fused electrolyte, its life being shortened by alternate immersions and withdrawals. As we have before insisted, the makers of carbon electrodes have yet fields to conquer, and the production of a form of plate or rod at once refractory and non-pervious is a problem which they might well attack.

It is curious to note that the critical decomposing voltage for fused sodium chloride is found by Mr. Vautin to be about two volts. The voltage necessary for the decomposition of solid sodium chloride calculated from the heat of combination of sodium and chlorine is a little over 4 volts, whence it appears that the sensible heat requisite to fuse sodium chloride, must be capable of supplying a portion of the energy absorbed in its decomposition; or, in other words, that sodium chloride however heated to fusion, is about half way to the point at which it would dissociate. In estimating the commercial prospects of the process, it may be said that while the low voltage needed for electrolysis is a pleasantly small item on the debit side of the energy account, the heat supplied as such to the electrolytic vessel may prove a somewhat heavy charge. Fortunately, it always pays to replace electrical by heat energy, even at a lower efficiency. A third matter of some moment is the claim that was made by Mr. Cross in the course of the discussion on Mr. Vautin's Paper, that a wet process for the electrolysis of sodium chloride had an efficiency of 85 per cent. It may be taken for granted that the critical voltage for the decomposition of sodium chloride in aqueous solution is about 2 volts, as determined both by calculation and experiment. On the other hand, few, if any, wet processes have been actually worked with a smaller pressure than 4 to 5 volts. The method adopted for arriving at an efficiency of 85 per cent. from these data, is far from obvious.

The question whether certificates should be granted in the preliminary examination in Electric Lighting and Power Distribution, by the City and Guilds of London Institute, is opened in our Correspondence columns this week. Our correspondent thinks that certificates should be granted; and bases his belief on the fact that a very large proportion of the pupils who pass the preliminary stage would be unable to proceed any further. But, surely that is the very best reasons why certificates should *not* be granted. The examination is only a preliminary one, intended to sift off the duffers who would be sure to fail in the more serious subsequent stages, and who, if not sifted off, would become a great incubus on the examining body. It is only necessary that the student should receive an informal intimation that he has passed the preliminary stage; and if an official certificate, signed by high officers of the examining body, is granted to him, there is a great liability of his displaying the cardboard to the world as a guarantee of knowledge. The unsuspecting world would not stop to inquire *how much* knowledge, and the dangers of improper, and indeed fraudulent, usage would be very great. By merely publishing a list of preliminary "passes" at the examining centres, the City and Guilds Institute has done all that is necessary to inform the examinees; while, at the same time, it has safeguarded its own status and the interests of the electrical profession.

Since our leading article for this week was written, we have received the first number of "The Mathematical Gazette, a terminal journal for students and teachers." Of its eight pages, more than six are concerned with geometry, and one with arithmetical approximations. It is intended to confine this journal to elementary mathematics. The unexpected preponderance of geometry is accounted for by the fact that the Association for the Improvement of Geometrical Teaching, which has widened its basis so as to include all branches of elementary mathematics and mathematical physics, is adopting this means of furthering its objects. We wish it all success, hoping that, as a by-product of its labours, geometry itself may be developed.

The inclusion in our Leader last week of the anti-4πist among the body of screamers which fringes the outskirts of science does not imply, of course, that every anti-4πist is a screamer, nor that every anti-4πist can give anything approaching to a scientific reason of the faith that is in him. While, on the one hand, there are eminent scientific authorities whose objection to the constant 4π is both temperately stated and scientifically framed, there are, on the other hand, many who scream against the poor constant just because they love to scream, even though they know not any good reason for doing so. One of our American contemporaries, in a Leader on magnetic units, is strikingly original in the manner of its outcry against 4π, and it is as strikingly unscientific. "If, for example," it says, "our present system of linear measurements were based on π instead of on 10, then, while the ratio of the circumference to the diameter of a circle would become unity, the diameter would have to be expressed in terms of π." The fact that this particular sentence has been claimed by our contemporary to be a "slip of the pen," does not really affect the case; for, the

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spirit of the above quotation runs through the entire Leader, and it emphasises itself again where the writer suggests "that π should be given the value of unity with respect to a circle." This is the worst, unkindest cut of all—and from an influential electrical paper, too! What a novel system of geometry would result, according to this showing, from the adoption of π as the radix of notation! For example, to travel all round a circle would involve a journey no greater than to traverse a diameter; while it would be only half as far to go by a semicircular route between any two points as to go by a straight line. Poor Euclid, thy glory hath departed!

Cambridge University Engineering Laboratory.—The new engineering laboratory will be opened on Tuesday, May 15th, at 3 p.m., by Lord Kelvin.

Personal.—We learn that Mr. C. Ashmore Baker, A.I.E.E., has established himself at 28, John-street, Bedford-row, W.C., in the capacity of consulting electrical engineer.

Cable Interruptions:

	Date of Interruption.
Cayenne-Paramaribo	Oct. 25th, 1893.
Bissao-Bolama	Nov. 24th „
Brest-St. Pierre (P.Q. Co.)	Mar. 29th, 1894.

Labuan-Hongkong Cable was opened for traffic on 7th inst.

Dynamo and Transformer Construction.—On the 29th inst. Mr. James Swinburne will commence a course of lectures to the students of the Electrical Standardising, Testing and Training Institution, on "Dynamo and Transformer Construction."

Richmond.—The Richmond Electric Light and Power Company have now commenced to work the whole of their plant, and are supplying a continuous current day and night. Fifty-three premises have already been connected with the mains, and are using lamps equivalent to 2,400 8-c.p. lamps.

Royal Institution.—At the general monthly meeting of this institution the special thanks of the members were returned for the following donations to the Fund for the Promotion of Experimental Research at Low Temperatures: Sir William O. Priestley, M D., £50; Sir David L. Salomons, Bart., £50.

The Heilmann Electric Locomotive.—The Heilmann electric locomotive drew on Wednesday a special train from the St. Lazare terminus (Paris) to Mantes, a distance of 33 miles, performing the journey in 55 minutes. The train was composed of five coaches and a break van, and at certain portions of the line a speed of 65 miles an hour was attained.

Charing Cross, Euston, and Hampstead Electric Railway.—This Bill, which proposes to enable the Company to acquire property for the purposes of the railway in Villiers-street, Buckingham-street, Oxford-street, and at Camden Town, came on Tuesday before the Committee presided over by Mr. Mellor, Chairman of Ways and Means, as an unopposed measure. The Committee passed the Bill, and ordered it to be reported for third reading.

Electric Traction at Bristol.—The opposition, which at one time threatened to become violent, to the proposal to construct an overhead wire electric tramway between Bristol and Kingswood, has at last subsided, and the Tramway Company's Bill will go before the Unopposed Bills Committee of the House of Lords. This enables the Tramway Company to push on with their preliminary arrangements, so as to start work at the earliest possible date, and we learn that estimates for portions of the contract have already been tendered.

Feeding the Turbines.—The *Birmingham Daily Post* announces to its readers that a benevolent Mr. Hadley had arranged to present the Worcester Corporation electric supply station with "a piece of land which was needed to feed the turbines." The gift is made on the condition that the banks of this piece of land are to be garnished with chestnut or mountain ash trees. The amount of land requisite for "feeding the turbines" is not stated, but we are glad to hear that the generous offer made by Mr. Hadley has been accepted.

Rheims.—At Rheims electric lighting plant has been erected in the gasworks, and the Brown dynamos, constructed by MM. Weyher et Richemond, are driven by gas engines, two of 50 H.P., two with two cylinders of 80 H P., and a single-cylinder engine of 45 H.P. The regular working of the engines has permitted, with the addition of an automatic starting arrangement of the electric accumulators being done away with, and the light is very steady, even when the motors only work with one-fifth of their full charge. The price of the kilowatt hour is nearly a shilling, but is to be reduced as the number of consumers increases.

Hull.—At a meeting of the Hull Town Council last Thursday week, the Electric Light Committee presented a proposal to reduce the price from 7d. to 6½d. per unit. In moving its adoption Dr. Holder (the Chairman) stated that they commenced by supplying 3,790 eight-candle lamps, and ended the financial year with supplying about 9,400. During the 11½ months 74,600 units were used. The present cost of production was 6¾d. per unit, but the increased consumption which ought to follow the reduction would, he thought, turn a trifling loss into a profit. During next year they hoped to be able to make a considerable reduction.

Corrosion of a Fagotted Iron Bar.—In the current number of *Engineering* there is an illustration of a curious example of corrosion of an iron bar. The surface of the bar is rusted, not uniformly, but in parallel streaks running the lengthways of the rod; these streaks giving the rod the appearance of having been built up of a number of parallel plates. Under the original test the bar, when new, gave no indication of lamination or fagoting, and the ultimate tensile strength proved to be 24·21 tons per square inch. But, after some months of lying about, the rod presented the curious appearance described. It is evident that the rod was originally made from fagoted iron, and the difference in electro-chemical condition of the alternate layers has given rise to oxidation only of the alternate positive layers.

Measurement of Inductance.—In the April number of the *Journal de Physique*, M. H. Abraham gives an account of a method for measuring self and mutual induction, which he says is capable of giving the quantity which is being measured to within one part in a thousand, the method employed consists essentially of balancing a steady current passing through one pair of coils of a differential galvanometer against a succession of induced currents sent, by means of a commutator rotating at a known speed, through the other coils. The commutator then being stopped, the secondary circuit, containing one pair of coils of the galvanometer, is connected with the extremities of a resistance r in the primary circuit. The value of r is altered till the galvanometer is undeflected, then, from a knowledge of the value of r and the speed of rotation of the commutator, the value of the mutual induction can be calculated. In many ways the method resembles that employed by Profs. Ayrton and Perry in their secohmmeter.

Technical Books.—The Cambridge University Press will shortly publish a treatise on the "Steam Engine and other Heat Engines," by Prof. Ewing; the seventh volume of the edition of Prof. Cayley's collected Papers, and the first volume of the collected Papers of the late Prof. Adams. An "Elementary Treatise on Electricity and Magnetism," by Prof. J. J. Thomson, is in the press, and also a new edition of Prof. Lamb's "Hydrodynamics," largely rewritten and extended. An "Elementary Treatise on Hydrostatics," by Mr. John Greaves, has just appeared, and a Key to Mr. C. Smith's "Arithmetic" is nearly ready. The completion of Mr. H. M. Taylor's "Euclid" is also announced, and will be published in August. In the series of Cambridge Natural Science Manuals, Mr. Glazebrook's volumes on "Light" and "Heat," recently published, will be followed by volumes by the same writer on "Mechanics and Hydrostatics," and on "Electricity and Magnetism." "*The Electrician*" Printing and Publishing Company will shortly publish a book on "Electric Lamps and Electric Lighting," containing Prof. Fleming's recent lectures at the Royal Institution.

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London, Walthamstow, and Epping Forest Railway.—At the sitting of Sir John Kennaway's Committee, on Monday, Mr. Balfour Browne, Q.C., stated, on behalf of the promoters, that, having regard to the onerous terms which had been put upon them by the Committee at the instance of the London County Council of running workmen's trains at 1d. for nine miles, they were advised that it would be impossible to raise the capital for the line, and that if the proposal were insisted upon there was no alternative but to withdraw the Bill. He suggested that a suspensory clause should be inserted, so that those conditions should not apply until there had been some dividend paid upon the capital. The Chairman said that the Committee regarded the line of great importance, and hoped that some arrangement would be come to to obviate the necessity of withdrawing the Bill, and the proceedings were adjourned till after Whitsuntide to enable the promoters to further negotiate with the County Council. Although alternative powers for the use of electricity are provided for in the Bill, we understand that it is the present intention of the promoters to use steam as the motive power.

The London County Council and Technical Education.—It is announced that, with a view to promoting a better understanding of the needs and desires of the various trades in the matter of technical education, the Technical Education Board of the London County Council propose to hold, during the months of June and July next, a series of public conferences between the representatives of the principal London industries. Each conference will be strictly confined to representative practical men belonging to one particular group of trades. Every trade union belonging to the group will be asked to nominate delegates. Every employers' association will be similarly invited. The London Chamber of Commerce and the London Trades Council will also be asked to designate other representativn employers and workmen. The meetings will take place from 8 to 10 p.m., probably at the County Hall, Spring-gardens, on dates to be subsequently announced. The first meeting will be devoted to the building and furniture trades. The three subsequent meetings will follow at fortnightly intervals, and will deal respectively with the engineering, shipbuilding, and metal trades; the book, paper, and printing trades; and the clothing, leather, and miscellaneous trades. The names and addresses of representatives should be sent at once to Prof. Wm. Garnett, Secretary of the Technical Education Board, 13, Spring-gardens, S.W., from whom any further particulars can be obtained.

Transmission of Power.—The Government of Holland invited last year plans and tenders for the construction and delivery of the motive power for the new sea locks of Ymuiden, the seaport of Amsterdam. The plant, says *Engineering*, was to consist of the machinery for 12 lock gates, 24 sluice valves in these gates, 12 sluice valves for bypasses, and 12 capstans. Machinery for the lighting by electricity of the surroundings of the locks was also to be provided. The subscribers were at liberty to tender either for electric or hydraulic machinery. In all some 13 plans were submitted, viz., eight for hydraulic machinery, four for electric machinery, and one for compressed air machinery. The Government has now decided that none of the plans submitted are entirely satisfactory as they stand, but have nevertheless purchased the following schemes: For electric machinery: 1. The plans of Messrs. Gebrs. Figee, engineers, at Haarlem, and Mr. P. H. ter Meulen, electrical engineer, at Amsterdam, agent of the Electrizitäts-Actiengesellschaft formerly Messrs. Schuckert and Co., at Nuremberg, Germany, for the sum of 1,200 guilders. 2. The plans of Messrs. Siemens and Halske, of Berlin, for 700 guilders. For hydraulic machinery: 1. The plans of Messrs. C. Hoppe, engineers, at Berlin, 1,200 guilders. 2. The plans of Sir W. G. Armstrong, Mitchell, and Co. (Limited), at Newcastle-upon-Tyne, for 700 guilders.

Electric Railways and Tramways.—At a meeting of the King's College Engineering Society, held on Friday, April 20th, Mr. Makovski delivered his presidential address on "Electric Railways and Tramways." He commenced his Paper by dividing the methods of conducting into three primary divisions—the overhead, the side rail, and the centre rail system. Each of these divisions could be subdivided by employing a separate rail for return current. He also mentioned that a variation of the last method was to have a centre rail in a conduit under the ground. Of the first system he took the Molding Bouhl Railway as a type, and described the inverted tube with slit used in connection with the boat for carrying the current, which he also described. Next followed descriptions of the trolley-wheel contact with overhead solid wire, and Mr. C. T. Brain's method of enclosing the conductor in a conduit with a cover, which is of steel, and raised and lowered by rails on the contact maker. Mr. Makovski then gave details of the City and South London plant, more particularly the direct-driving motors, in which the armatures are wound upon the axles. The Portrush Railway, in which the motive power is obtained through turbines, and the Mont Salève Railway were then described. The latter is a rack railway with a gradient of 1 in 4. Next followed interesting details respecting the relative merits of overhead and other conductors, also of direct as opposed to gear-driving.

Joule's Equivalent of the Heat Unit.—"In whatever way," says a correspondent of the *Engineer*, "the determination of the value of J is approached, there are three constants whose values must always be determined—(1) the value of g; (2) the temperature coefficient of the specific heat of water; and (3) the thermometric scale. This last usually involves the reduction from mercury in glass to perfect gas thermometers. In 1878 Joule published his last research on the numerical value of J, and gave $J=774{\cdot}6$ (not 772, &c.). This, by the application of Regnault's formula for the specific heat of water, was reduced to 772·5. In 1880 Rowlands redetermined J, and paid special attention to points (2) and (3) above; he also compared Joule's mercury thermometers with his own air thermometer, and gave the corrections on Joule's figures, both on this account, and also for the difference in the specific heat of water, as determined by himself and by Regnault. Rowland's work has lately been confirmed by Griffiths—1887 to 1892. In *Science Progress*, April, 1894, Griffiths sums up, 'our present knowledge of the value of the mechanical equivalent' and recommends that $J=778$ be now adopted." It is scarcely probable that writers and others will forsake the old-fashioned 772·5 for the newer determination, until engineers and scientists have held a Congress over the matter and decided on some universal value of the constant. Until that happens we may comfort ourselves with the reflection that the difference between the two values is less than one per cent.

Dynamometry.—Dr. Louis Duncan, writing in the *Electrical World*, of New York, says:—"The transmission dynamometer which I am going to describe has been found useful for some special experiments for a number of years. I have used an absorption dynamometer, consisting of a copper disc rotating in a magnetic field. The power was calculated from the pull on the magnet and the speed of the disc. The heat was absorbed by water running through the apparatus. This dynamometer is of a rather limited range, unless belting is resorted to. For the purpose of trying some experiments on the efficiency of air propellers, a transmission dynamometer was designed on somewhat the same principle. It consisted of a copper disc fastened to the propeller to be rotated and placed in the field of a rotating electromagnet. The apparatus was calibrated by turning the magnet at known speeds and measuring the pull of the disc, which was kept stationary. After this, to measure the power transmitted, it is simply necessary to know the speeds of the field magnets and the copper disc, and the pull is proportional to the difference of the speeds, and can be obtained from the calibration curve. The disc is so constructed that it can be cooled by allowing water to flow on it in such a manner as not to absorb power, and a temperature correction can be applied if necessary. The speed of the disc can be regulated by varying the speed of the magnets and the strength of the magnetic field. In this way power can be transmitted without the intervention of any belt or gearing, and it forms an exceedingly convenient apparatus for some purposes."

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Magnetic Measuring Instruments.—At a recent meeting of the Academy of Sciences of St. Petersburg, says *Nature*, Dr. S. Wild read an interesting Paper on some improvements in the design and construction of magnetic instruments. The Paper is divided into four parts, the first containing the results of some experiments which show that metallic wires are preferable to the silk threads usually employed for the suspension of the magnets in magnetographs. The second part deals with the question of the accuracy of the readings given by the instruments employed to record the variations in the magnetic elements, when these instruments are contained in buildings composed of a material (such as ordinary red brick) containing iron. The experiments on this subject, commenced in 1878, have been continued, and show very clearly that a brick building has no influence on the measurements of the strength of the field, while the influence on the dip is quite negligible. The above result has also been deduced theoretically by M. Chwolson by means of the known value of the susceptibility of the bricks. The third part of the Paper contains a description of a small magnetometer for determining the value of the horizontal component of the earth's magnetism, designed for the use of travellers in countries where it would be difficult to carry the ordinary instruments. The instrument fits on Hildebrandt's small universal theodolite, which instrument is fitted with a compass. The combined instrument, although of small weight, is capable of giving results of considerable precision. Thus the dip can be determined to within half a minute of arc, and the horizontal component to within one part in four thousand. Lastly, the Paper contains a description of some changes which Dr. Wild has introduced into the portable magnetometer.

Introducing the Quadruplex into England.—In a letter to the *Electrical Engineer* of New York, Mr. Gerritt Smith gives, *apropos* of Mr. Preece's "Notes of a Trip to the United States and Chicago, 1893," the following account of the introduction of the quadruplex into this country :—

In view of the openly expressed doubts as to the success of the system abroad, the trial was looked upon as purely in the line of experiment ; and predictions were freely made that stormy weather, with the usual accompaniment of a London fog, would prove an effectual barrier to its successful working. It was therefore with considerable pride that from time to time during the first week or two, information was communicated to Mr. Preece of the satisfactory working during weather that proved almost too much for the duplex circuits between London and Liverpool ; but these occasions served to indicate what might be expected when the now anxiously looked for London fog should arrive. The patience of my faithful co-operator at the Liverpool end was soon rewarded by the arrival of a storm from across the Atlantic bringing with it conditions for the development of a veritable London fog which reached a maximum density about 11 a.m. when even the street traffic was rendered somewhat perilous. The service with Liverpool opened rather tardily upon all the regular circuits, the quadruplex being the exception. It was at once supplied with business for all sides owing to the partial suspension of other circuits. At about 10 o'clock a.m. the various duplex circuits between the London and Liverpool exchanges and main offices began to fail, and at 11 o'clock the condition of circuits had arrived in which it was deemed useless to attempt further working, and with the various Liverpool files well filled with business awaiting transmission the following memorandum was dropped to Mr. Preece : "11 a.m., Liverpool duplexes all suspended work. Quadruplex working finely four sides." In less than five minutes Mr. Preece came to the operating room accompanied by Mr. Patey and a sufficient number of the officials from the various departments interested to form a complete circle around the quadruplex table, at which four operators were easily working, two sending and two receiving. Among the group also was Sir William Thomson, whose interest in the exhibition was clearly shown by earnest inquiries respecting details of the service, condition of the line, &c. The experimental stage having been so successfully passed, the incident above narrated is put on record as part of the heretofore unpublished history of the introduction of multiplex telegraphy abroad ; I will simply add thereto the following clipping from the *Telegraphic Journal* of December 1, 1877, as follows :—"The quadruplex instruments continue to work excellently well between London and Liverpool. There can be no doubt that the system is a perfect success. Messrs. Gerritt Smith and Hamilton who have so ably superintended the setting up and working of the apparatus have returned to America."

Electric Heating for Street Cars.—The use of electric heaters in America for street cars propelled by electricity has already passed the experimental stage. They have been demonstrated during the past two winters to be both electrically and commercially successful, and are now very generally adopted all over the country by street railway companies. At the present time over 200 electric street railway lines in the United States are equipped in whole or in part with electric heaters. Comparative tests have been made between the electric heaters and the coal stove, and with most satisfactory results. The cost of operating electric heaters depends upon the cost of current, and this varies greatly in different localities. The average cost, however, per car day is about 25 cents. At Niagara Falls, N.Y., the street railway company has 38 electric heaters in operation on its cars. The extra cost per day for coal burned to generate electricity to operate the heaters is 75 cents, and it is estimated that the total cost per car day is 18½ cents, or about 5½ cents in excess of the cost of operating coal stoves. During last winter the Central Electric Heating Company have made an elaborate series of tests on the cars of various roads equipped with their heaters, in which thermometers were placed in various positions inside the car and on the platforms. These show that the electric heaters maintain the temperature at from 25deg. to 30deg. above that of the outside air, but what is most important, maintain an *even* temperature over the entire car. Thus on a test made on the Atlantic Avenue Railroad, Brooklyn, N.Y., on Feb. 24th, on an 18ft. car, the outside temperature for the trip averaged 7°F., while the temperature inside the car averaged 39°F. Only four heaters of the "B" style were employed and the current averaged 5⅓ amperes, which at the average E.M.F. of 436 volts on the line, shows the low consumption of 2,325 watts. On another test with the outside temperature averaging 28°F., the car was maintained at over 55°F. It is claimed by Mr. Silliman, electrical engineer of the Atlantic Avenue Railway Company, that the extra space obtained in their cars by using the American electric heaters more than pays for the extra amount of current consumed to operate them, and that these cars have been quite warm enough, even in extreme weather.

Electric Discharges through Gases.—In the course of his recent Friday evening discourse at the Royal Institution, Prof. J. J. Thomson, who took as his subject "Some Properties of the Electric Discharge through Gases," devoted his first experiments to showing the apparent reluctance of the electric discharge to pass from a gas into a metallic electrode. In one of the experiments by which he illustrated this a bulb was employed into which two long electrodes projected. The discharge between these was not from point to point, but from the point of one to the base of the other. He then showed how the states of electrification in a bulb through which an alternating current is being passed vary according to the gas and electrodes used. Oxygen gives a strong positive electrification, while with hydrogen it is different in different parts of the bulb. The discharge from an electrode of oxide of copper in hydrogen is negative till the oxide is reduced, when it becomes positive. Prof. Thomson then went on to consider the discharge through gases without metallic electrodes, and for this purpose used the rapidly-alternating current produced by the discharge of two Leyden jars, connected with a Wimshurst machine. The discharge wire was made into a coil, in the centre of which were placed bulbs containing the gases to be experimented upon. When two gases were to be compared in respect of conductivity, &c., the wire was made into two coils, in one of which the gas to be tested was placed and in the other a standard bulb. The brightness of the discharge in the latter gave an indication of the amount of energy absorbed by the former. From this and other experiments, the lecturer deduced the conclusion that the conductivity of gases at a certain degree of rarefaction is greater than that of any metal, and almost infinitely greater molecule for molecule. At a higher degree of rarefaction, however, conductivity is diminished, and in a perfect vacuum, as has been shown by some of Prof. Dewar's experiments, it is probable that the discharge as such would not pass at all. Prof. Thomson showed that when a vacuum bulb was enclosed in a vacuum jacket which had been made with mercury and the whole apparatus placed inside a coil, the discharge occurred only in the inner bulb. But upon increasing the density of the mercury vapour in the annular space, the discharge took place there instead of in the inner bulb. The last experiment performed referred to the influence of a magnetic field on the discharge, which was shown to take place more easily along the lines of magnetic force than across them.

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MOTIVE POWER AND GEARING.*

BY E. TREMLETT CARTER.

(*Continued from page 713, Vol. XXXII.*)

Furnaces and Boilers.

Draught.—We shall now enter into a more particular study of the working of steam generators, and will commence with some important questions relating to the furnace. Of these latter, one of the most important is the question of draught, *i.e.*, the proper supply of air to the incandescent and gaseous fuel in the combustion chamber. We shall find it convenient to consider two classes of draught: the induced or vacuum draught, and the forced or plenum draught.

Induced Draught.—Induced draught occurs where the products of combustion are drawn through the flues, and air is thereby led into the combustion chamber by means of a sucking action, *i.e.*, by lowering the pressure of the gases below that of the atmosphere at the end of the flues at which the gases are discharged. This class of draught is produced by the chimney, or the so-called natural draught, as well as by the steam blast.

Forced Draught.—Forced draught occurs where the products of combustion are driven through the flues against the atmospheric pressure and the frictional resistance of the flues, by virtue of a supply of high pressure air at the entrance end of the flues; it is therefore due to a positive rise of pressure above that of the atmosphere at the fire end of the flues. In a purely induced draught the pressure in the flues is everywhere less than that of the atmosphere, or a partial vacuum is produced; while in a purely forced draught the pressure in the flues is everywhere greater than that of the atmosphere. It will be noticed that in the former, cold air will rush into the flues through every accidental or intentional opening in the flues, such as through the fire door or through pores in the brick setting; while in the latter, on the other hand, cold air will never tend to rush in through openings, but hot gases will tend to rush out of them. In many boiler plants a combination of induced and forced draught is used; while in others it is often the practice to use chimney draught on ordinary occasions, and to assist this by forced draught when a larger supply of air is required. Various forms of blowers are used for forcing draught into the flues. With a combined forced and induced draught there will be a positive pressure in the early parts of the flues, and a partial vacuum in the later parts. If the forced draught is not vigorous, and is applied beneath a thick fire, it may happen that there will be vacuum everywhere beyond the grate.

Draught Gauging.—It is the usual practice to express the value of a draught in terms of the number of inches of water which give an equal head, or pressure; and a water-gauge is commonly employed for determining the draught. This gauge consists of a bent glass tube, forming a **U**-tube with one limb bent horizontally, and the other prolonged vertically. The horizontal end is placed in direct communication with the part of the furnace where the pressure or vacuum is to be measured, and the other end is open to the air. Water is placed in the bend of the tube. Fig. 10 shows the action of such a gauge; on the right hand, when there is a forced draught, and on the left hand when the draught is induced. It will be seen that the amount of vacuum in inches of water is shown by a depression of the water in the straight limb of the gauge G, while the amount of plenum, or pressure above the atmosphere, measured in the same manner is shown by the amount of forcing of the water column up the vertical limb. The head is, of course, represented by the difference in horizontal level of the surface of water in the two limbs of the gauge. To avoid inequality in surface tension effects at the surface of the water, it is well to arrange that the water level does not fall to the bent portion, W, of the tube. We shall find it convenient to represent any draught due to vacuum by a negative sign prefixing its value; while a positive sign will represent draught due to plenum. The total draught in a system of flues may not be capable of measurement at any one place; for it is evidently represented by the difference of pressure, reckoned algebraically, between the entrance and outlet of the flues. All that the gauge tells us is the effective pressure at any one place, as measured above zero pressure, *i.e.*, the atmosphere. It is like an electrostatic voltmeter connected between earth and one point of an electric circuit; it may tell nothing of the motive force. In the case of a simple draught, *i.e.*, of one produced wholly by induction or by forcing, the total draught *can* be indicated on the gauge, if the proper place be selected at which to fix the gauge. This place is the point where the draught is applied—at the base of the chimney in induced draught, or by the blower twyer, where the air enters the flues, in forced draughts. But if the draught is not simple, being due to both induction and forcing, the gauge must be fixed first at the entrance to the flues, then at the exit from the flues, or two gauges may be used simultaneously; the algebraic difference of the two values giving the total draught propelling the gases. It is often instructive to take an indication on the gauge at intermediate points in the flues, with a view to finding how the draught is distributed. Throughout the length of the flues there is a continual fall in absolute pressure, due to flue friction, change of speed of the gases, and so on. By carefully gauging the flues at a number of points, it is often possible to detect sources of inneconomy in the distribution of the draught.

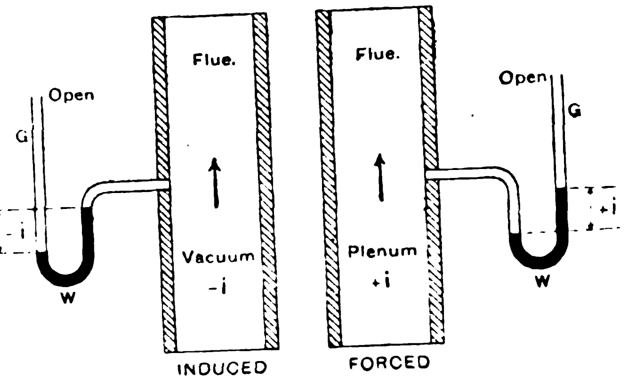

Fig. 10.

Amount of Draught.—Ordinary furnaces are usually worked at full load under a head equal to from ¼in. to 1¼in. of draught, rising sometimes to 1½in.; and an average draught in furnaces used in large electric power stations may be taken at from ½in. to ¾in. The amount of draught required in a boiler plant depends upon several considerations, of which the following are the most important:—(1) The quality and thickness of the fuel on the grate; (2) the area of the grate; (3) the length of the flues; (4) the surface exposed to the moving gases in the flues; (5) the velocity of the furnace gases; and (6) the requirements of rapidly getting up steam, or of extra rapid steaming for short intervals. Other things being equal, ordinary slack requires 25 per cent. higher draught than round steam coal, and should never have less than ½in.; round anthracitic coal requires from 80 to 100 per cent. more draught than round steam coal, coke breeze 50 per cent. more, wood and straw about 50 per cent. less. Town refuse requires nearly 2in. of draught for its satisfactory combustion.

Chimney Draught.—A chimney of not less than a certain height is always required by the local authorities to be used in conjunction with electric power stations, in order that the products of combustion may not become a nuisance in the neighbourhood. The chimney, therefore, forms a readily available method of supplying air to the fuel. Chimney draught, however, cannot be had for nothing, neither in regard to prime cost nor to the expense of constant running. To run a chimney draught, the escaping gases must be passed into the chimney at a high temperature; they will, therefore, represent a certain percentage of heat expended, or a certain number of tons of coal consumed per annum solely to keep up the draught. Chimney draught is caused by the difference in elastic pressure

* From a forthcoming work to be published by *The Electrician* Printing and Publishing Company. All rights are reserved.

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of the atmosphere and of the column of hot gases in the chimney, as measured at the bottom of the chimney; this difference arising from the lesser specific density of the hot gases, owing to their heated condition. The exact measure of the difference of pressure—*i.e.*, of the head—is equal to the difference in weight of a column of cold air equal to the height of the chimney and a column of the hot gases of the same height, the sectional area of both columns being unity. For any given average temperature of hot gases in the chimney, therefore, the draught produced will be simply proportional to the height of the chimney. On the other hand, for any chimney of given height, the draught will be proportional to the difference of the densities, and will, therefore, increase in direct but not simple proportion with the absolute temperature of the hot gases. Measured in inches of water, the theoretical value of a chimney draught is expressed by the formula:—

$$-i = 7\cdot6\,H\,\frac{T_2 - T_1}{T_2\cdot T_1}, \quad . \quad . \quad . \quad . \quad (79)$$

where H is the height of the chimney in feet, T_2 is the absolute temperature of the chimney gases, and T_1 is the absolute temperature of the atmosphere.

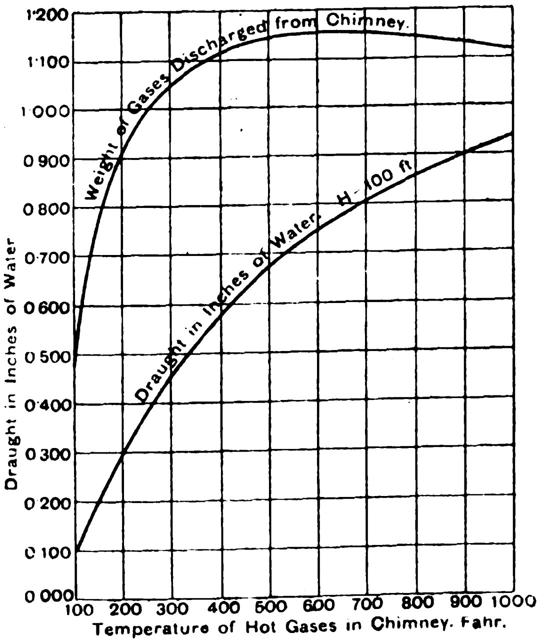

Fig. 11.

This equation is represented by the lower curve in Fig. 11, in which the ordinates measure inches of water and the abcissæ measure the temperature (on the ordinary scale) of the gases, the temperature of the air being taken at 60°F. The sectional area of the chimney does not enter into the formula, but, if the area is too small at the top, the draught will be seriously reduced. Again, the sudden check in the speed of the gases as they issue from the orifice into the air, will produce a back pressure and reduce the draught. The formula is calculated on the assumption of a still atmosphere, while experience shows that the liveliness of a chimney draught is enormously modified by the direction and force of the wind.

The purpose of a chimney is not merely to produce a certain number of inches of draught; it is further required to discharge a certain number of pounds of hot gas. We have seen that in proportion as the gases are at a high temperature in the chimney, the draught increases, but in like proportion will the volume of gas to be discharged become greater. Moreover, while the volume of the gases representing so many pounds of products of combustion rises in simple ratio with the absolute temperature, the draught rises at a decreasing rate, as is seen in Fig. 11. Consequently, there will be a certain temperature beyond which the power of the chimney to remove the gases will increase at a less rate than the bulk of material to be removed. It is manifestly a useless expense to allow the gases to escape at any higher temperature than this limit. Rankine has shown* that the weight of material removed by a chimney, acting alone and without forced draught, is proportional to

$$\frac{\sqrt{(0\cdot96\,T_1 - T_2)}}{T_1} \quad . \quad . \quad . \quad . \quad (80)$$

This expression becomes a maximum when

$$T_2 = 2\tfrac{1}{12}\,T_1. \quad . \quad . \quad . \quad . \quad . \quad (81)$$

Accordingly, with cold air at 60°F., the most effective temperature for the gases in the chimney will, theoretically, be about 600°F. At any other temperature a larger chimney would be required in order to do the same work. The variation of the function given in equation (80) is shown by the top curve in Fig. 11. It will be seen that, while this function is a maximum at about 600°F., it is not sensibly of lower value at neighbouring temperatures, and that even at 300°F. it is not more than about 4 per cent. of lower value. The output of the chimney is practically the same whether we allow the gases to escape at 600°F. or at only 300°F. On the other hand, the amount of heat permitted to escape with the gases is very much less at the lower than at the higher temperature. If we assume a specific heat of 0·25 for the hot gases, there will be no less than 75 B.T.U. reclaimed per pound of gas, or

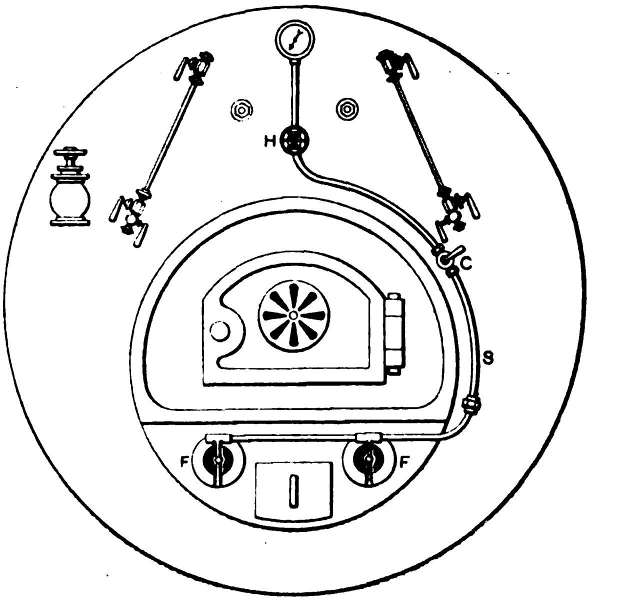

Fig. 12.

from 1,500 to 2,000 B.T.U. per pound of coal burned, by allowing the gases to escape at the lower rather than at the higher temperature. The element of working economy introduced thereby is by no means inconsiderable, and may represent a saving of many hundreds of pounds in the annual coal bill, in a large power station. It is true that by adopting the lower temperature we shall reduce the draught of the chimney; but that is remedied at little extra cost, by building the chimney a few feet higher. The economy of heat cannot well be carried below about 300°F., for at lower temperatures than this the gases would be but little hotter than the water they are required to heat. It should be pointed out that by increasing the economy the weight of gases to be discharged will be decreased, enabling a chimney of lesser section to serve the purpose equally well. Under ordinary conditions, a well-built chimney of 134ft. height will give one inch of water of draught, and the draught with any other height will be simply proportional to the height.

Meldrum's Forced Draught.—A form of under-grate forced draught which has been found very economical in some electric power stations is that known as Meldrum's forced draught. This invention is practically a live steam blast applied, not at the chimney end of the flues, but under the grate; and it consists of a nozzle supplied with steam from the boiler, and an

* Rankine: "Steam Engine and Other Prime Movers." 1885. Page 289.

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annular orifice communicating with the air, through which air is drawn by the vacuum produced by the steam blast. Both air and steam are forced into an expanding funnel, in which their motion is efficiently slowed down, and are discharged immediately below the fire-bars. Two of these air-injectors are usually placed under each grate. Fig. 12 gives a sketch of the steam connections for the apparatus, at the front of the boiler. The expanding funnel is shown at F, and the steam pipe leading to this at S. The supply of steam is regulated by the handle H, and may be shut down at any moment by the cock C. It will be seen that the ashpit is closed; but the fire-door may be opened for stoking by hand. Where a very high draught is used it is sometimes customary to close the cock C before stoking; and this must, of course, be done when removing ashes. The Babcock & Wilcox boilers at the West Brompton station of the House-to-House Electric Supply Company are fitted with these draught generators; and at this, as well as at other stations, a considerable economy of fuel and increase of steam production have been realised. In some other systems of forced draught by steam induction, such as that invented by Mr. D. K. Clark, the air and steam are admitted over the grate, the jet being directed towards a point immediately behind the bridge. The ash-pit is then left open, but the fire-door must remain closed while the blast is in action. This form of over-grate draught is usually employed as an auxiliary, to be used only just after stoking in order to supply air to the volatilised fuel, and thereby prevent imperfect combustion. One of the difficulties attending the use of forced draught is the melting of the fire-bars by the intense local heat. This difficulty renders it inadvisable to apply forced draught to ordinary grates, except where only a moderate draught is required. In the Meldrum furnace each fire-bar is locked to the next by a series of lugs or pins fitting into slots on the adjacent bar; so that it is impossible for any bar to be lifted above the level of the grate, and melting is thereby reduced to a minimum.

(To be continued.)

MAGNETIC QUALITIES OF IRON.*

BY J. A. EWING, F.R.S., AND MISS HELEN G. KLAASSEN.

(Concluded from page 8.)

A more striking example of the influence of the molecular shaking which is brought about by reversals of a magnetising force will be found in the experiment of Fig. 32. This experiment, like the last, was made with a magnetic curve tracer in which the metal under examination had two independent magnetising coils wound on it. Through one of these, Q, a current was passed which, when acting alone and carried through a cycle of values, gave the usual curve, *a b c d*, the dotted line, *a b*, being obtained after the metal had been neutralised by reversals in the usual way. Next the current in Q was brought to some steady value, and a violent molecular shaking was produced by rapid reversals of a current in P, which, starting with a rather high value, was gradually reduced to zero, while a rapid reversing key in its circuit was kept in motion. It would be inappropriate to call this process by the accustomed name (of "demagnetising by reversals") inasmuch as its effect was to leave the iron more or less strongly magnetised in consequence of the existence of the constant magnetising force due to the current in Q. The maximum magnetising force produced in this process of reversals by the current in P was about equal to the maximum force which was excited by the current Q at the extreme point, *b*, of the curve. Reversals of a force beginning with this high value and decreasing to zero gave the metal so thorough a molecular shaking up that the magnetising effect of the steady current became, under their influence, almost wholly independent of the previous magnetic history of the piece. In other words, the effects of hysteresis nearly disappeared. The points marked thus + in Fig. 32 were obtained in this way. They represent the relation of B to the magnetising force after reversals of an auxiliary force had been used to produce violent molecular agitation. Some of the points are marked thus •, and in these cases the process of magnetic shaking was performed after the steady current had been so manipulated as to lead to a point on the descending limb of the ordinary cyclic curve; the application of reversals then brought the magnetism down to the marked value. On the other hand, the points marked + were reached by applying reversals to raise the magnetism from a point on the ascending limb of the main cycle. It will be seen that the points marked • lie as nearly as possible on the same smooth curve with those marked +. That is to say, the effects of hysteresis are obliterated by this method of agitating

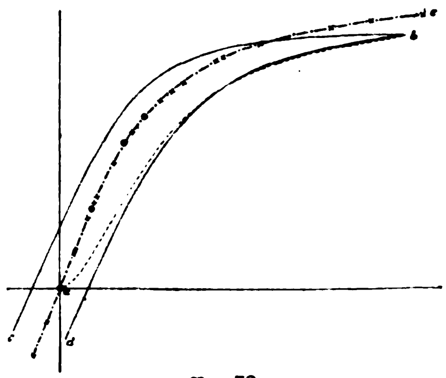

Fig. 32

the metal even more completely than they are obliterated by mechanical vibration in soft iron.* Ascending and descending limbs alike become merged on the single curve *a e*.

Reference has been made above to the evidence of time-lag in magnetisation which the magnetic curve tracer furnishes. It is in the softest iron that these are most apparent, and especially when the pieces under test are solid or imperfectly laminated. When solid rods of soft iron are used, three quarters of an inch or so in diameter, the movements of the mirror of the curve traces take place as if it were controlled by a dash-pot, or were immersed in a viscous fluid. Even a comparatively slow gradual change in the magnetising current is followed, after it ceases, by a continued creeping of the reflected spot of light lasting for some seconds,† and, when a cycle of reversal is performed at even a very moderate pace, the curve assumes a wholly different form from that which would correspond to a quite slow process. This is illustrated by Fig. 33, where (*a*) is the curve taken quite slowly for a pair of soft iron rods 1·9cm. in diameter, and (*b*) and (*c*) show the results when the period of a cycle was 3sec. and 0·43sec. respectively.

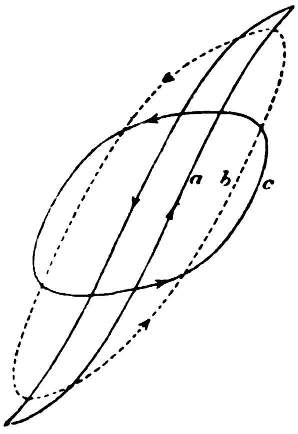

Fig. 33.—Magnetic Curve Tracer Curves for Soft Iron Bars. *a*. Cycle performed slowly; *b*. Period of Cycle, 3 seconds; *c*. Period of Cycle, 0·43 second.

* Abstract of Paper read before the Royal Society.

* Compare a corresponding experiment in which tapping was found to make the ascending and descending limbs of the magnetic cycle approach coincidence, *Phil. Trans.*, 1885, Part II., pp. 564-566.

† Compare the direct magnetometric observations described in Roy. Soc. *Proc.*, June 20, 1889.

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The influence which even the lower of these speeds has on the form of the curve is extraordinary. The maximum of the magnetising current is nearly the same in all three curves (owing to the self-induction of the magnetising coil it is a little less in the faster cycles, but enough non-inductive resistance was put in the circuit to make this difference small). It will be seen that the effect of time-lag in lowering the maximum of magnetisation (namely, the maximum of the mean magnetisation taken over the cross-section of the rods) is enormous, the effect of change in frequency being most noticeable when the period is comparatively long. Again, the influence of time-lag in augmenting the work spent in magnetic reversals is conspicuous, and here, again, it is remarkable how great this influence is at very moderate speeds of reversal. The exact form which the curve takes at any assigned speed will, of course, depend on what particular function of the time the applied electromotive force is caused to be, as a consequence of the exact form of the commutator plates and other conditions of the experiment. In the present case it appeared that the applied electromotive force was made to vary rather quicker near its mean values and rather less quick near its extreme values than would have been the case had it been a simple harmonic function of the time.

It is noticeable that the area of the curve increases at first and finally decreases as the frequency is increased. In other words, with a given maximum of magnetising current the work expended in reversals is a maximum, per cycle, for some one frequency. This, of course, results from the fact that at higher frequencies the magnetisation fails to penetrate sufficiently into the interior of the bar.

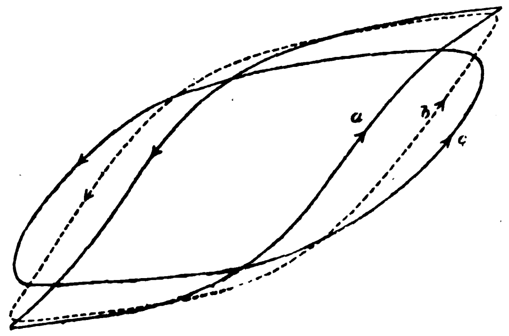

Fig. 34.—Magnetic Curve Tracer Curves of Steel. *a.* Cycle performed slowly; *b.* Period of Cycle, 3 seconds; *c.* Period of Cycle, 0·6 second.

In steel these phenomena are much less apparent than in soft iron, but they take place to some extent. Fig. 34 shows the results of a similar experiment made with a pair of bars of tool steel of the same dimensions as the iron rods of Fig. 33 Here again (*a*) shows the effects of perfectly slow reversal, while (*b*) and (*c*) are cycles performed in periods of 3sec. and 0·6sec. respectively. In both of these experiments (Figs. 33 and 34) the cycles marked (*b*) and (*c*) were produced by using an electric motor to drive the commutator, regularity of speed being essential to steadiness of the figure, especially at the slower speeds.

Whether these manifestations of time-lag in magnetisation are entirely explicable by reference to Foucault currents is not easy to answer. It appears possible that another cause may contribute to produce time-lag. In the upsetting of a group of molecular magnets time is needed for the disturbance to gradually spread from the point, or points, where the mutual controlling forces which produce equilibrium are first overcome. Let a group of pivoted compass needles, for example, be subjected to a gradually augmented deflecting magneting force; the first to yield will in general be some outlying member; its yielding will reduce the stability of its neighbours, and the disturbance spreads to them and from them to others. In a bar of iron we may conceive the molecules next the surface to be less strongly controlled than those in the interior, and to be, therefore, more likely to act as origins of disturbance when the equilibrium is upset by application of magnetising force. From this point of view, the greater amount of surface a mass of iron present the more quickly it is likely to take up the full amount of magnetic induction proper to any applied magnetic force, and hence in laminated iron the influence of time-lag should be less conspicuous than in a solid piece. To distinguish an effect of the kind here suggested from the effect of Foucault currents is evidently difficult, since both effects depend on the metal being tested in relatively large solid masses. A possible experiment might be arranged in which a rod built up of a number of concentric cylinders should be compared with an equal rod of the same iron built up of a number of sectors parted by radial planes. Both modes of lamination would reduce whatever part of the time-lag is due to the cause just suggested, but the second mode only would be effective in preventing Foucault currents.

It is clear from the experiments of Fig. 33, and even those of Fig. 34, that ordinary ballistic tests are liable to serious error when the specimen tested is a solid bar of any considerable section, especially when the material is soft iron, unless the ballistic galvanometer has a much longer period than is usual. The need of insulation, as well as lamination, is well exemplified by the case of Ring VIII., described above.

Experiments with Groups of Pivoted Magnets.

The remainder of our experiments relate to the molecular theory of magnetic induction discussed in a former Paper by one of us.* It was there shown that, if we adopt Weber's view that the molecules of a magnetisable metal possess magnetic polarity, the phenomena of hysteresis and other prominent characteristics of the magnetising process follow as consequences of the control which the molecular magnets exert on one another by their polar forces. Thus, in the application of magnetic force to an unmagnetised piece, the molecular magnets are at first deflected stably, and in this stage there is no hysteresis. But when the force is sufficiently increased certain molecules are deflected so far as to become unstable, and a breaking up and rearrangement of molecular groups supervenes. Finally, after this process has occurred throughout the piece a third stage is entered on, when further stable deflections through a small range bring about the completely "saturated" state. Hysteresis is found whenever any of the molecules pass from one stable configuration to another through a phase of instability, and this transition, being mechanically irreversible, involves a dissipation of energy. It was shown that this conception of molecular structure gave an explanation of very many known facts regarding the magnetic quality of iron and steel, and that some of these may be effectively illustrated by means of a model consisting of a group of small magnets pivoted like compass needles on fixed centres, and placed near enough to one another to allow their mutual polar forces to be strongly felt.

In further elucidation of this theory, we have made a number of experiments with such a model. In some of them as many as 130 little magnets have been used. These were cut out of sheet steel. They were mostly lozenge-shaped, and were about an inch long and half an inch wide, but some were smaller; each had a central recess punched in it to form a socket for the supporting pivot, which was an inverted drawing-pin with a sharp point. The pins were stuck through a sheet of paper to hold them at the desired distance apart, and the paper was laid on a horizontal sheet of glass which stood between a pair of coils, through which current was passed to produce a deflecting magnetic field. Two layers of such magnets were generally used, one above the other. The aggregate magnetic moment of the group was measured by means of a mirror magnetometer, which was furnished with an adjustable compensating coil to neutralise the direct effect of the current in the two field-coils of the model.

The group having been well stirred up and allowed to settle in the absence of directing force, the current in the coils was slowly increased by means of a liquid rheostat, and galvanometer readings of it were taken, along with magnetometer readings of the aggregate moment. The numbers (with arbitrary scales) are given below, and are drawn as a curve in Fig. 35. The highest value of the current was strong enough to bring the group of magnets to a configuration approaching "saturation." It will be seen that the three stages of the magnetising process are well reproduced in the behaviour of the model, and,

* "Contributions to the Molecular Theory of Induced Magnetism," Roy. Soc. *Proc.*, Vol. XLVIII., p. 342 (June, 1890).

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notwithstanding the limited number of "molecules" which took part in the operation, the readings lie fairly well on a smooth curve, which has all the general character of the curve of magnetisation in actual iron.

Current.	Moment.	Current.	Moment.
0	0	50	28
4	0	58	41
10	1	63	48
17	3	83	119
26	5	145	145
33	11	184	160
41	11	447	174

In the same way Fig. 36 shows the results obtained in carrying a group of pivoted magnets through a complete cycle, by double reversal of the directing field, after the cycle had already been gone through once or twice. Fig. 37 shows an immediately succeeding experiment on the same group, designed to illustrate the formation of small loops by the removal and reapplication of magnetic force. In these operations the behaviour of the model agrees in all respects with that of a magnetic metal.

The same close correspondence is found even in less obvious features of the magnetising process. This is illustrated in Figs. 38, 39, and 40.

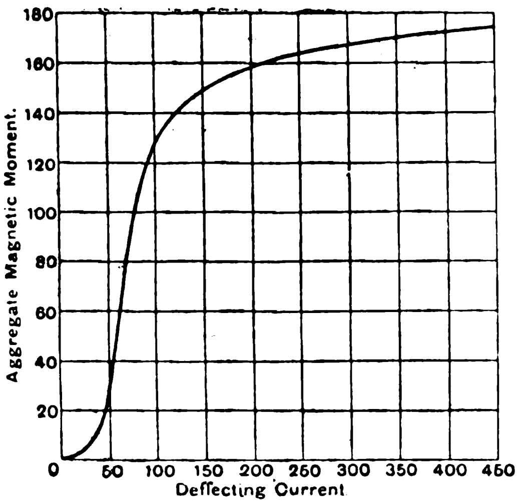


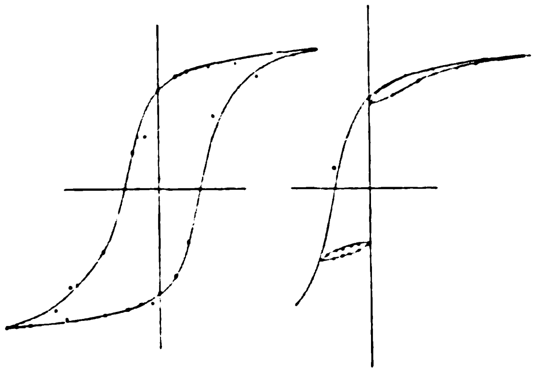
FIG. 35.—Curve showing the behaviour of a group of 130 pivoted magnets subjected to increasing directive force.

When a piece of previously unmagnetised iron or steel is acted on by a magnetic force sufficiently strong to carry the metal to the stage of high permeability, but not strong enough to make it approach saturation, and this force is then caused to vary between equal positive and negative values, it is found that the first application induces more magnetism than is induced by subsequent applications, and that the changes of magnetism do not become cyclic until the force has been several times reversed. And during this gradual approach towards a cyclic *régime* the range, through which the magnetism varies between its positive and negative extremes, becomes reduced. These effects of hysteresis are well shown by Fig. 38, which is copied from a former Paper,* and represents a test of a piece of annealed steel.

The same phenomena occur in the model, provided the little magnets have been previously shaken up and allowed to settle in the absence of any directing field: a condition which may be supposed to correspond with the annealing of the solid metal. Fig. 39 is a characteristic instance. It represents a test of the same group of pivoted magnets as was used in Figs. 36 and 37. After all effects of earlier deflecting fields had been eradicated by shaking up the group, a rather weak directing force was applied, first to the positive side, and then this was reversed three times. At the third reversal the changes of aggregate moment on the part of the group had become nearly cyclic, but with a range of variation which was decidedly less than that indicated by the first application of the field. Corresponding results were found in another experiment where the first application of the field was towards the side called negative.

* *Phil. Trans.*, 1885, Plate 61, Fig. 28. *See* also Fig. 26 on the same Plate.

Again, using a model in which there were only 36 magnets, notes were made of the position assumed by each member of the group when the directing field was (1) applied, (2) reversed, (3) re-reversed, and so on. It was seen that the configuration assumed in the first application was not reproduced in the third, nor that of the second in the fourth. But the fifth application made all the members of the group take up the same position as they took in the third, and again the sixth agreed with the fourth.



FIGS. 36 and 37.—Cyclic processes in a group of pivoted magnets.

Further, tests of iron and steel show that if we have to deal, not with a previously unmagnetised piece but with a piece on which the process of "demagnetising by reversals" has been performed, the phenomena which have just been described are not found, or, at least, are much less conspicuous than in virgin metal.

They reappear after the primitive state is reproduced by annealing. In this respect the molecular state of iron which has been demagnetised by reversals of a strong magnetic force (diminishing to zero) differs from that of a piece which has been demagnetised by annealing—or even, it may be added, by mechanical vibration.*

The same difference is found in the behaviour of the model after the two corresponding kinds of preliminary treatment. If a neutral initial state has been arrived at by a casual stirring

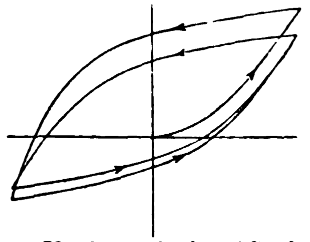


FIG. 38.—Magnetisation of Steel.

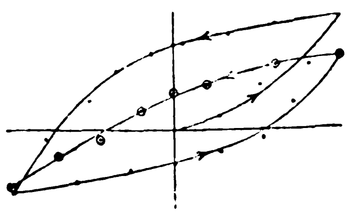


FIG. 39.—Corresponding process in Model.

up of the little magnets, the model behaves in the way shown in Fig. 38. On the other hand, if the neutral state has been produced by repeated reversals of a strong deflecting field, very slowly performed, so as not to throw the group into general agitation, and gradually reduced in range to zero while the reversals go on, the displacements of the magnets under a subsequently applied weaker field are found to fall at once into a cyclic *régime* when the field is reversed. An example of this is given in Figs. 40 and 41, which show experiments made with a group of 120 magnets. In Fig. 40 the magnets had been shaken up to begin with, and, in consequence, when the magnetic field was applied the displacements were not at once cyclic. Fig. 41 shows the behaviour of the same group under precisely the same changes of deflecting field after the process of "demagnetising by reversals" had been used to bring the group into a neutral state. Here we find a cyclic

* In illustration of this difference, reference may be made to Figs. 26 and 27 in Plate 61, *Phil. Trans.*, 1885.

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régime established at once, and as near an approach to symmetry in the curve as a model with a limited number of magnets can well be expected to show. Observations made on such a model are necessarily somewhat rough, and too much stress must not be laid on particular features of the curves.

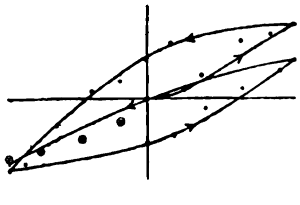

FIG. 40.

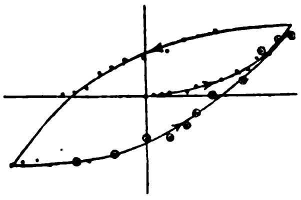

FIG. 41.

But in several repetitions of these experiments the same general distinction has always been apparent in the behaviour of the model after one and the other mode of preliminary treatment, a distinction which, as we have seen, forms a striking analogue to what is observed in actual iron or steel.

THE RELATION OF MATHEMATICS TO ENGINEERING.*

BY JOHN HOPKINSON, F.R.S.

Mathematics has been described in this room as a good servant but a bad master. It will be my duty this evening to prove by suitable illustration the first half of the proposition, and to show the service mathematics has rendered and can render to engineers and engineering.

In our Charter the Institution of Civil Engineers is defined as "A society for the general advancement of Mechanical Science, and more particularly for promoting the acquisition of that species of knowledge which constitutes the profession of a Civil Engineer, being the art of directing the great sources of power in Nature for the use and convenience of man, as the means of production and of traffic in states both for external and internal trade, as applied in the construction of roads, bridges, aqueducts, canals, river navigation and docks, for internal intercourse and exchange, and in the construction of ports, harbours, moles, breakwaters and lighthouses, and in the art of navigation by artificial power for the purposes of commerce, and in the construction and adaptation of machinery, and in the drainage of cities and towns." No better definition can, I think, be found for our profession than that it is the art of directing the great sources of power in Nature for the use and convenience of man. It covers all that the widest view of our work can include, and it excludes those applied sciences, such as medicine, which deal with organised beings. Mathematics has to deal with all questions into which measurement of relative magnitude enters, with all questions of position in space, and of accurate determination of shape. Engineering is a mathematical science in a peculiar sense. Medicine, the other great profession of applied science, has but little to do with questions of measurement of magnitudes, or of geometry; but the engineer finds them enter into everything with which he has to deal, and enter in the most diverse ways. The thing he has to determine is that the means he employs is enough and not unnecessarily more than enough to attain the end in view. For this he must necessarily numerically measure the end and the means and see that they are justly proportioned to each other. It is useless this evening to waste time proving, what all will admit, that no one can be even the humblest engineer without a knowledge of arithmetic and enough of geometry to enable him to read a drawing, that some trigonometry, some rational mechanics and a knowledge of projections, is a very useful part of the mental equipment of a draughtsman. It is hardly necessary to call attention to the great economy in the labour of calculations effected by the use of logarithms, a mathematical instrument for which we are indebted to Napier. We may with more profit examine what use the higher mathematics can be to the practical engineer, and what has been done in the past for engineering by its aid.

Judging from etymology, mathematics must have been begun by engineers; for surely geometry is the work of the earth measurer or land surveyor. But since the prehistoric times when geometry was initiated, engineers have not added much that is new to mathematics. They have rather sought amidst the stores of the mathematician and selected the handiest mathematical tool they could find for the particular purpose of the moment, but have done little or nothing in return in the way of improving the tools which they borrow. In this respect the relation of engineering to mathematics differs much from its relation to experimental physics. In electricity, magnetism, and heat, engineers have from their practical experience repeatedly corrected the ideas of the theorists, and have started the science on more accurate lines. If our subject to-night had been the use of the practical applied science of engineering in promoting the development of pure mathematics, we should speedily find that there was hardly any material for discussion. The account being all on one side, let us see to what the debt of the engineer to the mathematician amounts.

There is no department of practical engineering in which the application of mathematics is more familiar than in that which relates to the calculation of the strength and rigidity of structures of various kinds. It is impossible to take up any book dealing with the subject without finding that it is crammed either with mathematical formulæ, or with geometrical figures. The question is not whether mathematics is necessary to an adequate comprehension of the subject, but whether analytical or purely geometrical methods are more convenient. Of course, one might occupy many lectures in discussing the practical application of mathematics to the question of bridge building, roofs, guns, shafting, and the like. Our object must be to illustrate by various examples rather than to attempt anything like a complete discussion.

Consider the case of a long strut, so long that its transverse dimensions can be regarded as insignificant in comparison with its length. Whilst the strut remains perfectly symmetrical about its middle line, its strength will depend only upon the resistance of the material to crushing. Everyone knows that this would be an inadequate conclusion; we have to consider another element, namely, its stability, that is, we must examine what will happen to the strut if from any cause it is displaced somewhat from the direct line between its extremities. A mathematical discussion of the question results in a differential equation of the second order with one independent variable. Upon consideration of this we are enabled to see that if the thrust upon the strut be less than a certain critical value, a slightly bent strut will tend to return to its straight condition; but that if the thrust upon the strut be greater than this critical value, the displacement will tend to increase, and the strut will give way. Further, that the critical value will depend upon whether one or both of the two extremities of the strut are held free, or whether they are rigidly attached by flanges or otherwise, so that the direction of the axis of the strut at this point must remain unaltered. Again, we infer that if the ends are held rigidly fixed, the length of the strut may be twice as great for a given critical value of the thrust as if the two ends are free to turn. We can also infer what the critical value will be for struts of various lengths and of varying cross-sections. This critical value depends not upon the resistance of the material to crushing, but upon its rigidity.

Another example, having a certain degree of similarity with the case of struts, is that of a shaft running at a high number of revolutions per minute, and with a substantial distance between its bearings; for simplicity, we will suppose that there are no additional weights, such as pulleys, upon the shaft. How will the shaft behave itself in regard to centrifugal force as the speed increases? In this case, so long as the shaft remains absolutely straight it will not tend to be in any way affected by the centrifugal force, but suppose the shaft becomes slightly bent, it is obvious to anyone that if the speed be enormously high this bending will increase, and go on increasing until the shaft breaks. In this case also we may use mathematical treatment; we find that the condition of the shaft is expressed by a differential equation of fourth order, and from consideration of the solution of this equation we can say that if the speed of any particular shaft be less than a certain critical speed, the shaft will tend to straighten itself if it be momentarily bent, but that, on the other hand, if the speed exceeds this critical value, the bending will tend to increase with the probable destruction of the shaft. I do not know that either of these two questions can be properly understood without some knowledge of differential equations.

A problem having a certain analogy to those to which I have just referred is that of hollow cylinders under compression from without, such as boiler tubes. Whether the tubes be thick or thin, so long as they are perfect circular cylinders, they should stand until the material was crushed. But if the tubes are thin, what will happen if the tube from any cause deviate ever so little from the cylindrical form? The solution cannot be obtained without a substantial quantity of mathematics.

The next illustration shows how a mathematical conclusion, correct within the limits to which it applies, may mislead if applied beyond those limits, and how a more thorough mathematical discussion will give a correct result. Considering a case of shafting in torsion, it was show by Coulomb that the stiffness and strength of a shaft having the form of a complete circular cylinder could be

* The "James Forrest" Lecture, delivered before the Institution of Civil Engineers, May 3rd,

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readily calculated if the transverse elasticity of the material and its resistance to shearing were known. From the complete symmetry about the axis it is evident that points which lie in a plane perpendicular to the axis before twisting will still be in that plane when the shaft is twisted; it is also clear that the angle through which all points in the same plane move will be the same; hence the problem was as simple as problem could be. But many who had occasion to make use of Coulomb's results gave them an application which was wholly unwarranted. They assumed that they were equally applicable to other cases than complete circular cylinders; they assumed, in fact, that every point of the material which lay in a plane perpendicular to the axis would remain in that plane when the shaft was twisted, whether the shaft was symmetrical about its axis or not, and they consequently arrived at very erroneous results. That the assumption was erroneous is obvious enough from a consideration of an extreme case. In Fig. 1 is shown in cross-section a hollow cylindrical shaft, which is not complete, but divided by a plane passing through its axis. In this case the shaft when twisted will be as illustrated in the side elevation; two points, A and B, were in one plane perpendicular to the axis when the shaft was free from twist; they cease to be in one plane when the shaft is twisted. St. Venant* in 1855 investigated the questions of shafts without making incorrect assumptions; he expressed the condition of the material by a partial differential equation of the second order, and gave suitable surface conditions. A general solution of the problem for all forms of shafts has not been obtained, but St. Venant gives a number of solutions for particular forms, and he obtains some general results of interest. In all cases the stiffness of the shaft is less than would be inferred from an erroneous application of Coulomb's theory. Fig. 2 shows diagramatically the strain in a shaft of triangular section; the full lines indicate that the parts of the shaft which lay in one plane before twisting when twisted rise above the plane; the dotted

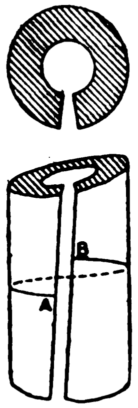

FIG. 1.

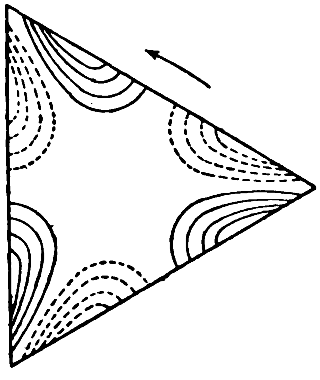
FIG. 2.

lines indicate that they lie behind the plane of the paper. The shearing stress is least at the angles of the triangle, and is greatest at the middle of the sides. At this point, then, the shaft will begin to break under torsion. The fact is probably well known to men of practical experience, but it is directly contradictory to the conclusion at which one would arrive by a careless use of Coulomb's theory beyond the narrow limits within which it is applicable. The longitudinal ribs which one often sees on old cast-iron shafts are useful enough to give stiffness to the shafts against bending, but are good for very little if torsional stiffness or torsional strength is desired.

Another application of mathematical theory which has been carried somewhat further than the premises warrant is found in the case of girders. It is almost invariably customary to treat a girder as though the sections retain when the girder is bent the form and size which they had before bending. Making this assumption, it is very easy to calculate the strength and stiffness of a girder of any section. Unfortunately, the assumption is untrue; but, fortunately, it is approximately true in the case of most girders with which engineers in practice have to deal. That it is untrue can be readily seen from consideration of a girder of exaggerated form, the section of which is shown in Fig. 3. Any practical man would at once see that the outer parts of the flanges would add little to the strength of the girder, but according to the usual mathematical theory, the outer parts of this flange should be as useful as the parts which are nearer to the webb. This problem St. Venant also deals with in a rigid mathematical manner. Amongst other things, he showed that a girder of rectangular section, such as shown in Fig. 4, would, when bent, take the form shown by the curved lines in the same Fig. The last two examples show how a little knowledge may be a dangerous thing, and how easy it is for anyone who attempts to apply mathematics without adequate mathematical knowledge to be misled.

The theory of thick cylinders under bursting stress from within has many important practical applications to hydraulic presses and to guns. It has been discussed more than once in this room. As usual, in considering these cases, we are immediately led to differential equations, which here are fortunately solved without serious difficulty, and the solution tells us the whole story. We learn that doubling the thickness by no means doubles the strength of the cylinder. And as a converse, that doubling the strength of the material will permit the thickness to be diminished to much less than one-half. Twenty-five years ago hydraulic presses were mostly made of cast-iron. Many people were not a little astonished at the great reduction in thickness and weight which became possible when steel was substituted for the weaker material. In the case of guns it is well known that greater strength can be obtained if the outer hoops are shrunk on to the inner ones.* Mathematical theory tells us what amount of shrinkage should give the best results. It may possibly not be worth while to follow the results of theory precisely, but without the guidance of theory it would not be unnatural to give so great a shrinkage that the gun would be weaker than if no shrinkage were used.

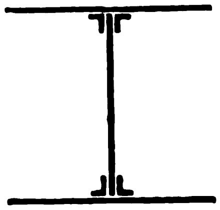
FIG. 3.

The rolling of ships in a seaway gives an illustration of a principle which has very varied application in many branches of physics. Suppose a body is capable of oscillating in a certain periodic time, and that it is submitted to a disturbing force of given period, the equation of motion easily shows that the resulting disturbance will be great if the two periods are equal or nearly equal. We meet with the principle in acoustics as resonance. If two tuning forks are tuned to the same pitch, and one is sounded in the neighbourhood of the other, that other will presently be thrown into vibration by the waves transmitted through the air from the first. You may try a similar experiment at any time on any piano. Strike the higher G in the treble, the sound ceases on raising the finger. Now hold down the middle C, and again strike G; the C string at once takes up the note sounded, and can be heard after the exciting string has been silenced by damping. The same fundamental idea is found in the lunar theory in the term in the equation known as the evection, and again in the theory of Jupiter's satellites. The reason why the metals present in the solar atmosphere give black lines in the spectrum by absorption, corresponding in position with the bright lines in the spectrum which the same metals give when incandescent, is again the same. Gas will absorb or take in from the ether waves of the exact period which it is capable of giving to the ether. The general explanation of all these phenomena is easy. Imagine a pendulum, and, suppose it experiences a periodic disturbing force, the first impulse of the disturbing force gives the pendulum a slight swing, the effect of the second impulse depends entirely on when it occurs, it may occur so as to neutralise the effect of the first, or it may occur so as to increase it. If the period of the force is the same as the natural period of the pendulum, the effect of the second, third, and later impulses will be added to the effect of the first, and the final disturbance will be great, even though the individual impulses be minute. But the mathematical theory tells us much more than any general explanation can do. It tells

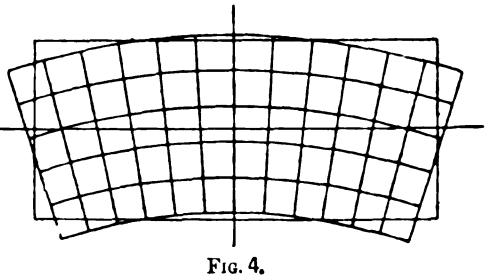
FIG. 4.

* "Mémoires des Savants Étrangers," 1855; and Thomson and Tait, "Treatise on Natural Philosophy."

* Lamé: "Leçons sur la Théorie Mathématique de l'Élasticité des corps solides," 14th Leçon.

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us exactly what the character of the effect will be, and its amount if the periods are nearly but not exactly the same. It tells us, too, exactly how friction affects the results. And the beauty of it is that the mathematical theory is much the same in all cases, so that having learned to deal with one case we are enlightened as to a host of others. The oscillating body may be an ironclad, or it may be an atom of hydrogen, the disturbing periodic force may be the waves of the Atlantic, or it may be the waves in the ether occurring five hundred millions of millions of times in a second; it is all one to the mathematician, the treatment is substantially the same.

The question of the speed of ships and the power to propel them is probably more effectually treated by experiment on models, as was done by the late Mr. Froude, than by mathematics alone; but in order to learn from the experiments all they are capable of teaching a mathematical understanding is needed. Given that we know by experiment all about a given model, that we know what force is needed to propel it at every speed, we want to know from these experiments how a great ship, 100 times as big, but similar in form in every respect, will behave, and here mathematics come in to aid us in making the inference.

The construction of ships at once leads us on to the methods of navigating them. In navigation I should find much material for my purpose, but navigation is not usually included in engineering, but many of the implements of navigation undoubtedly are. The mariners' compass has for ages been the mainstay of the navigator, and a simple enough instrument it was till it was disturbed by the iron of which ships came to be built. The disturbance of the compass by the iron of the ship was first seriously attacked by two senior wranglers, Sir G. Airy and Mr. Archibald Smith. The disturbance may be divided into two parts, the first due to the permanent magnetism of the ship, the second to the temporary magnetism induced by the earth's inductive action on the iron of of the ship—the first causes the semicircular, the second the quadrantal, error. One has only to open the "Admiralty Manual of Deviations of the Compass" to see how the mathematics of Archibald Smith have accomplished a proper understanding of the subject. The errors of the compass are dealt with in two ways: they are compensated by soft iron correctors, and by permanent magnets so placed as to have an effect equal and opposite to the effect of the temporary and permanent magnetism of the ship. Or they are dealt with by formulæ of correction which enable the error to be calculated when the course of the ship and the conditions of the earth's magnetism are given, or a combination of the two methods is used. Either method is based on Archibald Smith's theory. It is not possible to leave the subject of the mariners' compass without referring to the great improvements of Lord Kelvin. The improvements relate to every part of the instrument, and I venture to say that none of them could have been made by any one but a mathematician. In order to get his card steady he knew that its period must be different to any possible period of the waves, or he would have the resonance to which I have just referred coming in, so he gave his card a considerable moment of inertia; but this was managed with a light card, so that small needles could be used. If the needles are small the correction by soft iron masses and by permanent magnets is easier and more accurate. Then the bowl of the compass had to be suitably carried, so that it would not be unduly disturbed by shock, and provision had to be made for damping by fluid friction the oscillations of the bowl if they occurred. Lastly, a most beautiful method of correcting the compass, without taking a sight, was discovered. In every detailed improvement one can detect that the inventing mind was that of a most able and trained mathematician.

An essential of safe navigation is an efficient system of lighthouses. The optical problem of the lighthouse engineer is to construct apparatus which shall usefully direct all the light produced. The present forms of apparatus are in their leading features due to Fresnel, the able mathematician, who established on an absolutely firm foundation the undulatory theory of light. To properly design an optical apparatus formulæ must be used, and the advantage is great if the designer can with ease manufacture the formulæ he requires.

(To be concluded.)

ELECTRIC MINING MACHINERY.

Considering the protracted stoppage of the collieries last year, in the fruitless endeavour of the coalowners to enforce some reduction in wages, and the attitude taken by the Miners' Federation on the question of fixing a minimum rate of wage, which seems likely to result in further troublous times for the coal trade in the very near future, it would certainly seem strange, says a correspondent of the *Engineer*, that not more attention has been directed by colliery owners to the introduction of mechanical appliances for the getting of coal, not only as a question of economical production, but with a view of helping them out of the serious difficulties they have to encounter with the men. This question was raised in a Paper recently read before the Manchester Geological Society by Mr. Joseph Crankshaw, who described a pneumatic-electric coal-cutting machine, patented by Mr. Hurd, which is an improvement upon a similar machine which he introduced many years ago. The reader, in the course of his Paper, said that not only for the sake of economy, but in the cause of humanity, it was a reflection on the enterprise of Lancashire that there was not a single coal-cutting machine at work to-day in the Manchester district. In the discussion which followed upon the reading of the Paper, Mr. Hurd, the inventor of the machine, remarked that although they had numerous inquiries from abroad, and from such long distances as India and China, the home demand for these machines was practically *nil*. This, he thought, was an extraordinary state of things, as the saving to be effected by such mechanical appliances in the getting of coal was incredible. He had no hesitation in saying that by the use of these machines they could effect a saving of from 1s. to 3s. per ton on the total cost of production, according to circumstances. Mr. W. Saint, Government Inspector of Mines, the president of the Society, remarked that the machine seemed to be adapted more particularly for a long wall, whilst in Lancashire the system of working was mostly pillar and stall. Mr. Cockson remarked that the reason why coal-cutting machines had not been more largely adopted in the collieries throughout Lancashire was not that there was any prejudice against them, or unwillingness on the part of the coalowners to adopt mechanical appliances, but simply because the inventive engineers had not produced machines to work successfully with the bad roofs they had in most of the mines. Mr. Hurd replied that these machines were especially adapted for bad roofs, owing to the speed with which they got through the work, as compared with hand labour, which rendered the risk of roof falls very much less. Mr. Dickenson referred to a coal-cutting machine working successfully in the Normanton district, which had enabled the proprietors of the colliery to effect a saving in the getting of coal of fully 6d. per ton. It was strange, he added, that Lancashire should be so deficient in coal-cutting machines; they had, however, been tried in different collieries, but had been given up. Mr. W. Saint, in closing the discussion, agreed with Mr. Hurd that the rapidity with which the cutting was done by this machine might greatly tend to lessen the risk of falls of roof, and their introduction might be the means of preventing a large number of accidents which at present occurred in working places from this cause.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

TO-DAY) FRIDAY, May 11th.

PHYSICAL SOCIETY.

5 p.m. The following Papers will be read:—(1) "Electromagnetic Induction in Plane Cylindrical and Spherical Current Sheets," by G. H. Bryan, M.A. (2) "Dielectrics," by R. Appleyard.

SATURDAY, May 12th.

ROYAL INSTITUTION.

3 p.m. Tyndall Lecture: "Colour Vision," by Capt. Abney, F.R.S.

TUESDAY, May 15th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "Rubies: their Nature, Origin, and Metamorphoses," by Prof. J. W. Judd, F.R.S.

WEDNESDAY, May 16th.

ROYAL METEOROLOGICAL SOCIETY.

8 p.m. Ordinary Meeting at 25, Great George-street.

ROYAL MICROSCOPICAL SOCIETY.

8 p.m. Ordinary Meeting at 20, Hanover-square, W.

THURSDAY, May 17th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "The Solid and Liquid States of Matter," by Prof. Dewar, F.R.S.

FRIDAY, May 18th.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Students' Meeting at 28, Victoria-street. The following Paper will be read:—"Notes on Gas-Engines," by P. W. Paget.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "The Splash of a Drop and allied Phenomena," by Prof. A. M. Worthington, F.R.S.

SATURDAY, May 19th.

ROYAL INSTITUTION.

3 p.m. Tyndall Lecture: "Colour Vision," by Capt. Abney, F.R.S.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

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SPECIAL NOTICE.

Last week's number of "THE ELECTRICIAN" commenced Vol. XXXIII. and contained (Gratis) the Index to Volume XXXII.

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THE RELATION OF CAMBRIDGE MATHEMATICS TO ENGINEERING.

The "James Forrest" lecture, the first portion of which is printed in our present issue, is worthy alike of the occasion, of the subject, and of the author. In venturing, however, to criticise, and even to disagree with parts of this Address, we say once for all, lest our remarks may be misunderstood, that we neither underrate the value of mathematics nor the acquirements of Dr. HOPKINSON. Dr. HOPKINSON treats, not of mathematics, but as we have indicated in the title of this article—of Cambridge mathematics. Many times in these columns have we pleaded for the development of geometry and of graphics, and have commented on misplaced algebraical work; but we have never before had occasion to distinctly protest against the assumption that one branch of mathematics is of supreme importance. In the fourth paragraph of the Address a more liberal view is suggested, but it is not followed up, and the question it asks is not answered. "The question is not whether mathematics is necessary to an adequate comprehension of the subject, but whether analytical or purely geometrical methods are more convenient." The expression "analytical" is sometimes used for algebraical as distinguished from geometrical mathematics; whether it is so used here or no is not quite clear. In the last paragraph but three of the Address, "analytical" is used in an entirely different sense, and we shall therefore adopt the expression "algebraical" on the present occasion. The school of mathematics of which Dr. HOPKINSON is a representative

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is by no means to be despised. Pure science and much applied science would be at a standstill without it. The idea of Lord RAYLEIGH lecturing before the Royal Society on the relation of algebraical mathematics to physical science is all but ridiculous. The two things are nearly identical from the point of view of that distinguished physicist. The mere fact that MAXWELL in 1869 gave to engineers the graphic stress diagram for girders and appended certain diagrams to the end of his "Electricity and Magnetism," is almost sufficient to exclude him from the Cambridge School of mathematicians. This is the sort of mathematics which engineers can thoroughly appreciate and profitably use. Had MAXWELL lived, we do not doubt but that he would have bestowed other similar gifts; but Cambridge has not lifted a finger in this direction. Cambridge mathematics is the result of a vicious circle to which we have alluded on a previous occasion: school-boy, scholarship, wrangler, school-master. Another smaller circle, whose viciousness is inversely as its diameter, touches this wide one, and is: examinee wrangler, examiner. Few schoolmasters care to teach that which will not "pay" at the Universities, and where mathematics is concerned, the question is, what will pay at Cambridge? It is possible, however, that the question does not even arise, if the schoolmaster is a Cambridge man, and knows nothing and cares for nothing but the high and dry pure mathematics that he read at Cambridge. At Oxford, thanks mainly to the influence of that eminent geometrician, the late Prof. HENRY J. SMITH, graphics are better appreciated, and the great work of LUDOVICI CREMONA is duly recognised.

The first examples given by Dr. HOPKINSON are the strength and stability of struts and of revolving shafts, and he concludes "I do not know that either of these two question can be properly understood without some knowledge of differential equations." We are very sorry that this is so; it ought not to be the case. After alluding to one or two cases in which ST. VENANT pushed COULOMB's theory further than was admitted by the conditions, Dr. HOPKINSON confesses that "any practical man would at once see that the outer parts of the flanges would add little to the strength of the girder, but according to the usual mathematical theory, &c., &c. . . . This problem ST. VENANT also deals with in a rigid mathematical manner." We are not going to sing the praises of the practical man, still less to decry mathematics, nor even to blame ST. VENANT, but we quite agree with Dr. HOPKINSON that it is easy for anyone who attempts to apply mathematics without adequate mathematical knowledge to be misled; and this, we venture to think, is largely due to the liability of certain kinds of mathematics to mislead. With reference to harmonic vibrations, he says, "The mathematical theory tells us much more than any general explanation can do . . . and the beauty of it is that the mathematical theory is much the same in all cases, so that having learned to deal with one case, we are enlightened as to a host of others, ... it is all one to the mathematician, the treatment is substantially the same." Higher mathematics, indeed, deserves its name on this account, but we maintain that geometry, even in its present undeveloped state, has some claims to general application. That very FOURIER's theorem which Dr. HOPKINSON contemplates above as the key to harmonic vibrations, and much beside, can be set forth perfectly by graphic construction. Nay, the whole existence of that exquisite machine, the harmonic analyser, which will enable an ordinary skilled draughtsman to solve, in a few minutes, problems which not even Dr. HOPKINSON could without it solve in as many hours, is based on geometric properties, not on their merely algebraic expression. It is not too much to say that he who has learned FOURIER's theorem, from its mere algebraic representation as a trigonometrical series, without regard to its true geometrical significance, has not even begun to understand its real essence. Clock-face diagrams in alternate-current work, and Zeuner diagrams in steam-engine work, are examples of very valuable applications of pure geometrical mathematics to problems which become highly complicated if translated into algebraical language. We believe that both of these diagrams have a high degree of generality, to use a favourite mathematical phrase. "It is not possible," says Dr. HOPKINSON, "to leave the subject of the mariner's compass, without referring to the great improvements of Lord KELVIN. The improvements relate to every part of the instrument, and I venture to say that none of them could have been made by anyone but a mathematician. . . . . In every detailed improvement one can detect that the inventing mind was that of a most able and trained mathematician." Here we have to differ entirely from Dr. HOPKINSON: if we may be allowed without offence to say so, we venture to say that this statement could not have been made by anyone but a mathematician. We should say, on the other hand, that one can detect that the inventing was that of a good seaman and competent navigator, an experienced instrument maker, a practical electrician, a man of mechanical instincts, and indeed an engineer, for Lord KELVIN is all this and more. Indeed, it is notorious that when, less than two years ago, Lord KELVIN brought an action against a Liverpool compass-maker for an alleged infringement, the defence which the Court held proved was that Lord KELVIN's improvement had been anticipated. And the anticipator was not a trained mathematician at all! We should be sorry to undertake a voyage in a vessel equipped only with a compass designed by a mathematician.

Passing to lighthouses, we learn "to properly design an optical apparatus, formulæ must be used." We again venture to disagree entirely. The data of this problem are certain angles and a refractive index. No very high degree of accuracy, as in a trigonometrical survey is useful, because the source of light is far from being a point. The required result is a drawing or a set of templates. Any such problem can be safely and expeditiously solved by pure geometry, either by graphic methods or with the assistance of suitable mechanism. Where drawing pen and drawing paper fail, needle and sheet metal, almost unknown owing to the undeveloped state of graphics, may be used. In Dr. HOPKINSON's next example he is good enough to resort to a diagram showing, as indeed nothing else can show it, the propagation of an electric disturbance in a submarine cable, or the transmission of heat through a plate. A portentous formula accompanies this example, and Dr. HOPKINSON dismisses the subject with:—"Here again it is difficult to see how the differential equation and its solution can be evaded." Here again we differ diametrically; and unhesitatingly assert that this result can be obtained by a tolerably simple geometrical construction. We have never seen it, we do not know that it has been done, but we have seen something resembling it sufficiently closely to say that Dr. HOPKINSON is welcome to the formula, that all praise is due to Lord KELVIN who solved the equation, but that a graphic construction will suffice well within the limit of practical measurement and observation. Of course, the graphic construction will not tell the mathematician or the physicist so much as a formula; but we are concerned here with a definite piece of design; the engineer, as an engineer, has no time for mathematical or physical investigations into scientific side questions. No hard-and-fast line can be drawn between problems which are

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suitable for geometrical treatment and those which can only be attacked by algebra. That by which the desired result can be most cheaply attained is the best one for the engineer. In estimating the cost of a calculation, not only the time but the value of the calculator as a tool must be considered. It may be cheaper to employ a draughtsman for three hours than a wrangler for three minutes. MAXWELL did not suggest that stress diagrams should altogether supersede the older methods of calculation. "In calculating the stresses of frames," he wrote in the Paper to which we have referred, "the graphic method is really useful, and is less liable to accidental errors than the trigonometrical calculation. In cases of continuous stress, however, the symbolical method of calculation is still the best, although, as I have endeavoured to show in this Paper, analytical methods may be explained, illustrated, and extended by considerations derived from the graphic method."

Dr. HOPKINSON's examples serve to weaken the case which he might have made out had he kept to generalities, and had he left his hearers in some doubt as to the kind of mathematics to which he was referring. The value of mathematical research to engineering science cannot be over-estimated, but this is not the theme of the lecture. It treats of mathematics as the good but not always faithful servant of the engineer. So far is geometry behind algebra to-day, that it is difficult to say that the former will ever become so powerful and general a branch of mathematics. Its present condition in this country is largely due to the neglect, and we would even say, the ignorance of geometry at Cambridge. Two or three men have written on graphic methods, chiefly of an apparently special character. Their generality will lie unsuspected, but we are convinced that it exists. "Engineers," says Dr. HOPKINSON, "have not added much that was new to mathematics." Dr. HOPKINSON himself, as an engineer, rather than a mathematician, gave us that invaluable diagram, which MARCEL DEPREZ afterwards called a "characteristic curve." Let the honour of this discovery atone for all the shortcomings which we have attributed to the Cambridge school of mathematics in its relation to engineering.

THE ELECTROLYSIS OF FUSED SALTS.

Mr. Claude Vautin read a Paper on this subject before the London Section of the Society of Chemical Industry on Monday last. The essential point of the processes which the author described is that a cathode of some heavy metal, *e.g.*, lead or tin, is used in a bath of the salt (generally a chloride) to be electrolysed. Thus, tin may be employed as the cathode in a vessel filled with fused potassium chloride, or lead in one containing sodium chloride. The course of the reaction caused by electrolysis is the same in all cases. The metal whose chloride is electrolysed appears at the fused metallic cathode, and forms an alloy, while the chlorine is given off at the anode (of retort carbon) dipping in the fused salt. In this way potassium-tin and sodium-lead can be readily prepared. The latter is, of course, of most commercial importance, as on its production a practicable process for the electrolytic manufacture of caustic soda and bleaching powder is based, the method being thereby put at once into rivalry with such wet processes for the decomposition of sodium chloride as are now being tentatively worked. The question of the best form of apparatus is not yet settled, though a trial plant is being erected near Manchester; but in all cases the type of apparatus will consist of a basic-lined electrolytic pot, covered to collect chlorine and externally fired to keep the salt in a state of fusion, and a decomposing vessel into which the sodium lead is run and treated with water or steam for the production of caustic soda. However the apparatus may differ, the reactions involved are identical, being given by the equations—

$$NaCl = Na + Cl,$$

the sodium being absorbed by the fused lead cathode; and,

$$Na + H_2O = NaOH + H,$$

caustic soda being produced and hydrogen given off. The function of the fused lead cathode is to collect and retain the sodium which would otherwise float upon the surface of the bath and volatilise or unite with the chlorine. The sodium-lead alloy, which is formed at the cathode, is a curious material, being remarkably brittle and oxidising with great rapidity. A clean fractured surface tarnishes immediately on exposure to air. The alloy can be prepared of various degrees of richness in sodium, its ease of oxidation naturally increasing with its content of the alkali metal. It can be kept under petroleum, but decomposes water with a speed dependent upon its content of sodium, the richer alloys reacting with almost explosive violence. The lead is not affected by this reaction, but is set free in a loose, spongy form, none, it is stated, going into solution. By regulating the admission of steam to the surface of the fused alloy, as it is proposed to do in the process of manufacture, no water in excess of that needed to form caustic soda need be used, and the fused caustic can be drawn direct off the surface of the fused lead (thus freed from sodium) in a marketable condition. The evaporation necessary for recovering caustic soda from electrolysed brine is therefore done away with and a saving effected. The absence of a diaphragm and the low resistance of the electrolyte also give the process tangible advantages over wet methods. The efficiency claimed as deduced from experiments recently made is 80 per cent., but no estimate of manufacturing cost has yet been given. Data on this most important point will be, presumably, forthcoming when the trial plant alluded to above is at work.

A high current density up to several hundred amperes per square foot can be adopted, and the minimum voltage at which the decomposition can be conducted is stated to be a little under two volts. In the discussion which followed the reading of the Paper, the upholders of wet processes for the electrolytic decomposition of common salt claimed an efficiency as high as 85 per cent., and insisted on the additional cost incurred by the need for salt in the solid form for the dry process in place of brine for the wet. Doubt was expressed as to the perfect freedom from lead of the caustic soda produced, a point of some moment. The conclusion was arrived at that whatever the relative merits of wet and dry electrolytic methods for the manufacture of alkali and bleach, the very worst electrolytic method was intrinsically farther in advance of the chemical processes at present in use than was any given electrolytic process better than its rivals of the same kind.

COST OF ELECTRICAL ENERGY.*

BY R. E. CROMPTON, M.INST.C.E., VICE-PRESIDENT.

(Concluded from page 11.)

When speaking of the differences which exist between the calculated consumption of fuel and water by the plant when tested under full load and that which is observed from the water and coal bills in the month's or year's working, I was at one time doubtful whether any single 24-hour test would include within it the observed losses; but during the past year, having made a large number of such 24-hour tests at our Chelmsford works, I have come to the conclusion that such 24-hour tests which follow a complete cycle of the working are a fairly trustworthy guide to the annual losses; and I cannot too highly recommend the practice of taking such tests, and of showing them graphically in the manner universally adopted by mechanical engineers, and shown by Prof. Kennedy in the discussion which followed on my Paper in 1891. Diagram VII. shows the way in which we plot a 24-hour test at Chelmsford, and this may be applied to any other works. Many of you will ask how I have been able to obtain the electrical work at the terminals of the dynamo in the case of the Chelmsford works, where we use alternating dynamos. My answer is, that it is only during the last few months that I have been able to do this; and it is owing to the extreme kindness

* Paper read before the Institution of Electrical Engineers, April 26th.

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of Prof. Fleming, and his unwearied attention in perfecting the Mengarini wattmeter for our purpose, that we have been able to obtain a daily record of the electrical energy generated by our alternating plant, as well as that generated by our direct plant. Diagram VIII. shows an enlarged diagram obtained from this wattmeter, and we have divided it up into known portions of the load from cards taken on other nights. We are able to separate the load in the town shops from the load in private houses owing to the fact that it is the custom at Chelmsford on Wednesday night to close all the shops, so that our load on that night consists entirely of the public lighting, which is an ascertained and invariable quantity, on which is superposed the lighting in the private houses only.

It will be interesting to many here to know that the circumstances under which we work at Chelmsford of supplying the light between certain hours has enabled us to greatly cut down the transformer loss, so that we have been able to show an efficiency of distribution reaching 76 per cent., which I believe is probably as high as has ever been reached with alternating plant; but if we were compelled to keep the supply up through the remainder of the 24 hours, I am afraid the state of affairs would be widely different. We are also aided by such a large part of our load being public lighting, which goes on throughout the entire hours of darkness in summer and in winter.

Fuel and Water.—Part III.

Effects of Distribution Efficiency.

I am obliged to introduce this question into this Paper, as there can be no doubt that the high consumption of fuel shown by certain works is partly due to low-distribution efficiency; but I do not propose to dwell on this highly important question, which merits a Paper to itself, besides being of a highly controversial character. I find that in few cases have the engineers of supply works had the pluck to face this important problem, and to ascertain and state boldly what distribution efficiency they have noted. In several cases, however, this has been done, so that I am able to make the Table VI. reasonably complete. From it you will see that the efficiency of distribution of direct systems, including meter losses, varies between 85 and 91½ per cent., whereas that of converted systems varies between 60 and 82 per cent.; the higher figure being only found where the system of switching transformers in and out of circuit is practised. In the very small loss of from 10 to 12 per cent. observed in the direct systems are included all those due to the accumulators, to the C^2R losses in the mains, to leakage, and to meters failing to register; and I do not think it is likely in the future we shall be able to improve much, if at all, on this distribution efficiency—in fact, we are assured by our American friends that it would pay us better to somewhat reduce this efficiency by putting less copper in our mains; but we consider that our English practice is right, as in order to get thoroughly steady lighting and good regulation it is necessary to work at this high efficiency, and at the present price of copper it can be easily shown that it pays to do so.

Stores, Water, Labour, and Superintendence.

Under the head of "Stores used in the Generating Works" are usually included water (which in London and many other towns has to be paid for), oil, grease, waste, packing, gauge glasses, and other materials which are from day to day used in the working of a supply works. The decrease in the stores item in several of the companies has been very noticeable during the last few years of working. In the case of the Kensington Court works of the Kensington Company, the stores have in some months reached as low a figure as 0·025d. per unit sold, and there is no doubt that even a lower figure will be reached as the output and load-factor improve. In this question of use of stores, the closed type of engine, such as those made by Messrs. Willans, Bumsted and Chandler, and Belliss, of Birmingham, compare most favourably with the open type of engines. During a visit paid to Vienna, two years ago, I was told by Mr. Melhuish, the engineer in charge of the Imperial Continental Gas Association, that the consumption of oil by an open-type compound engine which they had recently erected in that station was 16 times as great as the consumption of oil by a Willans engine of equal power, and I think that in many cases differences almost as great as this will be observed between the two types of engines. When it is considered that in the close type the only glands there are to pack are those of the governor gland and at the two ends of the crank shaft, whereas in a compound or triple open-type engine there are certainly not less than eight important glands to pack, and not less than 20 oiling points requiring separate attention, it will be seen how great the difference is. In the case of rope-driving sets there are in most cases three dynamo bearings to be oiled instead of the one bearing in the case of the direct-driven set, and the side strain on the bearings necessitates nearly a fivefold use of oil.

Table VII. gives the cost of stores in the same works as Table III., from which it will be seen that, whereas some of the works using direct-driven plant have already come within a measurable distance of the figure of 0·03 for water and petty stores, those using belt, or rope-driven sets are a very long way from it.

Table VII.—*Comparison of Stores, Wages, and Superintendence Costs.*

Works.	Distinguishing letter.	Stores and water.	Labour and superintendence	Description of plant.
Converted Alternating System.				
Newcastle & district	A	0·27	0·83	Steam turbine.
Leeds	B	0·21	1·37	Alternators, rope-driven
Bournemouth	C	0·27	1·24	" "
House-to-House ...	D	0·41	1·25	" "
Newcastle-on-Tyne.	E	0·163	0·72	" "
Metropolitan.........	F	0·24	0·75	Mixed system.
Eastbourne	G	0·14	1·4	Alternators, rope-driven
Exeter	H	...	...	" "
Average	...	0·24	1·19	
Mixed System.				
City of London	I	0·23	0·91	Mixed system, driving.
Chelmsford	J	0·16	0·94	" "
Converted Continuous				
Chelsea	K	0·34	0·77	Dynamos, driven direct.
Oxford	L	0·045	1·24	" rope-driven.
Direct System.				
Preston	M	0·45	1·35	Dynamos, driven direct by d'ble-acting engines
Liverpool	N	0·15	0·37	Dynamos, driven direct by s'ngle-acting engines
Birmingham	O	0·17	0·82	" "
Charing Cross and Strand	P	0·185	0·61	" "
Hove	Q	0·2	1·44	" "
St. James & Pall Mall	R	0·11	0·75	(1892) " "
Bradford	S	0·094	0·81	" "
Brighton	T	0·162	0·96	" "
Kensington	U	0·15	0·61	" "
Westminster...... ..	V	0·19	0·95	" "
Knightsbridge	W	0·17	0·60	
Average............	...	0·15	0·72	
Ideal works	N to Q, S to W	0·03	0·2	

Items 4 and 5, Wages and Superintendence in Works.

On Table VII. I also give these two items for all of the works, showing a somewhat slow progress towards my ideal figure of 0·2d. per unit. This table shows that the lowest figure yet reached is 0·38d. per unit; but, as this figure is very largely a question of output, it is certain that from the increase of output alone, and without the introduction of any refinements having for their object the reduction of the staff employed in the stations, the wages and superintendence charge may be easily brought down. It is evident, however, that this charge must be much higher in the case of belt or rope-driven machinery than is the case with direct driving, and Table VII. shows this to a very marked extent. There is every reason to believe that with direct-driving closed-type engines 1,000 kilowatts will demand the services of only one attendant, whereas it is doubtful whether with rope or belt-driven and open engines one man could attend properly to more than 600 kilowatts of plant. This, however, it only my opinion, as in neither case has the output of any existing works been sufficiently large to enable the attendants to have their time occupied in the most profitable manner; it is quite certain, however, that under present conditions the use of accumulator storage has a most important effect on reducing the cost of attendance. Whether this will be so in the future, when the all-night loads begin to be heavy, I am at present not able to say, but I hold a very strong opinion that a proper proportion of accumulator storage will even in large stations reduce the cost of attendance at least 30 per cent., and in smaller stations from 40 to 50 per cent.

Maintenance.

I have considered this part of the subject with considerable care. It is the one point on which existing opinions vary through very wide limits, and, as far as I can judge, opinions incline at present in what I believe to be an unsafe direction; that is to say, too much has been made of the extremely light cost of repairs of existing works during the few years that they have been running, and figures have been founded on this which I am afraid will turn out to be altogether illusory. In all other businesses the upkeep of boilers which require to be periodically fired up and cooled down, and which have to be heavily fired at times of maximum load, is put down at a figure varying from 5 to 10 per cent. on the original cost of the boilers. The upkeep of steam-engines

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when worked at a far easier rate than is usual in electric supply works is usually taken at from 3 to 5 per cent. on their first cost; whereas the published accounts show that nothing like these figures have hitherto been spent on, or put aside for, the maintenance of these parts of the plant. I do not think that any accurate estimates can be formed of the ultimate cost of maintaining electric generating and distributing plant, other than on a percentage basis such as I have introduced in both my previous Papers.

I have, therefore, prepared Table VIII. to show what has been my own experience in this matter. This Table gives the actual sum spent on the maintenance of various parts of the plant of the works of the Kensington and Knightsbridge Company during the last four years out of the seven years that this Company has been supplying electrical energy. I have given in the Table the original cost of each part of the plant, and have worked out the annual percentage cost which the maintenance bears to the original cost. As some of the steam engines and boilers of this Company have been at work seven years, and the bulk of the plant has been at work five years, sufficient time has elapsed for the maintenance cost to have settled down to the figure at which it is likely permanently to remain. As might be expected, the upkeep of the boilers and the accumulators has been more costly than that of any other portion of the plant, but in neither case is the amount as high as I expected it would be. The noticeable feature is the very small sum spent on the upkeep of the engines, of the dynamos, and of the mains.

TABLE VIII.—*Cost of Maintenance of Works for a Period of Four Years*—1890, 1891, 1892, 1893.

Description of plant.	Original cost.	Spent on maintenance in four years.	Per cent. per annum on cost.
	£	£	%
Buildings	16,598	429	0·65
Boilers	8,124	1,704	5·23
Engines	9,900	704	1·77
Dynamos	8,660	264	0·76
Other plant	12,868	968	1·9
Accumulators	15,115	1,968	3·25
Mains and services ...	65,167	952	0·36
Meters	6,549	628	2·5
Total	£142,981	£7,616	1·35%

The cost of upkeep of the engines is confined to the substitution of small parts as they wear by new parts supplied from store. It will be seen that the upkeep of the dynamos is almost *nil*; but I must direct particular attention to the small sum spent on the inspection and maintenance of the mains, as this vindicates my often-repeated assertions that a well designed and conducted bare-copper system must cost less to inspect and maintain than any system of continuously insulated cables. At any rate, the sum expended on mains, as shown in this Table, is an outside sum, as it includes many alteration items, which can hardly be considered as fair wear and tear, but rather in the nature of improvements, and thus chargeable to capital.

The maintenance sum spent by this Company has been sufficient to keep the plant in absolutely as good order as when it was first put down; and, as I have just said, in some cases has enabled improvements to be introduced which have been charged to revenue. This gives me hopes that future experience will not show any marked increase in these percentage rates, but rather the reverse; so that the ideal figure I have proposed of 0·4d. per unit, which on 5,000,000 units will yield the very respectable sum of £8,300 per annum, will be a sufficient sum to maintain the entire plant in perfect working order for ever.

I have now taken you through all the items of cost of an electrical supply works, and have endeavoured, as far as possible, to compare what has been done up to date with an ideal possible standard. Whether this standard be ever reached or no, I think it will serve the useful purpose of holding before you a goal which we may all strive to attain, and that without the necessity for bringing out any wonderful revolutions in our practice, or, in fact, doing anything but intelligently perfect and use our present appliances.

I hope my efforts in preparing this Paper will be appreciated by those to whom it is addressed. I personally have the warmest sympathy with, and admiration for, the work of the large number of young electrical engineers who are now scattered over the various supply works, and to whose efforts we are indebted for the very marked advance in economy that I have this evening brought before you. I sincerely hope and trust that the means I have adopted of circulating the Paper before the meeting will have given time to these works engineers to appreciate some of my points, so that we may have the advantage of having the important questions that I have raised, ventilated and discussed by those who are most competent to do it, namely, the resident engineers of electrical supply works.

In conclusion, the art of electrical supply has now passed from the stage of estimate and talk into that of commercial enterprise. What is to be learnt from the tabulated results of commercial enterprise I have endeavoured to bring before you with the main object of showing what are the possibilities of cheapening electrical supply in the immediate future, as I feel strongly that if we electrical engineers are to play our part in making this an electrical age, the electrical supply must be so carried on that the poorest can avail themselves of it as well as their richer neighbours. Once this is done, many of the problems of electrical supply will be simplified. I think most engineers will agree that it is a far easier and more satisfactory matter to supply electricity to small consumers than to large ones, and it is certain that when electrical supply can be extended to small tenements it will have a very powerful influence in increasing the material comfort of the poor. In fact, I may say that until electric supply becomes general I consider we have only touched the fringe of our task. I say this because I think it quite possible that some of my critics will divert the discussion into side issues. I hope I have made it clear, however, that it is only in a careful study of the wider problems connected with the economical use of fuel, economical use of steam, and economy in maintenance that such future cheapening is to be looked for.

I cannot conclude this Paper without expressing my thanks to the very large number of gentlemen who have assisted me in my labours. In order to get together the data necessary for the production of this Paper, I have had to visit a number of stations, and write a large number of letters to the engineers of stations which I could not visit. As it may be the wish of many of these gentlemen to preserve their anonymity, I do not thank them by name. As regards stations with which I personally am closely connected, the importance of anonymity is not so great, and I have therefore the pleasure of stating that much of the splendid results that have been obtained from some of my own stations—the figures of which, no doubt, some of you have recognised in the Tables before you this evening—are due to the continued hard and intelligent work of Mr. Miller, the resident engineer at Kensington, Mr. Barley, the resident engineer at Knightsbridge, and Mr. Pott, the resident engineer at Chelmsford.

PROF. A. B. W. KENNEDY'S PRESIDENTIAL ADDRESS TO THE INSTITUTION OF MECHANICAL ENGINEERS.

(Concluded from page 15.)

Those questions about the running of a lighting station which are essentially matters of mechanical engineering group themselves mainly in three sections, according as they relate to (1) security, (2) efficiency of regulation, and (3) economy of working. It is obvious that the fundamental question of the choice of an electrical system in any particular case connects itself with all three, but this fundamental question I do not propose to discuss here, partly because it is not a matter which can be discussed in a few words, and partly because it is to so very large an extent an electrical matter that it does not fall well within the scope of my present address.

Of the three points I have put security first, because no doubt the absolute certainty that nothing short of a boiler explosion or of the burning down of a station shall stop the supply of current is really the very first condition of supply. Clearly with any machinery the burning of an armature, the seizing of a bearing, or the breaking of a shaft, are possibilities which may have to be faced at any moment. They seldom occur—very seldom happily—but sooner or later one or other will come about, and the engineer in charge has to be provided with means for preventing any such accident having more than the most transient effect on his light. Of course, the existence of proper reserve plant, such as I have already mentioned, is the first necessity of the case. Scarcely less important, however, is the necessity that such reserve should be almost instantly available. Where all the plant is running in parallel, *i.e.*, where all the dynamos or alternators are working straight through the same pair of omnibus bars on the switchboard, it will very often happen that the other machines which are at work may of themselves be able, at least for a few minutes, to take up the load of the one which has broken down, and so to allow time for another machine to get started. It may quite well happen, however, that these machines may be themselves running very nearly at full load, and that the broken-down machine may have had so large a load upon it that this is impossible. In any case a large machine, say 400-H.P. or more, cannot be started and got on circuit in a few seconds, and seconds are of importance in these cases. For this reason, in stations which use alternating currents it is usual, and

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probably necessary, to have one reserve machine always warmed up and running round at half speed, so that it is merely a matter of opening a stop valve to let it away in a condition ready for putting on circuit, although the synchronising-in is unfortunately always a matter which may cause some minutes' delay. In continuous current stations it frequently happens that a battery is used which can give so high a discharge for four or five minutes as to take the place—along with the machines remaining on circuit—of the machine which has given way, until another machine has been started and put on. So far as it goes, this is, no doubt, a great advantage, but it must be remembered that the mere existence of a battery, and even of a battery quite sufficient for helping in day and night light loads, is not sufficient to ensure that the battery shall be available for help in this fashion. Two details are easily seen to be essential when it is remembered that the failure may occur during the hours of full load. As the volts are highest at such a time, the battery must not only have sufficient capacity, but also must have a sufficient number of cells to give in discharge the full E.M.F. of the station, and this will not be the case unless the engineer has specially provided for it by an unusually ample number of cells. Secondly, the battery must have been fully charged beforehand so as to have the maximum E.M.F. per cell available. This involves that the battery charge should have been completed during the day, before the hour at which full volts could possibly be required from it in case of any accident. A battery which could only discharge heavily at 215 volts would be practically no use whatever as security against a drop of pressure after an accident which might possibly occur at 230 volts.

In an alternating current station where the machines are not run in parallel, but where each alternator supplies current to its own separate circuit or bunch of circuits, the sudden failure of a machine must instantly cause extinction of light in the circuit affected for the fraction of a minute which must elapse before the circuit can be thrown on to other machines, or the few minutes which it must take to get another engine started and plugged on. In a station worked on this plan however, the machine which is turning round as stand-by can be kept excited, and giving the volts corresponding to its speed, and can be plugged on in readiness, so that the circuit from any machine which has broken down can be instantaneously switched on to it, and it can be run up at once to full E.M.F. without, of course, any of the delay which would be unavoidable if it had to be synchronised and put in parallel. It has also to be borne in mind that in cases where a number of alternators are running in parallel the breakdown of one may tend directly, in certain cases, to endanger all the others—a trouble which does not exist if circuiting be used. On the other hand, the circuiting system causes inevitable, if slight, flickers in the light, which are quite avoided by running in parallel. It also necessitates the use of comparatively numerous circuits, as no one can be allowed to carry more than from 30 to 50 kilowatts at a time when it is switched on or off.

It must be recognised that in one matter the requirements of security and of economy are more or less opposed. If an engineer is quite certain that whether by the help of batteries or otherwise he can bring his reserve into action so promptly that the worst breakdown will not spoil his lighting, he will no doubt always run each unit of his plant as nearly at its full capacity as possible. But if for any reason he cannot be so sure of his reserve, he will gain greatly in security by running his plant always so far under its maximum that he can distribute the load of any one unit for a few minutes over the others without endangering them. But, of course, this is practically equivalent to underrating the whole capacity of the plant by a considerable percentage, probably 20 per cent., and consequently of increasing the capital cost of the plant per unit of normal maximum output by just the same percentage—a result which one does not wish to face.

I have spoken of possible breakdown of engines or dynamos. There are, of course, other accidents to be provided against. Short of a boiler explosion, the most serious of such accidents would doubtless be one occurring to a steam-pipe. The physical consequences of the actual bursting of a steam-pipe are not of course, the matters at present under consideration. In all probability such an accident would disorganise any station, no matter how well arranged. But short of the actual bursting of a pipe many things may happen which may render it necessary to shut down a certain portion of piping. It is generally necessary, therefore, to provide any lighting station with something in the nature of a ring-main system, or its equivalent, by which any engine in the station can be supplied with steam from two directions. In a properly arranged ring-main system it should be possible to disconnect or cut out of use any section of steam-pipe which may be giving trouble without stoppidg a single engine. Of course, it is not necessary to provide pipes so large that under these conditions there should only be the normal drop of pressure between boilers and engines. One can put up with an extra drop without grumbling if it only occurs under these circumstances. It is inevitable, to reach the required degree of security in this matter, that the steam-pipe should be fitted with a very large number of valves, and these are undoubtedly objectionable if only on account of the very considerable loss by radiation which is almost inevitable from their covers and flanges. But after all, the making of good steam joints in large pipes at 150lb. pressure is nowadays a very simple matter, and the unavoidable complexity of the arrangement is more than counterbalanced by its usefulness.

The duplication of the steam-pipes must obviously extend to the boilers as well as to the engines. The hanging up of a safety-valve, the blowing of a mudhole joint, the bursting of a tube, or any one of half-a-dozen other such accidents, may put a boiler suddenly *hors de combat*. It must be possible, therefore, at the shortest notice, to cut out any boiler without interfering with the working of the rest. Fortunately, boilers can be forced more readily than engines or dynamos, and such an accident could almost always be met by forcing the remaining boilers somewhat.

Reserve in boilers stands thus in the same position as reserve in machines, except in so far that the boilers can be more easily forced, as I have just pointed out. With them, however, as regards security of working, there comes in an even more difficult question than that of reserve, namely, that of readiness for emergencies other than breakdowns. Even in London, where a fog may cause the load on a station to increase ten times in as many minutes, there is practically no difficulty in getting the engines started quickly enough. It is otherwise with the boilers, which, although so easily forced when actually in work, are terribly sluggish in getting up steam, as compared with the rapidity with which unexpected darkness used to come over London, and doubtless will come over again when the sun has recovered from its present attempt to outshine all artificial lights. At the most inconvenient time for a breakdown, namely, the time of full load, the engineer knows at least that an engine or dynamo accident can hardly affect him to more than 15 or 20 per cent. of his whole work, of which at the worst a considerable portion can in most cases be taken up by the remaining plant. But the most inconvenient time for a fog to come on is at light load, and then the increase coming on in a few minutes may be anything from 500 to 1,000 per cent. ! And the engineer must be able to meet this in June as much as in December, and with even less notice. Practically this means that even in summer enough boilers must be kept under steam—if not at full pressure at something near it—to be able to take up this enormous increase of load in ten minutes, as soon as ever their fires are brought forward and their dampers opened. (I am speaking here of such cities as London, or Manchester, or Glasgow. Of course I know that there are happy places like Rome or Aberdeen where fogs are unknown, and where therefore all this provision against them is unnecessary.) I need hardly point out to you, after going over all these points, that it is improbable that the fuel consumption per indicated horse power-hour in electric light stations will ever reach, or can ever reach, anything like so low a figure as has often been reached in first-class steamers, where the engines and boilers work on continuously day and night at pretty much their most economical load.

I will mention just one more point as to security of working in a station—the feed arrangements. Here in London I have several times run considerable risk of stoppage from this cause. A duplication of feed pumps and pipes is an obvious precaution, and one that probably every one adopts. But few of us can keep water stored in sufficient quantity to last for more than three or four hours at full load, so that without special arrangements we are liable to be extremely inconvenienced by any accident happening to the mains of the water companies outside, which may compel them, on short notice or even no notice at all, to cut off the supply for a few hours. The best arrangements to meet this contingency vary in different places, but the engineer must not lose sight of the fact that the difficulty is one which may occur at any time, and from causes altogether beyond his control and even knowledge.

Outside the station the question of security comes in in connection with the mains. To a certain extent every station which uses either high or low tension feeders has some reserve in their very number. When a company has more than one station, trunk mains led from one to the other are also a considerable security, as well as a great help to economy. Mr. Frank Bailey, of the Metropolitan Electric Light Company, has carried out a most excellent ring or looped main system on his high tension distributors, by which he can make sure that any consumers can be supplied two different ways round the circuit, so that any accident to the mains may cause a minimum of inconvenience to a minimum number of consumers. In ordinary low-tension distributing networks, the same result should be aimed at, although it cannot generally be obtained in what the mathematicians would call so " elegant " a manner.

Many points occur in connection with the arrangement of electric mains which might be discussed in this connection, as to the means for isolating and testing them, the desirability of putting large sections into parallel or working them separately, &c., but these matters rather lie on the electrical than on the mechanical side of the subject, and I must abstain from discussing them here.

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I have next to speak of the *regulation* of an electric lighting station, as forming along with its *security* the two matters which chiefly affect the consumer of electrical energy. All that the consumer cares about is that the pressure in his house should be steady to the eye, and should be not less than its nominal value and not very greatly above it. In all stations working on a large scale this constancy of pressure in the consumers' houses necessitates a constantly varying pressure at the station in order to make up for the loss of pressure in the mains, which is itself—wholly or in part, according to the system of supply—dependent on the amount of current passing through them. In an ordinary alternating current station the pressure at times of maximum load exceeds that at times of minimum load by about 5 or 6 per cent. In an alternating current station with low tension distributors the excess may be about 12 or 15 per cent. In an ordinary low tension station with three-wire system it may often be 20 per cent. The actual figure of course depends on the current density permitted in the copper, but the figures I have given illustrate the sort of percentage which different engineers have found it advantageous to adopt on a large scale.

The primary requisite for proper regulation is obviously enough that the engineer shall know the actual value at each instant of the pressure which he desires to keep steady. In every case where low tension distributing mains are used this pressure is the pressure at certain feeding points or at certain sub-stations, and it is best known at the central station by direct indication—bringing back pilot wires or potential leads from such points direct to the station, and connecting them to suitable voltmeters there. In these cases the regulation consists in so running the machines that the pressure indicated by these voltmeters is always kept at the desired amount. What appears to me a less satisfactory method is sometimes adopted, namely, the determination by calculation or by experiment of the loss of pressure corresponding to each output, adding this loss to the normal pressure, and regulating the dynamos to the corresponding sum, transformed if necessary. Apart from the fact that in this case the pressure actually received by the consumer is only estimated and not really measured, so that the thing measured is not the really important quantity, there is the additional drawback that the regulation is to a varying quantity instead of to a constant one, and is therefore less likely to be thoroughly satisfactory.

In cases where distribution is by high tension with isolated transformers, there is, of course, no direct means for keeping the pressure constant in the consumer's premises. If the distance between the nearest and the furthest consumer on any circuit is much less than the distance from the station to the nearest consumer, there may be a reasonably good regulation by the indirect means I have just described. In the case where the distance from the station to the nearest consumer is small in proportion to the distance from the nearest to the furthest, no such regulation is practically possible, and, in fact, in these cases the section of the copper must be made so large as to reduce the drop of pressure within negligible limits.

By one or other of the methods which I have mentioned, and preferably, no doubt, by the use of pilot lines, the engineer in the station knows to what pressure he is to work. In every case the station must work at a varying pressure, although in some instances the variation may not be great. The highest pressure must occur always at the times of greatest load. Several means are at the disposal of the engineer for varying this pressure. Best of all, I think, as being most convenient and most easily controlled, is the provision of sufficient additional resistance in the fields of the dynamos or exciters to enable the magnetic field to be altered by the mere moving of a switch having many contacts. Of course to a certain extent this method wastes energy; but the quantity so wasted is so very small in proportion to the whole that it is not too high a price to pay. The switches can be placed upon the switch gallery so that the whole of the regulation may be done by the man in charge there, and be quite removed from the actual control of the engine-drivers. In order that this method may be satisfactorily carried out, the engines must be so arranged that they can be run entirely upon their governors, the stop-valves being opened fully as soon as the machines have taken up any load. In this connection it is worth while noticing that for continuous-current machines constancy of speed—which is, of course, to be distinguished from steadiness of speed, quite a different matter —is not in itself in the least a thing to be insisted on. The governor must be so set as entirely to prevent the engine racing in the case of a sudden short circuit or other breakdown. But apart from this, an alteration of five per cent. or more is not a matter of the least moment. In fact, for practical purposes it is generally better that the governor should not be too finely set. Of course, it may quite well happen that in the case of any one engine it may have to run throughout nearly its whole range of power at the same electrical pressure. If, therefore, the governor is so arranged as to allow of a drop in speed at full load, the field resistance must be so proportioned that notwithstanding this drop it can either keep the pressure constant or allow it to be increased within the desired limits.

A much less satisfactory method of regulation is by means of the stop-valve—that is to say, by the engine-driver actually opening or closing his main steam-valve according to the pressure required. If this has to be done, each engine-driver must be able to see the pressure to which he has to regulate, and instead of regulation taking place by an easily moved switch in the hands of one man, it has to be carried out by the action of half a dozen stop-valves in the hands of, perhaps, as many different men. The enormous voltmeters which were made a few years ago, and, I believe, are still used in America in some places, having faces so large that they can be seen all over an engine-room, were designed in connection with this particular method of regulation. Regulation by field resistance was perhaps then not so well understood as it is now. At any rate there can be no doubt which method is the better on all practical grounds.

I have been speaking of efficiency of regulation so far as it affects or is affected by the gradual alterations of load such as are represented upon the diagrams on the wall. At times of full load this is practically the only matter of importance, because at such times any sudden increase or decrease of load are small proportionately to the whole load of the station. But in a station where the load every afternoon is, say, 1,000 kilowatts, it may quite well happen that in the early hours of the morning or during a bright forenoon the total load is little more than a hundredth part of this. In such a case the sudden throwing on or off of a motor without proper starting resistance, or even of a photographer's arc lamp under similar conditions, may increase or decrease the actual output by 20 or 30 per cent. or even more. Such variations are most often excessively sudden and of extremely short duration, so that they are particularly difficult to regulate for, and one must only be thankful that in the nature of things they can only occur at times when a little flickering of the light is not noticeable. In stations which are able to use batteries, there is no doubt that the battery acts practically the part of a flywheel in respect to these rapid variations.

I now come to my last section, namely, that of economy of working a station, still looking at the matter, of course, from the point of view of the mechanical engineer. Economy of working covers two sets of questions. There is first the reduction of direct cost of coal, oil, stores, water and maintenance per unit or per horse-power hour, and secondly, the obtaining of the greatest possible ratio between the net useful and the gross indicated horse-power. Taking these matters in their order, the question of coal naturally comes first. In an electric-light station the cost of coal averages not far from four-tenths of the total working expenses. While, however, this matter is so important a one, it is yet one on which so much has been said and written that it need not detain us long. There is no one type of boiler, at least I do not know of any, which is better than all others under the conditions of an elecric-light station. Indeed, I would go so far as to say that from the point of view of economy there are five or six types of boiler which with equally good stoking will yield equally good and in every respect first-class results. Of course any type of boiler may be badly arranged or badly proportioned, may be under-worked or over-worked, but if an engineer is not capable of so proportioning the boilers of whatever type he adopts as to give thoroughly good results, or of finding out whether his results can be improved, he had better at once take to some business which is less complicated than that of scheming an electric-light station. It may no doubt sometimes be necessary in order to get a specially large output out of a boiler to provide it with one of the thousand infallible nostrums for that purpose. So far as my own experience has gone however, I think that almost anything can be done with a really well-designed boiler, if only the engineer in charge knows how to handle his dampers and how to deal with his particular fuel under the conditions where coaxing is required. I have lately had some remarkable illustrations of the way in which a particular boiler could have its output increased 60 per cent. by the application of certain particular apparatus to it, and an exactly similar boiler could then, when the stoker had found out how to manage his fires, give exactly the same increase in output without any change being made in it whatever!

One thing which tells very much against the economy of an electric-light station in respect to its evaporation per pound of fuel is the extent to which, during all day in many places, fires must be kept alight and pressures up in boilers capable of giving 8 or 10 times the actual output, and the extent to which in all stations fuel must be expended in getting boilers ready for the heavy load which comes on only once in 24 hours. These stand-by losses are not, as one would think, losses which get less as the output of the station increases, for the proportion which the stand-by boilers will bear to the actually used boilers at any moment will be practically constant whatever the output of the station. I have found that the total stand-by losses can be reduced in some cases to under 8 per cent. of the total fuel. Below this I have not yet succeeded in coming,

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although I hope a lower ratio will be obtained in the future. I am afraid it is often considerably more than 10 per cent.

I believe that a far larger proportion of fuel waste in a station occurs through causes beyond the boilers than in the boilers themselves—that is to say, it is much more easy to get a good evaporation per pound of coal than a small consumption of water per indicated horse-power. Of the causes which contribute to this the first is undoubtedly the very great loss which occurs by condensation in the steam pipes, and by leakage through drains and other valves before ever the steam gets to the engines at all. This is probably much greater in proportion in an electric-light station than in most other places, because the requirements of security which I have already discussed necessitate the use of a very elaborate system of steam pipes, much more elaborate than is found in any other works. Not only does this system of steam pipes present a large radiating surface, and in various ways offer particular facilities for cooling the steam, but also the absolute necessity of keeping the pipes clear of water at at all times, so that any section of them can be used safely at a moment's notice, involves the use of drain-pipes and cocks. These necessary adjuncts to a system of steam-pipes, along with the apparatus which we call by courtesy steam-traps and use in connection with them, are a continual source of waste and annoyance to the engineer. The drain-cocks get left open, or if they are shut they leak themselves open, the steam-traps require more looking after than the whole of the rest of the machinery put together, and altogether the whole system of pipes, drains and traps, probably cost us in many cases 10 per cent. of our whole fuel. In some experiments which I recently had made I have found the proportion to be 8·8 per cent., and I have reason to think that it is often far greater. I know of no heroic remedy which can be applied to the matter. Probably we have not in general paid sufficient attention to the proper covering of the pipes, including their flanges and the flanges of the stop-valves. Certainly we have not somehow succeeded in obtaining steam-traps which will really work with any approach to permanent satisfaction under the trying conditions of every-day work. I hope that the use of superheated steam may be found very largely to reduce this particular cause of waste. Apart from this matter, I know no reason why any engine in an electric-light station should not work every day and every hour at exactly the economy which the same engine reached on special trials made at the same load under the strict conditions of a specification. I have, in fact, on many occasions compared the running of engines in this way with the running of the same machines at the same loads on their original tests. When I have subtracted the amount of steam used for the feed pumps, the difference was never greater than I have found to be covered by the condensation losses which I have mentioned. Of course, it it necessary to remember that engines working in a central station at very varying powers cannot be expected to give average results equal to those obtained at full power on trial. The results should be compared on the basis of tests at corresponding powers, and in order that this comparison may be carried out I always have a series of graduated tests made before taking over machinery.

After the cost of coal comes the cost of oil, water, and stores. These three items together cost in the average about one-fifth as much as the cost of coal alone. There is not much which can be said in circumstances like the present on the question of economy in this part of the expenditure, which really depends altogether on the good management of the engineer in charge. Such matters as the filtering and re-using of lubricants, and as the prevention of all needless waste of water, are obviously to be considered. It is, perhaps, generally sufficient for the engineer to find out the very lowest cost under these heads obtained in any other station, and to believe he can do a little better if only he tries hard enough. Cost of repairs and maintenance, still more than that of oil and stores, is one about which little can be formulated. There is no one type of engine or dynamo, so far as I know, that can be definitely said to be ahead of all others in respect of the fewness of its repairs. There are several types of machine which in the hands of careful engineers certainly give very good results, although it is somewhat difficult to compare the published figures under this head on account of the number of electrical stations which are still wholly or partially in the hands of their contractors, and in which, therefore, the full amount of repairs does not appear in the accounts.

I have mentioned that the economy of a station depends on two sets of considerations, namely, the actual quantity of fuel, stores, &c., per indicated horse-power hour; and, secondly, on the actual relation between the useful power and the gross power. It is obvious that it would be of no use to save 10 per cent. on the coal per indicated horse-power hour if that saving involved the use of machinery whose mechanical efficiency was 10 per cent. lower than it would otherwise be. This brings us face to face with the question which is always one of the most important to the engineer, namely, when he has got his horse-power in his engine as cheaply as possible, how to arrange so as to utilise the largest possible proportion of the horse-power thus obtained. The utilised horse-power is represented, in the case of an electric-light station, by the energy passing through consumers' meters and paid for by them. Between this useful horse-power and the indicated horse-power of the engine there comes first the loss in the engine itself, then the loss between the engine and dynamo, thirdly, the loss in the dynamo itself, and fourthly, all the losses between the terminals of the dynamo and the consumer's meter. As to loss in the engine itself, this does not appear to vary very much in different types of engines of first-class make. Approximately, it may be taken as about 10 per cent., sometimes a little less, of the full power of the engine, and as remaining very nearly constant at all powers as long as the speed is constant. Thus the mechanical efficiency of an engine which is 90 per cent. at full load, will be only about 80 per cent. at half load. The efficiency of a dynamo at full load is much higher, it may be as much as 95 per cent., and may be still 90 per cent., far below half load. Thus the ratio of electrical to indicated horse-power of a first-class steam-engine and dynamo may be 85 per cent. at full load, and something like 76 per cent. at half load. This assumes that the engine drives the dynamo direct, and that there is therefore no loss in transmission between them. I must confess that it remains a complete puzzle to me, a puzzle of which I have never found any solution, why engineers should wish, in addition to these practically unavoidable losses, to spend certainly 5 per cent., and on the average probably much more, of the whole of the power in their station in moving ropes or leather belts which have nothing whatever to do with the ultimate result, and which take up an enormous amount of space. The true solution of the matter really appears to me beyond all doubt to be either the use of quick running engines, as is so common in this country, or of slow running dynamos, as is so commonly the case on the Continent. I am, of course, here speaking of driving by steam-engines, not by gas-engines, in which latter case a number of other considerations come in.

As most steam-engines take practically the same power *per revolution* to drive themselves, it is obvious that at low powers an increase of mechanical efficiency will be obtained by running at a less speed than that used for full power. This, of course, requires a specially-arranged adjustable governor and a wide range of control in the field regulation. But I think it is worth doing in many cases.

The losses between the dynamo terminals and the consumers' lamps are, in a low-tension system, simply the losses in the leads. In a high-tension system they cover the losses, in general very much smaller, in the leads but also those in the transformers as well. This is not a place nor a time for entering on a discussion of the relative merits of high and low-tension systems—a matter which to anyone who is not a partisan of one or the other could certainly not be adequately discussed in any time short of the whole of that which has been occupied by this Paper. Moreover, I need hardly point out that the choice of a system cannot possibly rest upon any one single point, such as the relative magnitude of the losses from a single cause. At present, so far as the figures to which I have access go, it may be interesting to you if I mention that in the case of a low-tension system where the maximum proportion of loss in the feeders is allowed to reach 20 per cent. or thereabouts, the actual average loss of energy throughout the whole year amounts to about 10 per cent. This is, of course, entirely due to ohmic resistance of the feeders themselves and of the network. I have no statistics by which I can compare feeder losses only in an alternating-current system with the figure I have just mentioned, but so far as those figures go to which I have access apparently the total losses both in mains and transformers in a high-tension system are not less than 25 per cent. of the energy generated. It is probable, indeed I think it is certain, that this figure will be very considerably reduced in the cases where banked transformers are employed with low tension distributing mains. I hardly think, however, that it can be expected that the total losses will ever be so low as with a low-tension system.

I have already alluded to the extent to which the economy of a station is affected by the average load at which its units are run. To attain the greatest economy it is obviously advisable that the machines actually at work at any moment should all be as nearly as possible fully loaded. The extent to which this can be actually reached in practice is shown in Diagrams 5 and 6. In one of these cases it will be seen that the average load during 24 hours is 78 per cent. of the load which would have been reached if the same machines had run the same number of hours each at its full power. In the other case the percentage is 58. What this particular percentage may be always depends on the exact relations between the load and the size of the units, and therefore in any station may vary very greatly at different times of the year. It is, however, not at all as easy as has often been thought to make the load factor, to use the expression in the sense of the above ratio, very high. I find it difficult enough in many cases, even with the use of comparatively numerous units, to keep it up to an average even of 65 per cent. Of course, it has to be remembered that whether or not it is economical, the station engineer has to make certain that he has sufficient plant running to take up the work as

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it comes on. It is much the less of two evils that he should have every engine running every day half-an-hour before it is wanted, than that once a year he should be just too late with one or two of his machines. When the system of transformer sub-stations comes to be worked out practically a little more than it is at present, I believe that this load-factor problem will be found to be there even more troublesome than it is in the engine room, and that the capacity of the transformers which the engineer will consider it necessary

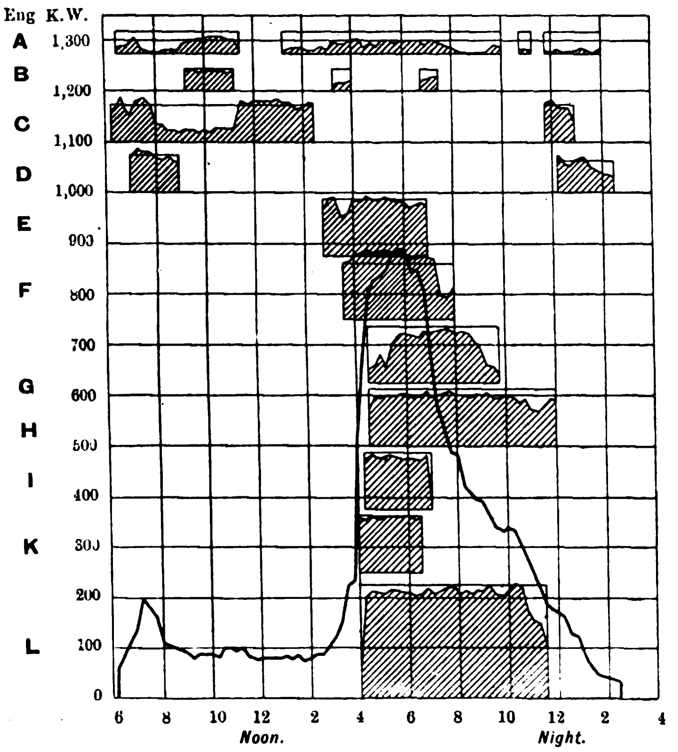

Fig. 5.—Diagram of Load Factors.

to keep on circuit in order that he may be always safe against breakdown of any of them, will be considerably greater than has been often assumed.

I would only, in conclusion, mention one other matter. The mechanical engineer may be supposed to be of all others one who will most naturally take to the making of measurements of all kinds. Any passion which he may have for this has ample scope in connection with electrical work. Electrical measurements, at least with continuous currents, can be made more easily, with simpler

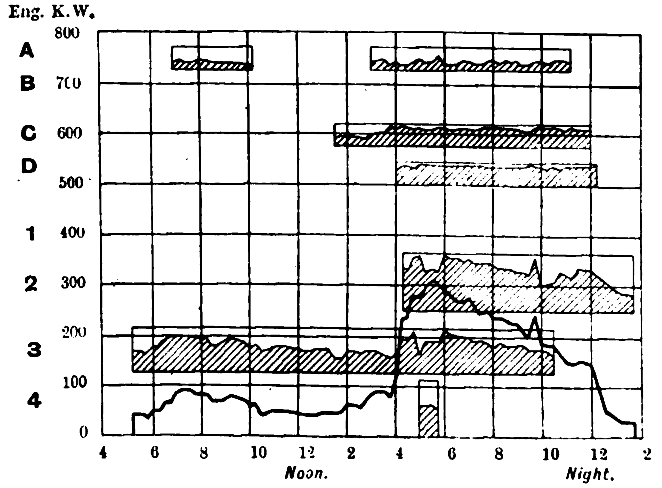

Fig. 6.—Diagram of Load Factors.

apparatus, and more accurately, than any other such measurements. I do not doubt that this fact has helped very much in the extremely rapid progress made during the last few years in matters electrical. Apart altogether from the more refined measurements which should be made from time to time for special purposes, there is no difficulty in getting continuous measurements, self-registered, with an average error of not more than 1 per cent., of the current sent out from each dynamo in a station. The average station volts can also be easily obtained with fair accuracy, and the amount of electrical energy developed at the dynamo terminals can thus be continuously measured as no other similar amount ever has been measured. This amount has to be compared with the amount of energy actually paid for, that is with the sum of the readings on the meters of consumers. Some of the electrical companies have published with their annual reports detailed electrical balance-sheets which show how very small the unaccounted-for quantity now is. In the case of the Westminster Electric Supply Corporation it was over 5 per cent. in 1891, 3·16 per cent. in 1892, and was still further reduced to 1·28 per cent. in 1893.

Unfortunately, with alternating currents, measurements are very much more difficult and troublesome, and, consciously or unconsciously, I think this fact has, to a certain extent, hindered their adoption. There are now, however, alternate-current wattmeters practically free from error due to circuit induction, and capable of giving results with quite sufficient accuracy under the actual conditions of station practice. I believe that very great improvements in the economy of alternate-current working will date in every case from the time when the station commences to make accurate determinations—based on something different from the engine-driver's hourly entries in a log—of the true energy generated and the way in which it has been expended.

I am sufficiently conscious of my own weaknesses to know that it is very dangerous for me to touch on the subject of measurements, especially at the very end of an address which has extended to so great a length as this. I will not, however, yield to the temptation, but will be content with simply having mentioned the matter. And in conclusion I will only say further that I hope the active electrical engineers among our members will forgive me for having spent an hour on such a very plain statement of matters familiar to them, if I have by this means been able to place before our non-electrical members some intelligible account of the problems at which we are working, looked at from their own point of view.

THE GLASGOW CORPORATION ELECTRIC SUPPLY.

The following is an abstract of the two evenings' discussion which took place on Mr. W. Arnot's Paper on the Glasgow Municipal Supply, which we published in our issue of April 27th :—

The PRESIDENT said it was rather difficult to discuss this Paper adequately, bristling as it was with figures, but he hoped that some of the electrical experts present would start the discussion. The mention of Prof. Kennedy's name as consulting engineer to the Corporation Electric Lighting reminded him that the University of Glasgow had seen fit to confer upon him the degree of Doctor of Laws. He was one of their honorary members, and he thought it showed the discrimination with which their honorary members were selected.

Mr. H. A. MAVOR said that although he considered the system adopted by the Corporation unsuitable for the work to be accomplished, he wished to compliment Mr. Arnot on the successful starting and working of the Glasgow station. He thought it would be evident to all engineers present that there was something wrong when the Glasgow Corporation, having undertaken to light not only the compulsory area (which is really all they had been compelled to consider up to this time), but the whole Royal Burgh of Glasgow, already in their first winter, had nine separate engines running in the station. Not only that, but the station, as at present constituted, could not be very much increased in size. The answer to that was, that another one would be started, and that it was better not to have too many eggs in one basket. Various other reasons which had a certain amount of cogency were pleaded in excuse. There was a limit to the size of stations, it was true, but there was also a limit to the possibility of starting electrical factories all over a city like Glasgow, and it seemed reasonable to suppose that in lighting such a city as Glasgow they should look to the experience of gas distribution as a guide to what they might do with electricity. He contended that there should be as many stations for electric lighting as gas works at present, because the problem was the same. He hoped at next meeting to bring forward some considerations which might interest the Institution with regard to some of the points Mr. Arnot had mentioned, especially with respect to the load curves and to the efficiency of the engines. It would be evident to anyone who looked at those curves that to use steam-engines, or any other source of power, for the production of electric lighting was not an economical thing to do. Most of the time they were standing idle and doing nothing. That was a kind of industry which was not a paying one, and therefore strenuous efforts had been made to find some means of storing the work of the engines so as to apply it to the circuit when the load curves reached that very high peak which occurred during the greater part of the winter between five and six o'clock in the evening. The attempt to do that had been so far unsuccessful. The use of accumulators was indicated in that diagram, and they would see how very small a part they played in the operation of the station. It was totally insignificant as compared with the work done by the engines, and, although they were useful in their way, he thought that on the whole the practice adopted in America would be followed in this country, and that batteries would not be used in lighting stations. There were some other points that he would beg respectfully to differ with Prof. Kennedy upon in his arrangement of the switchboard.

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It seemed to him that his arrangements of the switchboard were very complicated—it seemed to him to be partly owing to the use of batteries, which led to more complication than was warranted by their use in working. Perhaps Mr. Arnot would be good enough to say what was the maximum loss in the feeders. He mentioned that under certain circumstances it was 25 volts or 12½ per cent., or thereby. Now, that was another matter which meant a considerable amount of complication on the switchboard. If there was a loss of 12½ per cent. between the generating plant and the most distant part of the system, that loss had got to be compensated for in the engine-room, and as the loss varied with the load the compensation would vary, and that necessitated constant watchfulness on the part of the attendant, and was one of the reasons why the continuous system was more difficult to work than the alternating current system.

Prof. JAMIESON said he did not agree with Mr. Mavor on many points, and especially that part where he said that they should have great big engines working at one big centre. He believed rather in using comparatively small engines, and consequently in being able to put in or take out power as the public demanded the same.

The discussion was then adjourned till next meeting, Tuesday, April 24th, when Mr. WILLIAM McWHIRTER, Faraday Works, Govan, who had moved the adjournment at the previous meeting, said the Paper had thrown a great amount of light on the Glasgow electric lighting installation, but it was just sufficient to cause those who had been able to follow it, or had since read it to desire more light. Still, there was time enough to remedy that in the reply on the discussion. He was satisfied that the right system had been adopted, but he could not for the life of him see why such an absurd voltage as 200 had been adopted. No one had been able to tell him why, but, perhaps, Mr. Arnot would do so. It would certainly have been much better to have adopted 220 or 230 volts. There would then have been a gain of 10 or 12 per cent. in the distribution of current, as also a very great gain in the working of the arc lamps. On the question of efficiency he had no doubt that the Glasgow installation showed a combined efficiency between the engine and the dynamo of 88 per cent. commercial, and 17·5 of water per horse-power, which, he thought, was all that one could desire. He did not think that, if they had adopted the alternating system there would have been got an efficiency exceeding 66 per cent., or something like that. There was thus a clear gain of 20 per cent. conversion, and there might be, as was said by Mr. Mavor at the previous meeting, a considerable loss in the distribution as compared with the alternating system. Coming to the question of accumulators, he could not say that he was at all in love with them in their present capacity in Glasgow. They were only able to carry on the lighting for a very short portion of the 24 hours. He did not know what the cost of the cells was, but it was probably something like £2,000; and he reckoned that the cost of maintenance would be at least 13 per cent.; indeed, it was nearer 30 per cent. That was something like £260. If they took that figure, he was quite certain that it would do more than fill up the interval over which the accumulators carried on the lighting. Then there was another thing to add. They would not get more than 85 per cent. efficiency from the accumulators, so that there was another 15 per cent. gone. After some remarks about faulty cells, the speaker went on to refer to the underground mains, regarding the insulation, of which he desired some information from Mr. Arnot. Speaking as a telegraph engineer, he remarked that he never saw in all his life such an attempt at insulation as there was in Glasgow; indeed, it was enough to make some old telegraphic engineers turn in their graves. He did not think that the resistance, as measured in megohms, exceeded three figures. Going on to calculate the loss, he was of opinion that it amounted to an ampere of current; and if that was going to waste it, meant 18 grammes of copper being removed from the positive conductor every hour, or about an ounce of copper every day. Whatever might be said of the other parts of the Glasgow electric light installation, the insulation of the underground mains was very far from what it might have been.

Mr. HENRY A. MAVOR said the first striking difficulty that appeared to him was what led the Corporation and their engineers to put down the station on the site which it occupied. All the coal had to be carted to the place, and there was no water available for the condensers. The ground was dear, and it was not by any means in the centre of the district which they were able to supply. By an arrangement which he suggested, he would have had four large engines and three balancing engines, or seven engines in all, making up a total of 3,000 H.P. In the Glasgow Corporation station, however, there were 13 engines, the biggest of which was one of 350 H.P., and the engine shop was more like a toy-shop. The load curve on December 26th, which was about the date of the heaviest curve of the year, between the 27th and 28th they would see how rapidly the load ran up from about one-fourth of the output of the station right up to the top inside of an hour. Could they imagine the trouble that was involved in the starting of no less than twelve engines between the top and the bottom of that load? It seemed to him a manifest absurdity. But he was like the man crying in the wilderness in hope that there was yet time to remedy the defect. There were still three engines of 350 H.P. each which it was proposed to lay down, and he hoped that the Corporation would be persuaded to put down as big an engine as the place would hold, and abandon that duplication of ridiculously small engines. Mr. Mavor further illustrated his position by reference to what he had seen in New York about four years ago, and the recommendations which he had made and had been successfully adopted. For such a station as that of Glasgow he considered that there was no necessity for having any engine smaller than 630 H.P., but as a concession to risk of breakdown he would put in one of 300 H.P. He estimated that the station had cost from £2,500 to £3,000 more than it would have cost if engines of the size which he spoke of had been put in. Further on he said that, looking to the large area still to be lighted, he thought it would only be fair to ask the Corporation to place the order with Clyde engineers, and ask them to make the next engines, and give them time to do the work.

Prof. JAMIESON gave his idea as to the extension of the Glasgow central station. He said he would place a suitable gas engine at each of the various points of the circumference of the system, and whenever the pressure lowered so as to indicate to the man at the station that the load was more than the central station could well develop and meet, then the men at any one or other of those points would each start up their gas engines in a few minutes; and for all the short time that it would take to do so those small plants and gas engines would meet the circumstances, and would have a very large extended area of electric lighting. He would have, in suitable positions, gas engines here, there, and everywhere all round the circumference or greatest radius from the central station, at which it could conveniently work, and convert that station very much on that plan.

Mr. SAM. MAVOR made a few remarks, which he chiefly devoted to the type of engine that had been adopted by the Corporation. Such engines had formerly been extensively adopted by the Admiralty for electric lighting; but for some years, he said, there had not been a single engine of that type ordered. He also had something to say with regard to the mains, and especially the insulation of each wire, serious fault having in some instances been found with the three-wire system, or with the mode of carrying it out.

Mr. ARNOT made a somewhat lengthy reply to the criticism to which his Paper and the Glasgow lighting system had been subjected. As regards the voltage adopted, he stated that when the Corporation took over the lighting then going on, there were already some 5,000 lights working at 100 volts, which they had to continue, otherwise a voltage of above 200 would have been adopted. There were no complaints coming to the station as to low voltage, but, if there were, inquiry would at once be made and the matter put right. He gave some further information as to the mode of working the feeder mains, and how the potential was kept up. No difficulty on that score had yet been met with, but if it did occur he had no doubt that they would be able to cope with it. Since reading his Paper, he had had some experiments made on a Sunday afternoon with some of the feeders, and he gave the results of the same, which were highly satisfactory. He admitted that, as suggested by Mr. Sam. Mavor, there was some difficulty with the negative wire, but they had not been troubled with leakage on their mains. He also said a word in favour of the engines employed in the station, and would not condemn them because elsewhere the crank shafts had broken from being too light.

PHYSICAL SOCIETY.

At a meeting of this Society, on April 27, 1894, Prof. A. W. RÜCKER, F.R.S., President, in the chair, a Paper

"On the Mechanism of Electrical Conduction:
Part I. Conduction in Metals,"

was read by C. V. BURTON, D.Sc. Considering a body not at absolute zero of temperature, the author shows that electromagnetic radiation would result in heat being degraded into a lower form of energy, if any parts of finite electric conductivity were present, and from the fact that our planet is not devoid of heat, deduces the following Theorem I.:—"In a region containing matter, there may be (and probably always are) some parts which are perfect insulators and some parts which are perfect conductors, but there can be no parts whose conductivity is finite unless every finitely conductive portion is enclosed by a perfectly conductive envelope." This conclusion is in accordance with Poisson's theory of dielectrics and with Ampère's and Weber's theories of Magnetism and Diamagnetism respectively. Theorem II. is enunciated as follows:—"In metals, and in other non-electrolytes whose conductivity is finite, the transmission of currents must be effected by the intermediate contact of perfectly conductive particles;" and as a corollary Theorem III. is given:—"If we suppose that in a substance at the absolute zero of temperature there is no relative motion amongst the molecules or amongst their appreciable parts, it follows that every substance at this temperature must have either infinite specific resistance (which does not imply infinite dielectric strength) or infinite conductivity." Fleming and Dewar's experiments on pure metals tend to confirm this. The author then shows why, on the intermittent contact hypothesis, a conductor is heated when a current flows through it. On the assumption that in ordinary conductors the relation between the electromotive intensity in the intermolecular spaces and electric displacement, is a linear one, and that the electric forces are small in comparison with the ordinary intermolecular forces, Ohm's law is deduced. A model is next described by means of which contact E.M.F. and the Peltier effect can be represented and explained, and in considering Volta E.M.F.'s the author points out that it is doubtful whether experiments in a perfect vacuum could decide the questions at issue in the contact-force controversy. The fact that the transparency of metals is much greater than Maxwell's theory indicates might be explained without attributing any new properties to the electromagnetic field by supposing the dimensions of molecule not quite negligible in comparison with the wave length of light.

Prof. S. P. THOMPSON thought the Paper had an important bearing on the kinetic theory of solids. He saw no reason why Ohm's law should be proved, for he regarded it as a definition.

The PRESIDENT said the author represented all actions as being due to collisions, thereby introducing the same difficulties as were felt in the

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kinetic theory of gases, viz., that collisions would give rise to mechanical oscillations in the molecules of shriller and shriller pitch. Prof. J. J. Thomson had recently given an explanation of electrical phenomena by vortex filaments.

After some remarks on the visibility of molecules by Mr. Hovenden, Dr. BURTON, in reply to Prof. Thompson, said Ohm's law when expressed as $\frac{E}{C} = a$ *constant*, was really a law and not a mere definition.

A communication

"On the Design and Winding Alternate-Current Electromagnets,"

by SILVANUS P. THOMPSON, D.Sc., F.R.S., and MILES WALKER was read by the former. The Paper describes experiments showing that when the magnetic induction does not exceed 4,000 (C.G.S.) the pull exerted by a laminated electromagnet on its armature is the same whether it be excited by a continuous or by an alternating current of equal strength. For higher inductions the continuous current gives slightly greater force. Another experiment, made with solenoids and the U-shaped plunger of a Brush alternate-current arc lamp, gave similar results. In considering the question of winding alternate-current electromagnets so as to obtain a given excitation when the current is supplied at constant voltage, it is shown that the ampere turns are inversely proportional to the number of turns, for the impedance varies nearly as the square of the number of turns. One important property of such alternate electromagnets, when supplied at constant voltage, is that they give a fairly constant pull over a long range, for as the armature moves away from the magnet the current increases, thus counteracting to some extent the effect of distance. On the other hand, the alternating voltage required to obtain a given force is much greater than that needed with continuous currents. With the armature in contact with the core the ratio of the two voltages was found to be 170, whilst separating them by 9·2mm. reduced the ratio to 21·5.

Prof. PERRY pointed out that the constant pull of the alternate-current magnet followed immediately from the fundamental equation $e = re + n\dot{I}$ when re is small, for if e be constant, then $\dot{I}$, and therefore I and I^2 are constant. He was interested to see that the pulls for equal ampere-turns were the same, and indicated how the problem could be worked out mathematically when hysteresis was taken into account.

Mr. BLAKESLEY thought it better to fill the space on a magnet full of copper rather than use wire only just large enough to carry the current, for the loss of energy would be reduced. Some of the formulæ given might be put in simpler form.

Mr. SWINBURNE said an alternate-current magnet would only give constant pull in special cases. As another rule for winding alternate-current magnets, he said, wind the magnets as for continuous currents, and put a condenser in to take the same current, thereby reducing the voltage required.

Mr. BLAKESLEY said it would require a capicity of 600 microfarads to suit the magnet mentioned in the Paper.

Dr. THOMPSON, in reply, agreed with Mr. Blakesley that the condenser was impracticable in many cases.

Major R. L. HIPPISLEY, R.E., read a Paper on

"A Graphical Method of Constructing the Curves of Current in Electro-magnets and Transformers,"

and exhibited a machine for drawing the curves. The method of drawing the current curves step by step was explained. The machine for performing the process is illustrated in the Paper, and the curve for an electromagnet fed with alternating current shown. The case of a transformer without magnetic leakage is worked out at some length, and the curves of primary and secondary current determined.

Dr. SUMPNER said the author had used great care in working out a difficult problem more completely than usual. In cases such as arise in practice the R i term is small, and for this case Evershed showed how to determine the current curves of a transformer when the periodic state had been reached, some five or six years ago. He (Dr. Sumpner) had also shown how to graphically determine the current curves for circuits containing iron in 1888. The author's method was, however, of more general application.

Mr. TROTTER inquired whether the machine could be used in practical alternate-current problems, say, for example, to predetermine the E.M.F. curve of an alternator.

Major HIPPISLEY replied to the points raised.

LONDON CHAMBER OF COMMERCE.

At a meeting of the Electrical Trades Section held on Friday last at Botolph House, Eastcheap, Mr. Percy Sellon in the chair, the Secretary announced that circulars had been sent to the members, relating to the Antwerp Exhibition, but that no interest appeared to be taken in the subject. The question of the Acts of Parliament relating to the use of locomotives upon common roads was discussed. The Secretary said that he had written to the Commissioner of Police upon the subject of electrically-propelled carriages, who replied that he had been advised by his legal adviser that such vehicles were locomotives under the Acts. Mr. Sidney Morse gave the meeting some information with regard to the Vict. 41 and 42, and said that in the Acts of 1861 it was stated that locomotives were "likely to become common upon turnpike roads." The only definition of a locomotive was "a locomotive means a locomotive propelled by steam or by other than animal power." Mr. Morse thought that a vehicle containing its own motive power was not included. When a locomotive was put upon a cart and drawn by animals it would be allowed upon common roads without the attendance of two drivers and a man walking in front with a red flag, and a restriction of speed to two miles an hour. In the course of the discussion, it was observed that a test case had been tried some years ago at Woolwich, in which it was decided, that a steam tricycle came under the definition of a locomotive. Several members thought an approach to the Board of Trade or an attempt to amend the Acts would be premature seeing that the experimental attempts to construct electric vehicles for use on common roads have been very few, and have not been, as yet, attended with any marked success. It was suggested, with reference to a test case, that those who were interested in the subject should, if they thought fit, make a test case. Major Flood Page then entered the room, and took the chair, and said that he thought that electric traction of this kind was likely to come on very soon. It was eventually decided to write a letter to the Board of Trade upon the subject.

CORRESPONDENCE.

GALVANOMETER SHUNTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The Paper by Prof. Ayrton and Mr. Mather, which was recently read before the Institution of Electrical Engineers, upon "A Universal Shunt-box for Galvanometers," contains, as reported in your columns, a slip which may be noticed. In paragraph (1), speaking as of ordinary shunts, the writers state that, if the resistance of a galvanometer be say 1,000 ohms, the shunts of 1-9th, 1-99th, and 1-999th must have exactly 111·10, 11·11, and 1·111 ohms resistance. The figures, of course, should be 111·11, 10·101, and 1·001 ohms, as apparently they have in mind in the concluding lines of the paragraph.—Yours, &c., H. W. SULLIVAN.

29, Ladbroke-square, W., May 8, 1894.

METHODS OF MEASURING SELF-INDUCTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. Alexander Russell, on page 5 of your last issue, describes certain methods of measuring self-induction, but does not mention to whom these methods are due. I therefore desire to state that the first method, in which the self-induction of a coil is compared with the capacity of a condenser, was first described by me, together with a number of other methods, in a Paper read before the Institution of Electrical Engineers on May 12, 1887. It has been found a most satisfactory method, and has been used by the students at the Central Technical College for the last seven years. The second method mentioned, in which alternating currents are used, has been known for a still longer time, and is due to M. Joubert.—Yours, &c,

May 8, 1894. W. E. SUMPNER.

PATENT AGENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your otherwise impartial article on Patent Agents you reflect somewhat unfairly on the backers of the Bill promoted by the Society of Patent Agents; and have been led astray, I fear, by the misleading article in *Engineering*, to argue in favour of the Institute's Bill. As one of the incorporators named in the first Bill, I can state that it was owing to the action of the Board of Trade and the Chartered Institute that we have been forced to come to Parliament at all, and you may feel assured that the gentlemen who backed our Bill had very strong grounds for doing so. As to the word "Act," to which you fairly take exception, you will find from the evidence we shall offer that it is an immaterial part of the Bill, the main object

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of Mr. Alban Gibbs's Bill being to enable the whole profession to govern itself, instead of by a few individuals, as has been done illegally hitherto.

You quote from the memorandum of Mr. Warmington's Bill the words that it is not intended to create a monopoly, with evident approval, and refer to its promoters as being naturally jealous of their royal charter. You, and many others, are evidently unaware that the charter is practically inoperative, as the bye-laws under the charter have not been allowed by the Privy Council, owing to the opposition of patent agents who are not members of the Institute; and a further search into the provisions of the Bill would show you that a new meaning has been given by the promoters to the word "monopoly." I am writing simply to suggest that it is possible that all the honest, capable and honourable men in the profession are not in the Institute, and have no wish to be there until a very great change has taken place, and that it is advisable to suspend judgment in the matter until the other side is heard.—Yours, &c., J. Sinclair Fairfax,

Vice-President Society of Patent Agents.

433, Strand, London, W.C., May 8, 1894.

THE PRELIMINARY EXAMINATION IN "ELECTRIC LIGHTING AND POWER DISTRIBUTION."

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Following is a copy of a letter addressed by me to Sir Philip Magnus relating to the way in which candidates in the above examination are to have the results made known to them. This, and the reply thereto, will, I venture to think, be of interest to both teachers and students.

There is little doubt that the number of candidates will rapidly increase year by year, and it is to be hoped that at some future time the Institute authorities may see fit to modify their decision.—Yours, &c , W. Perren Maycock, M.I.E E.

Croydon, May 9, 1894.

[Copy.]

26, Stafford-road, Croydon, May 5, 1894.

Sir Philip Magnus, Secretary Examinations Committee, City and Guilds of London Institute, Exhibition-road, South Kensington, S.W.

Dear Sir: With reference to the newly-instituted preliminary examination in "Electric Lighting and Power Distribution," may I ask in what manner the results will be made known to the students?

It has been a matter for surprise to others besides myself that your Committee should have decided not to give certificates for this examination; but if each successful candidate is to receive a note from the Institute recording his success, that would, in a measure, make up for the absence of a formal certificate. From several years' workshop experience, I know there are very few electrical artisans proper who can hope to pass beyond the preliminary grade of this subject. To this numerous class of workers some duly authenticated acknowledgment of their having passed the examination in question would often prove of considerable value. If you will clear up this point you will confer a great obligation on other teachers than myself, and on the students, to whom I beg leave to make known this correspondence through the medium of the Electrical Press.—I am, Sir, your obedient servant, W. Perren Maycock.

[Copy.]

City and Guilds of London Institute Examinations Department, Exhibition-road, London, S.W., May 7, 1894.

Dear Sir: I need scarcely point out that the question of granting Certificates on the result of the Preliminary Examination in Electric Lighting has been carefully considered by the several Committees of this Institute, and that the rule on the Programme is the result of much deliberation. A list of candidates who may have passed that examination will be forwarded as stated to each centre at which they were examined, and it will be left to the Local Secretary to inform each separate candidate of his success or failure.—I am, dear Sir, yours very truly, Philip Magnus.

The Qualifications of a Canadian Electric Tramcar Conductor.—In addition to the usual requirements of electric tramcar conductors or "motor-men," the Montreal Street Railway Company has recently issued instructions that such men must be of a minimum height of 5ft. 5in., and weight 10st. 10lb. They must, in addition, be able to speak both languages—presumably English and French—so as to be able to make a proper report of each day's journeys.

LEGAL INTELLIGENCE.

Aldin v. Latimer Clark, Muirhead and Co.

Mr. Justice Stirling recently delivered judgment in this case. The plaintiff was the lessee of certain premises at Richmond, Surrey, and by this action he sought to restrain the defendants, who were the owners of adjoining property, upon which they had erected works for the purpose of supplying the town with electric light, from violating in various ways his rights as lessee. The plaintiff derived his title from a Mr. Munro, who was also the predecessor in title of the defendant Company. On July 1, 1878, Munro granted the plaintiff a lease of the premises occupied by him, with the buildings thereon, for 21 years, with a right of way over a portion of the adjoining property. Under a subsequent agreement the plaintiff, with the consent of Munro, erected an additional building upon the property, Munro advancing a portion of the cost and the plaintiff agreeing to pay an additional rent in respect of the shed so erected. Munro remained in occupation of the adjoining property down to his death in 1892. After his death his devisees sold the whole of his property to the defendant Company, who proceeded to erect thereon their electric lighting works. The matters mainly complained of by the plaintiff were the following:—(1) Interference with the access of air to the drying sheds used in connection with his timber business; (2) interference with the right of way granted by the lease of July 1, 1878; (3) interference with certain ventilators in the plaintiff's stables; (4) user of the defendants' property so as to heat the plaintiff's stables and render them unhealthy, and so as to endanger the plaintiff's premises and stock-in-trade and cause risk of damage by fire. The chief complaint, however, on the part of the plaintiff was that the works erected by the defendant Company injuriously affected the access of air to the drying sheds so as to render them substantially less useful for the purpose of the timber business which the plaintiff was bound to carry on upon the demised premises, and it was contended on his behalf that the acts of the defendants constituted either a derogation from the grants contained in the lease, or else a violation of the covenants for quiet enjoyment therein contained.

Mr. JUSTICE STIRLING, after stating the facts, said that the legal principle invoked on behalf of the plaintiff appeared to be recognised in several modern cases. In Robinson v. Kilvert a landlord let the floor of a house to a tenant for a paper warehouse, retaining a cellar immediately below. He afterwards commenced a manufacture in the cellar which required the air to be hot and dry, and employed heating apparatus which raised the temperature in the demised portion very considerably, with the result that some kinds of paper warehoused there were injured and made less valuable, though paper generally did not suffer. The landlord was ignorant at the time of the letting that the tenant was going to store any particular kind of paper which was liable to be deteriorated by heat which would not hurt paper generally, and it was held that the landlord was not liable either on the ground of nuisance or derogation from his grant, or breach of the covenant for quiet enjoyment. The result of these actions appeared to be that where a landlord demised part of his property for carrying on a particular business he was bound to abstain from doing anything on the remaining portion which would render the demised premises unfit for carrying on such business in the way in which it was ordinarily carried on, but that this obligation did not extend to special branches of the business which called for extraordinary protection. His Lordship concluded by saying that in the present case the lease was not merely granted for the purpose that the land demised might be used by the plaintiff for carrying on his business as a timber merchant, but it contained an express covenant binding him to carry on that business. In his Lordship's opinion, Munro became subject to the obligation to abstain from doing anything on his adjoining property which would substantially interfere with the carrying on of that business in the ordinary course; and that obligation bound the defendants as assigns from him, subject to the existing lease. His Lordship then proceeded to consider the evidence, and upon it came to the conclusion that some injury to the drying sheds had been made out, but not sufficient to justify the granting of an injunction. The plaintiff was entitled to an inquiry as to the damages he had sustained by reason of the buildings rendering the sheds less fit for use in the ordinary course of his business as a timber merchant.

De Livet v. Oliver and Others.

An application was made in the High Court for an interim injunction to restrain the defendants, until allotment to the plaintiff of 470.000 fully-paid £1 shares in the British Steam Generator and Refuse Utilisation Company (Limited) from selling, disposing of, or using the patent of the late C. de Livet. The plaintiff is the widow and personal representative of M. de Livet, who had invented and patented a means for burning and using refuse, of which accounts have recently appeared in the Press. Before his death, in August, 1893, he entered into an agreement with the defendants, Oliver, Sheridan, and Houldsworth for the purpose of forming a company to buy and work his invention. After his death an agreement was made between the plaintiff and the three defendants and the above-named Company for the sale to the Company of the invention in consideration of the allotment of the shares in question to the plaintiff. In March, 1894, the defendants entered into an agreement with the Atlas Syndicate, for the formation of a subsidiary Company for the purposes of taking and working a limited assignment of the patent within London and 20 miles round. The plaintiff stated that the shares in the original Company had not been allotted to her, and claimed an injunction.

The Judge decided that the plaintiff was entitled to an injunction until trial or further order, with costs.

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TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

TENDERS INVITED.—The Commissioners of Public Baths and Wash-houses for the parish of St. Saviour's, Southwark, require specifications and tenders for supplying and fixing an engine and dynamo at the baths in Lavington-street, London, S.E. Tenders must be in by 11 a.m. on the 16th inst. Further particulars appear in our advertisement columns.

——— The Corporation of Tunbridge Wells invite tenders for the construction, supply and laying down of the necessary plant and mains for the supply of electricity in the borough specifications, plans and forms of tender can be obtained from Mr. C. W. Cripps, the town clerk, to whom tenders must be delivered not later than June 6th. Further particulars appear in our advertisement columns.

——— The Guardians of the Portsea Island Union invite tenders for building workshops at the Union School and providing and fixing electrical fittings at the offices in St. Michael's-road. Tenders have to be in by 3 p.m. on the 16th inst.

TENDERS ACCEPTED.—The Chelsea Electricity Supply Company (Limited) have accepted the tender of Mr. J. Douglas, of Chelsea, for alterations to the sub-station in the Pavilion-road, Chelsea, for the sum of £391.

——— The tender of Messrs. Baxendale and Co., Manchester, has been accepted by the Visitors of the North Wales Counties Lunatic Asylum for the construction and maintenance, for a period of five years, of a telephone between the asylum and Glanywern Hall, Denbigh, a distance of about three miles.

——— The Stafford Town Council have accepted the tender of Messrs. Marshall, Sons and Co., of Gainsborough, for three horizontal engines for the electric lighting station.

——— The Worcester City Council have accepted the tender of the Brush Company for fixing the necessary mains for 26 arc lamps in several of the principal thoroughfares for the sum of £1,861, the Company agreeing to carry out the work as an extra on the terms of their present electric lighting contract.

TENDERS RECEIVED.—The Streets and Buildings Committee of the York Corporation have discussed the tenders received for the electric lighting of the City, and have passed the following resolution, "That any proposal for the electric lighting of the City by a system involving the use of low-tension currents only be not entertained." Six tenders were previously selected, and this number has been reduced to four, viz.:—The Brush Company, the Electric Construction Company, Messrs. C. A. Parsons and Co., and Messrs. Siemens Brothers and Co.

——— As mentioned in our last issue, the Lighting Committee of the Brighton Corporation have recommended the acceptance of Messrs. Crompton and Co.'s tender for the supply of engines and dynamos and accessories for the central station. The following were the tenders received :—

Easton, Anderson and Goolden	£6,503	0	0
Electric Construction Company	6,257	0	0
Johnson and Phillips	6,095	10	0
India Rubber Company	6,046	0	0
Siemens Brothers and Co.	5,930	0	0
Crompton and Co. (accepted)	5,550	0	0

——— The Improvement Committee of the Sheffield Corporation have recommended that the tender of the Sheffield Electric Light and Power Company (Limited) for the wiring of the Town Hall be accepted for the sum of £750, the Corporation to take the current from the Company's mains for twelve months from the opening of the building, the Company to keep the installation in good working order.

REMOVALS.—The offices of the Western and Brazilian Telegraph Company (Limited) and of the London Platino-Brazilian Telegraph Company (Limited) have been removed from 19, Great Winchester-street, E.C., to Blomfield House, London-wall, E.C.

——— The offices of the West Coast of America Telegraph Company (Limited) have been removed from 120, Cannon-street, to Winchester House, 50, Old Broad-street, E.C.

PLANT FOR SALE.—Messrs. Eardley, Holt and Co., of 28, Charles-street, St. James', London, S.W., advertise elsewhere electric lighting plant for sale, suitable for a country mansion or London house, the whole in sound working condition and equal to new.

"ANTI-SULPHURIC ENAMEL."—This material has been used in the accumulator rooms of the Carnaby-street electric light station of the St. James and Pall Mall Electric Lighting Company to protect the wood and metal work from the action of the acid fumes and spray of the batteries.

LITHANODE BATTERIES.—The Lithanode and General Electric Company (Limited) inform us that owing to recent improvements made in the manufacture of lithanode, all tending to reduce the cost of the material, they have decided to considerably reduce the price of electric lighting and other lithanode cells. The reduced price list can now be obtained of the Company, 64, Millbank-street, Westminster, S.W.

THE ELECTRICITY USERS' ASSOCIATION.—The first object of this Association according to its preliminary prospectus is "to provide members and the public generally with expert advice on all matters connected with the use of electricity." The other objects, advantages, rules, &c., appear to aim at providing the Association with clients who are to pay one guinea per annum for the privilege of receiving this expert advice. The circular which is being sent round suggests that electric lighting is so formidable an affair that it needs constant skilled supervision. The Association proposes to do the work of consulting engineers, and points out the advantage of tenders to a standard specification, as though it were something new. It is promised that members are to be "relieved from any expense (for the usual extras) beyond that specified in the original estimate." Inspection of boilers, engines, accumulators, and surveying of risks "for the fire insurance companies" is, after this, easy work. Among the many suggestions that electric lighting is a troublesome if not dangerous matter, unless periodically inspected by this new Association, we find, "such inspections are very necessary, as in the course of years experience shows that the original number of lamps is increased, and the mains becoming overloaded, heating is liable to ensue."

TELEGRAPHIC ADDRESSES.—Mr. H. Sell has just issued the first of the Quarterly Supplements to the 1894 edition of Sell's "Directory of Registered Telegraphic Addresses." The supplement is free to subscribers to the book.

CONRADY'S AUTOMATIC REGULATOR.—We have received from Messrs. Eugen Conrady and Co. a circular giving particulars of their automatic regulator for dynamo-electric machines, for which it is claimed that the work required is done automatically, and with promptness and accuracy. The regulator consists of a suitably wound solenoid, the core of which operates a reversing friction-clutch to which power is supplied mechanically. The solenoid has, therefore, no other work to do but to put the friction-clutch into or out of gear, and thus absorbs only a negligible amount of electricity (from 5 to 30 watts). The power required for operating the regulating being supplied from a separate source, may be made of any required amount without interfering with the prompt and accurate action of the regulator. The regulator may be adapted to operate either a variable resistance, or the brushholder of a series dynamo, or the throttle-valve or expansion gear of the steam or other motor driving the dynamo, &c. The regulator is made suitable to control electric supply systems of any kind, and it is claimed that the regulator will keep dynamos controlled by them within 1 per cent. of the required normal condition (current or voltage). In cases where variations of the speed or of the load of a dynamo cause appreciable variations of the E.M.F., the regulator will pay for itself in a very short time. The London agents for Messrs. Conrady's specialties are the Indestructible Ignition Tube Syndicate (Limited), 100c, Queen Victoria-street, E.C.

MEDICAL BATTERY COMPANY.—An application has been made before Mr. Justice Williams, in which the receiver in this Company (now in liquidation) asked for leave to continue the business for another two months, and to sell "electric" belts and appliances, the grounds of the application being that at the date of the stoppage of the business operations there was in hand a considerable stock of appliances, estimated to be worth about £6,000. In support of the receiver's application counsel argued that the belts and appliances were of "some curative value." A continuance order has been granted for a further period of two months, to ensure a more complete realisation of the Company's assets.

UNITED ELECTRIC WIRE COMPANY.—We are informed that Mr. T. Collingwood has retired from this firm, which is now being carried on under the management of Mr. F. H. Berry.

SELF LUBRICATING BEARING.—Mr. W. Farrar forwards a circular illustrating and giving particulars of Broughton's self-lubricating bearing, which it is claimed is specially suitable for dynamos, motors, &c. Several of these bearings have been running in Leeds for some months, and have, it is stated, given every satisfaction.

STRAKER'S OIL BEARING.—In reference to a Trade Note appearing in our last issue, we are asked to state that Mr. C. S. Northcote, in conjunction with Messrs. B. Verity and Sons, have taken up an agency for this oil-bearing at their Manchester offices.

ELECTRIC COOKING AND HEATING.—A Novelties Exhibition has been held in Bath during the past fortnight, at which one of the chief attractions has been the electrical displays, which have been carried out under the supervision of Mr. G. F. Metzger, of the Bath Electric Lighting Company. It is generally thought that much of the success of the Exhibition is due to the electrical installation.

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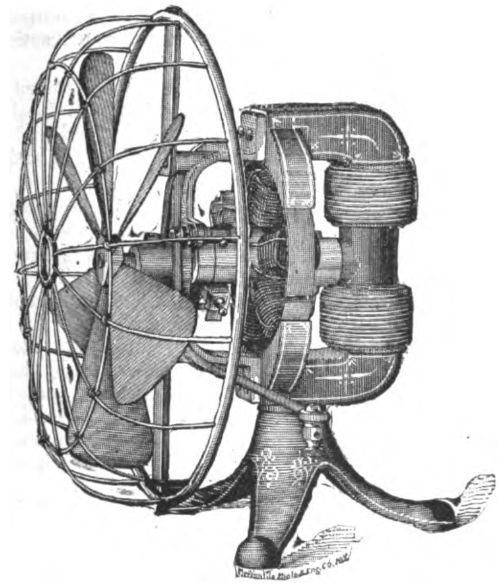
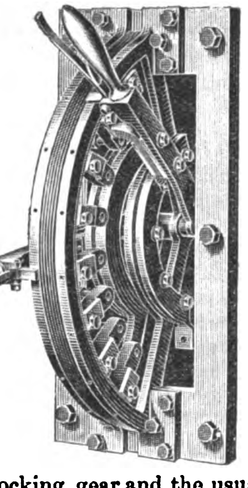
GENERAL ELECTRIC COMPANY.—We have received from this Company a new edition of their electric bell catalogue, which contains particulars and prices of a number of new articles. The Holden repeaters for electric bells have been modified, and are now offered to the trade. A large number of pushes, some made entirely of china, and front door pulls are illustrated. Amongst



other items dealt with in the catalogue are electric gas lighters, including spare parts for repairs, Edison-Lalande batteries, small motors, &c. The illustration shows a motor attached to a fan, but which would no doubt be useful for experimental and other purposes.

MESSRS. NALDER BROS.—On a recent visit to Red Lion-street, Clerkenwell, we saw a new form of battery switch, designed to occupy a minimum amount of wall space. This switch is made to carry 200 amperes, has eight pairs of contacts, but occupies only 10½in. by 1ft. 11in. space. The handles project 1ft. 4in. from the wall



in their mid-position. Locking gear and the usual resistance coils are provided, and the contacts are all adjustable for wear. We were surprised to find that this firm have a dozen "secohmmeters" in hand, and that these are practically used by manufacturers. A large "Anthony" bridge had just been completed, and is, we understand, destined for an American university.

BIRMINGHAM.—The Empire Palace was opened on Monday last, and is considered one of the handsomest buildings in the town. The electric light and telephone is installed throughout the building, the telephone in substitution of electric bells.

BRADFORD.—At the last meeting of the Town Council Alderman Moulson, Chairman of the Gas and Electricity Supply Committee, presented the minutes of the Committee recommending that a circular be issued to the residents of the districts of Frizinghall, Manningham, and Heaton, in order to ascertain their wishes in regard to the electric light supply, and authorising the electrical engineer to prepare an estimate of the cost of the suggested works, and further to circularise the residents of several of the large thoroughfares as to the support they were prepared to give to the Corporation scheme for extending the electric lighting area. After a brief discussion the minutes were adopted.

BREWERY LIGHTING.—The Chesterfield Brewery Company some time back placed an order with Messrs. Laing, Wharton and Down, of New Bond-street, London, for an extensive electric lighting plant for lighting their premises and cellaring at Chesterfield and the adjoining Station Hotel, of which they are the proprietors. The work has now been completed, and is considered a great success. The installation includes a battery of 56 cells. A special feature of the lights is an examining light for inspecting the barrels, which is peculiarly necessary in brewery lighting. This consists of a long thin-rod, inserted in the end of which is a small incandescent lamp enclosed to prevent breakage. This is thrust through the bung-hole of the barrel and enables the interior to be thoroughly inspected.

BRISTOL.—Complaints are being generally made against the charges for gas during the past year. It appears that the Sanitary Authority are charged, within a small amount, the same as before the introduction of the electric light, whereas a member of the Authority pointed out at the last meeting that a saving of some millions of cubic feet of gas had been effected. As private consumers have also complained of the amount of their gas bills, it is felt that something must be radically wrong somewhere. A written report is to be presented on the subject, which may prove interesting.

BURTON.—The Finance Committee of the Town Council have agreed that application shall be made to the Local Government Board for permission to borrow £55,771 for works in connection with their sewerage and electric lighting schemes.

BURY.—The Town Council have approved the plans for the scheme of electric lighting which has been adopted for the Borough, and for which it was resolved at the last meeting to apply for powers to borrow £25,000.

BUXTON.—A special meeting of the Local Board has been held to consider the electric lighting question. After some discussion it was proposed that a competent consulting engineer should be appointed, but the Chairman of the Board, Mr. C. F. Barnard, pointed out that the town had several important undertakings in hand, and if they adopted an electric lighting scheme, the rates would have to be increased. It was suggested that they should wait until several loans fell in in 1902 before any fresh important undertakings were contemplated by the town. Ultimately the Chairman's views prevailed.

CHISWICK.—The Clerk to the Local Board has received from the Board of Trade amended regulations regarding the supply of electric light in Chiswick, to which no exception has been taken by the Board. The Surveyor announced that the boilers were completed, and the engines would soon be ready. Plans are to be deposited next week.

CHURCH LIGHTING.—Mr. T. Harding Churton, of Leeds, has secured the contract for lighting the Great Synagogue at Belgrave-street, for which nearly 80 incandescents of various candle-power will be required.

COUNTRY HOUSE LIGHTING.—Storrs Hall, Windermere, has just been lighted throughout by electricity, 120 16-c.p. incandescents being distributed over the various rooms. The current is at present obtained from an electric launch owned by Mr. L. Parsons, by whom the installation has been carried out; but ultimately a complete plant is to be put down, including a battery of 52 E.P.S. cells.

DERBY.—At a quarterly meeting of the Town Council, just held, a question was addressed to Mr. Marsden regarding the electric light installation. In reply, Mr. Marsden stated that for business reasons he would prefer not to give any definite figures as to the expenditure or receipts in connection with the electric lighting scheme, but the success of the installation had exceeded their most sanguine expectations. The applications for current had been much larger than were at any time anticipated. More money would shortly be required, but not for laying down further plant, of which they had an ample supply. The money would be required for the supplying of fixtures and fittings to customers, and the more money the Committee expended upon such fixtures and fittings, the greater success would the scheme ultimately become.—— The Electrical Exhibition at the Mechanics Institute, Wardwick, Derby, is to be opened on May 14th, by the Mayor.

DUBLIN.—A rumour was spread that Captain Purcell had suggested that the recent disastrous fire upon the premises of Messrs. Arnot and Co., might possibly have been caused by the fusing of electric light wires. Captain Purcell has denied that such a statement had been made by him, and Mr. M. Ruddle, electrical superintendent at the central station, Fleet-street, Dublin, is anxious that such a report should be contradicted promptly. Mr. Ruddle explains that the electric lighting of Messrs. Arnot and Co's premises was all in order on the morning of the fire, and that at 2 p.m. it was found that the gas from a broken 3in. gas service was burning among the fallen ruins close to the electric lighting mains, and, solely as a matter of precaution, it was deemed advisable to disconnect the wires at this point, the disconnection only affecting three consumers on the system.

GLASGOW.—The *Evening Citizen* has recently got together some statistics as to the popularity of electric lighting in Glasgow, and, in a recent issue states that during 1893 the production of the

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electric current has been rapidly increasing. At the present date no less than 242 shops, 21 warehouses, 91 offices, 3 churches, 13 clubs, hotels and theatres, and 12 private houses, are using the electric light, and apparently to the general satisfaction of the users except in the matter of cost. Complaint is generally made that the charge of 7d. per unit is prohibitive to the more general use of the electric current.

GUILDFORD.—In regard to the dispute between the Guildford Town Council and the owners of the Electric Lighting Provisional Order for Guildford, the Board of Trade have suggested that a clause be inserted in the Provisional Order under which the Local Authority will have power to purchase the undertaking within six months after the expiration of 35 years from the commencement of the Order.

HEATH TOWN (WOLVERHAMPTON).—The Local Board have recently been in communication with the Parliamentary Agents as to the probable cost of obtaining an electric lighting Provisional Order and subsequent confirmation. After hearing the replies it was stated that the proper course was to consult an electrical engineer to advise the Board as to the proper steps to be taken to obtain an Order.

HULL.—Mr. Councillor Holder, Chairman of the Electric Lighting Committee, at the last meeting of the Town Council, gave a short account of the progress made during the past year with the electric lighting scheme. He pointed out that when the scheme was first broached, nothing but failure was predicted. He believed their critics were sincere in their fears, and would now be the first to rejoice at the unqualified success of the electric light undertaking, both from the points of view of illumination and finance. As an illuminant they had never had a single accident or flicker from their station, and as a commercial venture it would be seen by the balance-sheet that they had expended £1,631 to produce £2,519. They had paid working costs and up-keep, and had a balance of £888 to pay off the interest on £25,000 of capital. The interest absorbed £750, and left them with £138 towards the sinking fund. It had proved additionally profitable to the borough from the fact that they had borrowed from the Borough Fund surplus at 3 per cent., or ½ per cent. more than would have been received through the bank, and thus had enriched the town to the extent of £125. In the past year the progress made was shown by the fact that in the March quarter there were only 42 users of the electric current, whereas in December there were 148. In March 3,790 lamps were connected; in December, 8,036; and arc lighting had increased in a similarly satisfactory ratio. Up to December last they had delivered to consumers 74,600 units of electric current. The Council's engineers might, he thought, fairly be congratulated on possessing a station second to none in the Kingdom, however long they may have been in existence. Mr. Gibbings, the electrical engineer, had estimated that to cover the expenses for the current year it would be necessary to have an income of £4,388, which would require the sale of 162,000 units at 6½d. per unit, the price which they proposed to ask the Council to reduce it as from September next. They were sanguine that they would be able to sell this large number of units, and based their estimate upon the fact that they had sold with only 76 users in eleven and a-half months 74,600 units, whereas at the beginning of this year they had 148 users, which should give them the amount of support necessary to reach the extended total. In the first quarter of the year they had sold no less than 45,862 units towards their 162,000. They had, of course, the two summer quarters before them, but he felt sure that their estimated increase would be reached. As matters stood they were likely to lose slightly on their charge of 6½d. per unit, and they were, therefore, not justified in making any further reduction. Notwithstanding the undoubted success which Mr. Holder was able to show, there were not wanting members of the Corporation who looked askance at the enterprise, and this opposition culminated in an amendment referring back a portion of the committee's minutes for further consideration, but after some further discussion, the amendment was put to the vote, and lost by a majority of 25, and the committee's report was confirmed.

JOHANNESBURG.—Mr. J. Hubert Davies recently entertained a number of the residents to celebrate the inauguration of the electric lighting plant at the Crown Reef, which has been put down at a cost of about £10,000. Mr. Davies pointed out that the inception of the electric-lighting scheme was due to Mr. Jennings. An electrical plant under the conditions which prevailed at the Crown Reef was much more economical than a steam plant, and in the case of this mine all the working machinery either in the mine or on the surface (except the hauling gear) was driven from one generating point. Some of the machinery is a mile away from the motive power working it. The motive power would also have been worked by electricity, but for the fact that they already had an elaborate steam plant working it. Beyond the motive power, the electrical plant provided the lighting, which was equal to 1,000 16-c.p. lamps. Mr. Davies expressed his opinion that so economically could an electrical plant be worked, that several low-grade mines could be governed from one central station with satisfactory results, especially where water could be utilised as the motive power. Mr. Tudhope, in complimenting Mr. Davies, Mr. Jennings, Mr. Irvine, and Mr. Webber, and the staff generally on the result of their labours, said that the day would shortly come when low-grade properties, worked by electricity, would add 50 per cent. to the gold output of the Transvaal, and he looked forward to the ultimate utilisation of the Crocodile river as water-power.

LLANDUDNO.—It is stated that a committee of the Board of Commissioners has decided to oppose the formation of a local electric lighting company at Llandudno, which Mr. W. Kingsland and Mr. R. Bellis are promoting. The Committee's report will be discussed at the next monthly meeting of the Board.

LAUNCESTON (TASMANIA).—In response to the application for tenders for lighting this city by electricity, only two offers have been received complying with the conditions laid down by the City Council, and the tender of Messrs. Siemens Brothers and Co. (Limited), for £32,021, has been recommended for acceptance, as against the tender of Messrs. Henley for £28,615. At a public meeting held to discuss these tenders a resolution was moved that the specifications and conditions had been drawn up by the Council so as to exclude any English and American firms from tendering, and that the better course would be to call for fresh tenders, these to be referred to a Board of three accredited electrical engineers to adjudicate and advise the Council. This was carried, and it was ordered that copies should be sent to the City Council.

MANCHESTER.—The Electric Lighting Committee of the Corporation of Manchester have recently placed an order with Messrs. Mather and Platt (Limited), of Salford Iron Works, Manchester, for two "Edison Hopkinson" dynamos, each of 400 H.P. The machines are to be similar to the two machines already supplied by this firm, having an output of 410 volts 590 amperes at a speed of 400 revolutions per minute, and are intended to work upon the feeders of the 5-wire system. The committee have had so many applications for electric light that their present plant is fully loaded, and an extension is necessary before next season. These new dynamos are to be worked by "Galloway" engines, similar to those already supplied.

MERSEY DOCKS AND HARBOUR BOARD.—At their meeting this week the Board will decide as to the construction of a jetty at the south-east side of the Duke-street bridge, East Float, Birkenhead, to be provided with hydraulic cranes, and to be lighted throughout by electricity, the total sum to be spent being £7,500.

NEW ROYAL COLLEGE OF MUSIC.—This college, which was opened last week by the Prince of Wales, is lighted throughout by electricity, the installation having been fitted up by Messrs. Thompson and Ritchie. The organs are worked by electric motors fitted up by Messrs. Bergtheil and Young. A novel feature in the building, and which should prove extremely convenient, is the connecting of each of the nearly 100 class-rooms by telephone with the administrative offices and with the private room of the Director.

NORTHUMBERLAND.—The Committee of Visitors of the County Lunatic Asylum have presented their report, in which it is stated that the Visitors have carefully considered the question of adding to the existing gas works, or, as an alternative, the erection of electric lighting works capable of supplying the electric light to the asylum and the steam power required for the new laundry. The estimated cost, including superintendence during construction of the works, shows a total of £7,275, against an estimate for the extension of the gas works of £5,060. After consideration the Committee submit to the Northumberland County Council both schemes, but are in favour of adopting the electric light, and recommend it to the consideration of the County Council, subject to the approval of Commissioners in Lunacy and the Secretary of State.

POPLAR (London).—The District Board of Works have considered the report on the electric lighting of the district recently presented by Mr. Preece, in which it will be remembered that he strongly advises the Board to take into its own hands the lighting of the district for which the necessary Provisional Order has been obtained, and after discussion it was decided to refer the matter to the Works Committee for their consideration and report.

PLYMOUTH.—The Bill promoted by the Plymouth and Stonehouse Gas Company, authorising them to raise additional capital and to apply for a Provisional Order under the Electric Lighting Acts, was discussed before a Committee of the House of Commons this week. In support of the Company's application, it was pointed out that the Plymouth Company charges less for gas than any other company in the country, viz., 1s. 9d. per 1,000, against no less than 3s. 1d. by the leading London Company, in fact, gas was cheaper at Plymouth than at Newcastle.

PROVISIONAL ORDERS.—The Provisional Orders promoted by the Buxton Local Board, the Corporations of Chesterfield, Peterborough, and West Hartlepool, came before the Examiner of the House of Commons, on Tuesday, for proof of compliance with standing orders. In each case it was decided that the standing

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orders had been complied with, and the Bills will be reported for second reading in due course.

THE ROYAL ACADEMY.—Special reference was made at the recent Academy banquet to the effectiveness of the electric lighting installation in the galleries, and we are asked to state that the work was carried out by Messrs. Belshaw and Co., of Victoria-street, S.W.

RUGBY.—A deputation of the Rugby Town and Trade Improvement Association recently waited upon the Local Board, asking their assistance to provide the necessary number of subscribers to enable an arrangement to be entered into with the National Telephone Company for opening trunk communication with Rugby. The Board decided to take the suggestion into consideration.

ST. LUKE'S (LONDON).—In reference to the notices recently served by the County of London and Brush Provincial Electric Lighting Company, intimating their intention to commence the laying of electric lighting mains in the parish, the Parliamentary Committee of the St. Luke's Vestry have decided to take expert opinion as to whether the Order obtained by the Company is effective, in view of the fact that its terms have not been observed by the Company. A recommendation that the Company should be notified of the proposed action of the Vestry has been referred to a sub-committee, to consider and investigate the whole subject of the Electric Lighting Order.

ST. PANCRAS.—The Guardians have recently discussed the question of adopting the electric light at the workhouse and have referred the matter to the Finance Committee for their report, and the Baths Committee have been requested to take into consideration the question of lighting the baths by electricity.

SHEFFIELD.—The electric light has recently been installed throughout the Sheffield Library, and at the annual meeting held last week it was stated that the light had proved a complete success, to the gratification of all concerned.

SHIRLEY AND FREEMANTLE.—The Local Board have referred a letter from the Electric Construction Company to a special committee, and after discussing a report from the General Purposes Committee on the electric lighting subject, have appointed a sub-committee to investigate the whole question of lighting the district by electricity.

SHOREDITCH (LONDON).—Owing to the action of the Gas Light and Coke Company in declining to allow discount on the quarterly accounts, the Shoreditch Vestry have decided to push forward their electric lighting scheme with all possible dispatch. The Vestry have notified their opinion that a reduction in the price of gas should have been made before a dividend of 12 per cent. was declared by the gas company.——Messrs. Manlove, Alliott and Co. have reported to the Vestry on the question of dust destructors, and the utilisation of the heat for generating electricity and supplying the baths and wash-houses. In their report they state that, so far as they are aware, the only scheme to be considered as a practical mode of dealing with the question is that invented by Mr. Druitt Halpin. Under the scheme referred to in the report it is estimated the Vestry can make an annual profit of £1,390 by a capital expenditure of £17,500, of which £8,800 is put down for the destructor and £8,700 for the necessary steam generators, pumps, piping, buildings, &c. The estimated revenue is £4,290 per annum, at an annual maintenance charge of £2,900.

SOUTHAMPTON.—At the opening of a new emigrants' home it was announced that the electric light would shortly be introduced.

THETFORD.—The clock at St. Peter's is to be lighted by electricity from dusk to 11:30 p.m.

TRAIN LIGHTING.—We are informed that the German Postmaster-General has ordered 42 mail coaches for the night express train service, all of which are to be lighted electrically, and that Boese accumulators have been specified. The gas which is now used in the old coaches is to be replaced by Boese accumulators in all cases where the coaches come in for repair. The Austrian State Railway has also, we understand, adopted the Boese accumulators for train lighting. The International Electric Company, who are the agents for the United Kingdom and the Colonies for the Boese batteries, report that the sale is considerable, and that the demand is steadily increasing.

WORTHING.—Councillor Rafferty, Chairman of the Lighting Committee, and Capt. Fraser, of the Worthing Town Council, visited Brighton last week, and were conducted over the central station by the Mayor, Alderman Moon, and Mr. Wright, the superintendent of the works. Worthing is contemplating the introduction of the electric light on a system similar to that in use at Brighton.

ANNUAL SUPPER.—A party, numbering about 50, of Edinburgh electricians, held their annual supper at the Prince of Wales's Hotel last week, under the presidency of Mr. O. Cox-Walker. It having been mutually agreed that there was a good time coming for the Edinburgh electricians, the rest of the evening proved of an agreeable character.

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

March 31, 1894.

6,458. S. Z. DE FERRANTI. London. Improvements in dynamo-electric machines.

6,482. P. MOREAU and J. MUNIER. London. Improvements in, or relating to, multiple telephonic systems and apparatus.*

6,491. S. PITT. London. Improvements in and apparatus for converting electric currents. (A. Blondel and Sautter, Harlé et Cie., France.)*

6,495. E. HERMITE, E. J. PATERSON, and C. F. COOPER. London. A process for protecting iron pipes from corrosion by passage of electrolysed chloride solutions employed as disinfectants.

6,497. E. HERMITE, E. J. PATERSON, and C. F. COOPER. London. Improvements in apparatus for electrolysing chloride solutions employed for disinfecting.

April 2, 1894.

6,512. F. H. ROYCE. Manchester. Improvements in dynamo-electric generators and motors and allied machines.

6,528. F. H. ROYCE. Manchester. Improvements in dynamo-electric generators and motors and allied machines.

6,554. BULLERS (LIMITED) and E. J. CHAMBERS. London. Improvements in or additions to metallic tubular telegraph poles, and metallic tubular poles for other purposes.

April 3, 1894.

6,606. C. A. ALLISON. London. Systems for controlling electric lights. (The Electrical Specialty Company, United States.)*

6,623. P. R. ALLEN. London. Improvements in electric lighting apparatus.

6,649. A. KERSHAW. London. A new or improved mechanical indicator for electric and other bells.

6,661. T. J. RORKE. London. Improvements in electric switches.

6,669. J. C. FULLER, G. FULLER, and W. E. LANGDON. Improvements in porcelain and other insulators.*

April 4, 1894.

6,721. THE NATIONAL TELEPHONE COMPANY (LIMITED) and C. EGGAR. Glasgow. Improvements in apparatus for signalling between police stations and district call-boxes.

6,742. SIEMENS BROTHERS AND CO. (LIMITED) and G. S. GRIMSTON. London. An electrically operated electric switch.*

April 6, 1894.

6,850. W. T. UNGLEY, Jun. Electric lamp protector.

6,883. J. IMRAY. London. Improvements in telegraphic and telephonic apparatus. (La Société anonyme pour la transmission de force par l'électricité. France.)

6,912. The firm of KÖLNER ACCUMULATOREN-WERKE GOTTFRIED HAGEN and C. BEYER. London. Improvements in and relating to moulds for casting grids for the active material of electrical accumulators.

6,917. H. GUTHRIE. London. Improvements in apparatus for electrolytical purposes.

April 7, 1894.

6,937. W. DIXON. Glasgow. An improved method of illuminating by the electric arc.

6,942. D. SINCLAIR. Glasgow. Improvements in "cords" and plugs for telephonic switchboard circuits.

6,947. R. J. GÜLCHER. Liverpool. Improvements in plates or electrodes for accumulators.*

6,975. A. J. SMITH and H. J. WRIGHT. London. Improvements relating to the manufacture of plates or electrodes for electric accumulators, or secondary batteries, and to machinery or apparatus therefor.

April 9, 1894.

7,050. G. C. FRICKER. London. Improvements in electrically illuminated signs.

7,054. E. J. CLUBBE and A. W. SOUTHEY. London. Improvements in electrically propelled vehicles.

April 10, 1894.

7,080. J. OULTON. Bradford. Improvements in phonographs.

7,094. W. J. S. BARBER-STARKEY. Manchester. Improvements in and connected with secondary electric batteries.

7,116. C. BRADBURY. London. Apparatus for calling any desired station on a telegraphic or telephonic line. (F. Trinks, Germany.*)

7,121. W. BIDDLE and P. KENNEDY. London. Improvements in electric car-lighting apparatus.

7,132. H. CARDONNELLE. London. Improvements in microphones.

7,145. S. O. COWPER-COLES and B. W. WALKER, Bart. London. Improvements in, or connected with, the electro-deposition of metals or metallic compounds, and the treatment of deposited metals or compounds.

7,148. N. S. KEITH. London. Governor for electric, water, and other motors.

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7,155. A. HIGGINS. London. An improved multiple distributing electric cut-out.

7,165. E. J. CLUBBE and A. W. SOUTHEY. London. Improvements in secondary voltaic batteries.

7,176. H. CARBONNELLE. London. Improvements in and relating to telephonic systems.

April 11, 1894.

7,205. A. F. B. GOMESS. London. A new or improved process for the electro-deposition of aluminium and aluminium alloys.

7,206. A. F. B. GOMESS. London. A new or improved process for the electro-deposition of aluminium and aluminium alloys.

7,214. H. V. COAD. London. Improved safety arrangement for electric miners' lamps.

7,215. E. MAGNIN. London. Improvements in electric printing telegraphic apparatus.*

7,216. R. HURST. London. An improvement connected with electric switches.

7,238. Sir C. S. FORBES, Bart. London. Improvements in or relating to electric telephones.

7,239. C. COERPER. London. Improvements in alternating-current electric motors.

7,240. W. C BERSEY. London. Electrically-propelled common road vehicles.

7,244. W. H. AKESTER and H. H. PRICE. London. Improvements in apparatus for electrically-recording circular, longitudinal, or transverse motions of mechanical devices.

April 12, 1894.

7,258. G. BINSWANGER and H. J. COATES. London. Improvements in electric arc lamps.

7,287. S. ROBSON. London. A method of electrically lighting vehicles by their own momentum.

7,311. B. A. N. DOREZ. London. Improvements relating to secondary batteries.

April 13, 1894.

7,402. L. B. TAPPENDEN. London. A new or improved gas or electric light regulating apparatus for railway stations.

April 14, 1894.

7,467. A. J. MARQUAND and E. HANCOCK. London. Improvements in primary, electric, or secondary batteries.

7,468. E. ARNOLD. London. Improved method of, and apparatus for, distributing electrical energy by means of alternating currents.

7,477. H. EDMUNDS. London. Improvements in apparatus and means for vulcanising small articles, more especially intended for vulcanising the insulation at the joints of electric conductors.

7,479. F. J. BEAUMONT and F. HALLOWS. London. An improved electricity meter for registering the amount of current consumed on direct, or alternating, polyphase, triphase, or quadruplephase circuits.

April 16, 1894.

7,530. THE EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY (LIMITED) and J. M. MOFFAT. London. An improvement in electrical glow lamps.

7,539. G. L. DAVIES. London. Improvements in lifting, crane, and hoisting apparatus operated by electrical energy.

April 17, 1894.

7,603. C. J. HAMMERTON. London. Application of electricity to the manufacture of cyanides and ferrocyanides, and improvement in same. Preservation of vessels from corrosion.

7,607. W. DEFRIES and V. J. FEENY. London. Improvements in arc lamps.

7,617. H. B. COX. London. Improvements in thermo-electric generators.*

7,645. J. B. BRAND and C. L. FRANKLYN. London. Improvements in underground conduits for electric railways.*

April 18, 1894.

7,684. W. L. SPENCE. Manchester. Improvements in, or in connection with, electricity meters.

7,688. G. HOOKHAM and S. H. HOLDEN. London. Improvements in, or in connection with, electricity meters.

7,691. C. A. MÜLLER. Bradford. Improvements in the manufacture of carbon rods for electric arc lights. (C. Schmelzer, Germany.)

7,700. J. D. F. ANDREWS. London. Improvements in electric-light ceiling roses.

7,711. W. J. BISHOP. London. An improved arrangement of element board for electro-diagnosis.

7,718. G. G. M. HARDINGHAM. London. Improvements relating to mains for alternate current installations. (The firm of Felten and Guilleaume, Germany.)

April 19, 1894.

7,758. F. TUDSBURY. Sheffield. Improvements in induction electrical machines.

7,801. C. KELLNER. London. Improvements in or relating to electrolytical apparatus.

April 20, 1894.

7,815. T. J. TOMLINSON, Jun., and O. ROBSON. Newcastle-on-Tyne. Improved means for effecting the lighting of velocipedes by electricity.

7,853. W. A. THOMS and W. H. BURGUM. London. An improvement in the electro-deposition of heavy metals with a base metal alloy.

7,865. D. G. F. GERALD and A. W. SOUTHEY. London. Improvements in the construction and working of galvanic batteries.

7,875. F. FRITSCHE. London. A galvanic chain for curative purposes.*

7,879. C. COERPER. London. Improvements in and relating to reflectors for electric arc lamps.*

April 21, 1894.

7,905. R. J. CANAVAN. London. An improved shunt arc lamp.

7,920. J. B. ATHERTON. Liverpool. Improvements in lead sheath cables.

7,933. W. CORIN. London. Portable apparatus for heating by electricity water, milk, or other liquids contained in cups, jugs, or other vessels, and for making tea and other drinks.

7,935. K. O. A. GULSTAD. London. Improvements in electric telegraphy.

7,950. H. GUTHRIE. London. Improvements in apparatus for electrolytical purposes.

7,955. J. H. THOMSON. London. Improvements relating to electric measuring instruments.

April 23, 1894.

7,985. T. DRAKE. Huddersfield. An improved method, means, or process of producing caustic soda and chlorine gas by the electrolysis of common salt in solution.*

7,994. E. DE PASS. London. An improved electrolytic through or cell. (H. Thofehrn, France.)

7,995. H. HIRST. London. Improvements in fittings for electric lamps.

8,007. G. L. ANDERS and W. KOTTGEN. London. An automatic switch for telephones and other electrical apparatus.

8,011. F. JEHL and F. VON HARDTMUTH. London. Improvements in appliances for increasing the duration of the top carbon of electric arc lamp.

April 24, 1894.

8,043. H. B. WYMAN and A. C. GOODWIN. London. An improved insulating cleat for supporting conducting-wires for electrical circuits.*

8,045. W. G. WOOLF. London. Electric bell for application to bicycles, tricycles, and other cycles.

8,061. H. CARMICHAEL. London. Improved apparatus and process for electro-chemical decomposition.*

8,086. W. H. BRADT. Glasgow. An electric alarm for pressure gauges. [Date applied for under Patents, &c. Act, 1883, Sec. 103, November 22nd, 1893, being date of application in the United States.]*

8,115. F. E. ELMORE. London. Improvements in apparatus for the manufacture, electrolytically, of tubes and other articles of circular section.

8,125. H. N. PRENTICE. London. Improvements in dynamo-electric machines and electric motors.

8,149. H. H. LAKE. London. Improvements in electrical measuring instruments. (J. Van Vleck and E. Weston, United States.)*

April 25, 1894.

8,215. J. BIELSKI. London. Automatic current distributor for multiple telegraphic transmission.

8,218. C. S. JONES and H. C. COLLIER. London. Improvements in or connected with electric signalling or communicating apparatus.

8,224. J. G. W. ALDRIDGE. London. Improvements in electric lighting.

April 26, 1894.

8,238. A. B. H. CLARKE. Bristol. Improvements in electro-medical apparatus.

8,240. F. W BALL and J. H. WINTER. Bristol. An improved ceiling rose or suspending electric pendant lamps.

8,273. E. A. CLAREMONT. Manchester. An improved form of shade tilt for electric light flexible-wire pendents or other similar fittings.

8,285. J. W. ROGERS. London. Improvements in arc lamps, especially in the reduction of mechanism.

8,292. J. E. LIARDET. London. Improvements in or relating to the charging of electrical accumulators or secondary batteries.

8,307. J. J. FYFE. London. Improvements in and connected with arc-lamps, and the regulation of the feeding of their carbons.

8,315. W. C. BERSEY. London. Electrically-propelled tramway vehicles.

8,317. H. H. LAKE. London. Improvements in switches for use at central stations of telephone systems. (The Antwerp Telephone and Electrical Works (Société Anonyme), Belgium.)

8,328. G. THRELFALL. London. Improvements in electric condensers. (R. Threlfall, Australia.)

April 27, 1894.

8,343. G. F. SANDERS. Birmingham. An improved globe or shade-holder for electric, gas, or other lamps.

8,350. H. H. LEIGH. London. Improvements in electric batteries. (Vohwinkel, Austria.)

8,376. H. TOMMES and A. WELLNER. Cologne. Water-gauge with electric alarm for steam-boilers, water-towers, and reservoirs.*

8,412. A. FRAZER. London. Improved method of and means for controlling electric currents.

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April 28, 1894.

8,443. A. Fairley. Blackpool. An improved arrangement of electrical contact surfaces for producing electrical effects in theatres, &c.

8,478. E. J. Clubbe and A. W. Southey. London. Improvements in electrically propelled vehicles.

8,480. T. H. Rushton. London. Improvements in and relating to galvanic batteries.

April 30, 1894.

8,500. H. R. Vereker. Westport. Electrical connector for making insulated joints under water or clay, between cable or other insulated wires.

8,512. A. Wigglesworth. Liverpool. Improvements in and connected with insulators for overhead electrical conductors.

8,525. A. G. Waterhouse. London. A method of overcoming induction on telephone and transmitting lines.

8,534. W. C. Bersey. London. Improvements in electrically-propelled vehicles.

8,539. E. Andreoli. London. Improved telephone and exchange system. (P. E. Raverot and G. A. Hess, France.)

8,552. R. Kersberg. London. Improved commutator brush.*

8,556. E. Stoessel. Liverpool. An improved electrically operated door chain or the like.

May 1, 1894.

8,566. T. Parker. Wolverhampton. Improvements in alternating and multiphase current dynamos.

8,567. W. H. Scott. Norwich. Improvements in brushes and brush-holders for electric generators and motors.

8,585. D. E. Conner. London. Improvements in electric conductors for underground conduits.*

8,587. H. H. Lake. London. Improvements in and relating to electric railways. (W. B. Purvis and M. M. Armstrong, United States.)*

8,599. J. B. McKeown. London. Improvements in electric arc lamps or lighting apparatus.*

8,607. W. P. Thompson. Liverpool. Improvements in or appertaining to electrical exchanges. (A. E. Keith, United States.)*

8,613. W. P. Thompson. Liverpool. Improvements in or appertaining to automatic electrical exchanges. (The Strowger Automatic Telephone Exchange, United States.)*

8,617. T. N. White. London. An electric alarm bag.

8,634. J. C. Fell. London. Improvements in the means for controlling electric lamp circuits from a distance. (R. H. Postlethwaite, New Zealand.)

8,638. S. Pitt. London. Improvements in alternating current, simple or polyphase, dynamo-electric machines. (André Blondel, and Sautter, Harlé et Cie., France.)*

May 2, 1894.

8,654. R. N. Grenville and S. H. Terry. London. Improvements in apparatus used as brackets or chandeliers for electric light.

8,730. T. Froggatt. London. Improvements in, and connected with, supports for electrical batteries used on vehicles and the like.

8,731. T. Froggatt. London. Improvements in electric batteries.

8,733. H. Dawson. London. Improved electrical fire and burglar alarm.

May 3, 1894.

8,761. A. Archibald and G. Tarry. Improvements in and connected with electric fire-alarms.

8,773. F. H. Dennis. Chelmsford. An automatic electric fire-alarm time call.

8,794. P. E. M. Bastion. Birmingham. New or improved electrical appliances, enabling trains in motion to have constant and direct telegraphic communication with the stations or other trains on the same line.

8,795. A Connell. London. An improved holder or support for the receivers of telephones.

8,807. J. S. Gisborne. London. New or improved means for protectn magnetic needles from local attraction.

8 808. R. McL. McDonald and A. McDonald. Glasgow. Improvements in electric batteries.

8,812. Siemens Bros. and Co. (Limited). London. Electrical jacquard apparatus for looms. (Messrs. Siemens and Halske, Germany.)

8,813. Siemens Bros. and Co. (Limited) and W. Dieselhorst. London. Improvements in electric conductors.

SPECIFICATIONS PUBLISHED.

All Specifications price 8d. each.

1893.

6,528. Statter. Dynamo-electric machines, &c.

6,551. Hall. Electrically treating gaseous bodies, &c.

6,751. Placet and Bonnet. Extracting chromium by eletrolysis.

7,711. Schoop. Secondary batteries.

8,567. March. Electric lamps.

8,901. Mercadier and Anizan. Microphones.

10,081. Greenhalgh. Electro-motors.

10,042. King. Secondary batteries.

10,134. Sayers and others. Dynamo-electric machines.

10,142. Fritsche. Electric generators, motors, &c.

10304. Lobley. Lighting and extinguishing electric lamps.

10,584. Castner. Electrolytic apparatus.

10,942. Walker and Wilkins. Primary voltaic batteries.

11,122. Peyrusson. Secondary batteries.

11,176. Gent and others. Electric bell, &c., indicators.

11,384. Raworth. Electric generators.

11,728. Moy. Electric switches.

11,759. Turnbull. Electric bells.

11,973. Siemens Bros. and Co. (Limited) and Obach. Electrolysis of waters.

12,011. Brown. Electric alarm for steam boilers.

12,141. Tyer. Electrical switches.

12,458. Hutin and Leblanc. Dynamo electric machines.

14,469. Richardson. Electric arc lamps.

15,715. Little, W. G. and C. W. G. Distribution of electricity.

20,381. Claremont. Electric-light fittings.

20,816. Keithley. Connectors for electric conductors.

22,863. Lake. (Thomson-Houston International Electric Company.) Dynamo-electric machines, &c.

23,881. Thompson. (Coffin.) Heating metals electrically.

24,271. Bonnard and Piat. Telephonic apparatus.

24,274. Kellner. Electrolytical decomposition of metallic salts.

24,517. Mockler. Advertising reflector for electric light globes.

24,864. Thomson. Dynamo-electric machines.

24,911. Dewees. Electric cables.

1894.

3,045. Bäärnhielm and Jernander. Electric insulating compound.

3,111. Haddan. (Williams.) Electric signalling devices.

3,275. Chester and Rathbone. Arc lamps.

3,730. Claremont. Electric arc lamps.

3,902. Chamberlain and Hookham. Applying electro-motors to lathe work.

3729. Claremont. Dynamo electric machines.

3,749. Boult. (Cudell and others.) Galvanic batteries.

3,986. Thompson. (Ries Electric Specialty Company.) Electric motors.

4,083. Schleyder. Electric arc-lamps.

4,539 Dieselhorst and others. Joint for wires and electrical conductors.

5,118. Heys. (Heilmann.) Electro-locomotion on railways.

5,243. Lewis. Electric perforating pens.

COMPANIES' MEETINGS AND REPORTS.

West India and Panama Telegraph Company (Limited).

The thirty-fourth ordinary general meeting of this Company was held on Wednesday at Winchester House, Mr. C. W. Earle (Chairman) presiding.

The SECRETARY (Mr. R. T. Brown) read the notice convening the meeting and the minutes of the previous meeting, which were confirmed.

The CHAIRMAN: I suppose you will take the report as read? It is one that deals with an uneventful period in our history, and the advantage of such a condition of things is that it limits the material of my address to you, and consequently my occupation of your time. On the accounts, under the heads of Abstracts A and B, I have very little to remark, but, of course, I shall be happy to answer any question any shareholder may put to me upon them. The figures fluctuate within very narrow limits according to the incidents which more or less affect the business we carry on. The outcome of the accounts may be summed up in this way. We have received £4,093 less than in the corresponding period of last year, and our expenses are £2,553 less, the net result being that we are £1,540 worse off than we were at this time last year. Well, now, it is very natural that some shareholders should ask, How is it that as you are £1,540 worse off than in 1893 you can afford to pay us an extra 3d. dividend? Because at this time last year we only recommended a dividend of 6d. That is to be explained by the provisions we were enabled to make in the first six months of 1893. During that period we had what I might describe as a windfall. For some seven weeks there was an interruption in the French cable between Hayti and Cuba, and the consequence was that our competitor's international traffic, such as it was, passed over our line between Martinique and Cuba instead of going over theirs, giving us about £2,800. With the help of that addition to our receipts we were enabled to contribute £3,000 to our reserve fund, and to carry forward a considerable amount for us, namely, £4,000. In the present half-year, four months having elapsed, we are enabled to estimate what the probable outcome of the half-year will be, and looking to the saving that we shall make from our second ship being laid by in dock at home and so costing us about £200, instead of at least £4,000 a half-year if at sea, we think we shall be able to keep up the dividend for the current half-year to the amount it was before. In looking at the traffics, which are very disappointing, I must caution you not to regard with too gloomy a view the falling off shown in our last published traffic receipts, because the French cable interruption last year

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lasted from April 19th to June 5th, and therefore in comparing June 6th traffics, this fact must be allowed for. The most important part of our report refers to those raffic receipts which show a very sad reduction, and we have been trying to find out what are the causes. Well, no doubt trade is bad for one thing, and all the telegraph companies are suffering from declines in their traffics. As sugar is the great staple of the West Indies, it is interesting to see what are the prices of sugar now compared with the prices at this time last year. I find that the prices of muscovado, one of the principal qualities, are now from 10s. 9d. to 11s. 9d., against 14s. 9d. to 15s. per cwt. in 1893, and beetroot 11s. 9d., against 18s. 6d. These figures show a very serious falling off in the prices of the principal export of the West Indies, and no doubt it influences our traffic receipts. But then there are other causes, and one of the most striking is the perfection to which the telegraphing public have brought their codes. In 1874, 20 years ago, the average number of words per message was 15·94, say 16 words, whereas it is now 7·31. That is to say, the West Indian merchant, quite irrespective of reductions in tariff, is spending for the same amount of business, just one-half of his outlay in the olden days. Then, the losses that we have suffered from reductions we were obliged to make in 1891 are rather serious. They amount to £8,000 a year, and we estimate that £20,863 has been lost to us in the 2½ years which have elapsed since those reductions were made. In recent years the reductions have been as follows:—In 1889 the connecting companies reduced their tariffs 10½d. a word, and in 1891 we reduced the tariff to some of the more distant colonies 1s. 11½d. a word, and yet we cannot trace a single additional word having been sent, as the result of those reductions. That might be regarded as the normal consequence of reductions in countries like the West Indies, where the only people who use the telegraph are the commercial men and the official class. The bulk of the population would no more want to send a telegram, even if the charge were only a halfpenny, than to go up in a balloon. They do not want to telegraph, and nothing will tempt them. The immediate consequence of our reductions, or at least what followed, was that some of the colonies reduced their subsidies. After making them a present of £8,000 a year, they reduced their subsidies by £3,300 a year. It appears to me that the reason for their doing so was simply the necessity of bringing about an equilibrium in their Budget. I think the Chancellor of the Exchequer in England would be very glad if he could bring about such an equilibrium by appropriating the revenue of an institution which has no votes in the country, and squaring his receipts and expenditure in that way. Well, gentlemen, I do not think there is anything more that occurs to me to say to you. I shall be glad, as I said before, to answer any question, and in the meantime I will propose the following resolution:—

"*That the Directors' report and accounts for December 31, 1893, submitted to this meeting, be and the same are hereby received and adopted, and that, as recommended by the Board, dividends of 6s. per share on the First Preference shares, 6s. per share on the Second Preference shares, and 9d. per share on the Ordinary shares, the last free of income-tax, be and the same are hereby declared.*"

Mr. GERALD W. BALFOUR, M.P., seconded the motion.

Mr. DYET thought some of the expenses for stationery and printing, as well as the general expenses, might be reduced.

Mr. WEDGWOOD inquired, as the reductions of the tariff seemed to have failed to bring more traffic, if it would not be the best policy to raise the rates?

Mr. JAMESON wished to express his satisfaction with the report generally, and with the efforts the Board were making to bring about some satisfactory results in the Company. He should like to know, however, if it would not be possible to do their repairing with one ship instead of two.

A SHAREHOLDER asked what the present total subsidies amounted to per annum?

The CHAIRMAN: £18,900.

Mr. W. GRIFFITH said of course it was a question of policy whether they could return to the old tariffs. They would be justified in doing so, but it was a question which must be to some extent left to the discretion of the Board. But whether they took that step or not, he thought it might be wise to present a memorial to those Governments who had reduced their subsidies, telling them that their business had not increased, and that they did not get a fair return for the capital invested.

Mr. RICHARD CHAMBERLAIN asked if they were exposed now to the full competition which might be expected from the French cables, or must they look forward to something worse?

The CHAIRMAN: I do not think there is anything worse to come from them. As to the criticisms upon the stationery, I do not know whether Mr. Dyet has had any experience of working telegraphic stations or whether he has taken any trouble to compare our accounts with those of other similar companies. I can assure him, not only upon stationery, but upon every other item, they bear most favourable comparison with other companies' accounts, and show that the closest economy is exercised. We have 21 stations which we have to supply with message forms, papers for correspondence, the forms for publication of news which we are obliged to give for nothing. The stationery is supplied by contract, and I do not think it could be obtained cheaper. The same may be said of the general expenses. Every item is looked into. There is no better staff than ours in the City of London, and everything is closely watched by them and the Board. As to raising the tariff, we should be glad to do so, but it is difficult under present circumstances. With regard to the questions about the two vessels, I think I stated in my address to you that our future expenditure on this ship, the "Duchess of Marlborough," was calculated at something under £400 a year. The previous six months had been an exceptional time, as the vessel had to go to Sunderland to be repaired and refitted under Lloyds' survey. Of course these were expenses which would not occur again for a long time. We shall not send the second steamer to sea unless serious interruptions occur which one vessel could not manage. You must recollect that not only our traffic ceases when an interruption occurs, but our subsidies cease also. Therefore, we do not think that we could safely leave our property to the protection of one ship only. The "Duchess of Marlborough" is now in the docks at London, and we do not expect she will cost us more than £400 a year. We are obliged to keep two men on board, and there is the insurance to pay and a few other small matters. She is kept ready to proceed to sea in 24 hours. The suggestion that we should present a memorial to the Governments has already been carried out. I hope the shareholders do not suppose that anything we could think of as likely to affect the authorities has been neglected. We addressed one of these Governments the other day, and all the reply we got was that they would consider the matter. That is all we can get, and I am afraid memorials have little effect upon them.

The resolution was then agreed to unanimously.

Mr. W. ANDREWS moved the re-election of the Chairman as a Director. He said that from day to day Mr. Earle was at his post giving them the benefit of his large experience and knowledge of telegraphs.

Mr. H. HOLMES seconded the proposition, which was unanimously agreed to.

The CHAIRMAN: I beg to thank you for the continuation of your confidence. I must also thank my colleague, Mr. Andrews, for the flattering terms in which he has spoken of me. I feel I hardly deserve them, but I will accept them in the spirit in which they are made. Again I beg to thank you all.

Mr. R. CHAMBERLAIN proposed—

"*That Messrs. Deloitte, Dever, Griffiths and Co. be elected auditors of the Company at a remuneration of 40 guineas, and that they be authorised to expend 60 guineas on accountants' charges.*"

Mr. JAMESON seconded the motion, and in doing so took the opportunity of congratulating the Chairman upon the way in which his labours had contributed to improving the position of the Company.

The motion was then adopted.

The CHAIRMAN: That is all the business.

Mr. W. GRIFFITH: We ought not to separate without passing a vote of thanks to the Chairman and his co-Directors and to the staff.

Mr. F. W. CHURCH seconded the proposition, and it was agreed to unanimously.

The CHAIRMAN having acknowledged the compliment, the proceedings terminated.

London Electric Supply Corporation (Limited).

The seventh ordinary general meeting of the shareholders of this Corporation was held at the offices, Adelphi-terrace, Strand, on Wednesday, under the presidency of Mr. James Staats Forbes.

The SECRETARY (Mr. R. Stewart Bain) having read the notice calling the meeting, the report and accounts were taken as read.

The CHAIRMAN, in moving the adoption of the report, first referred to the accounts. The No. 1 statement, showing the position of the share capital, had in no sense altered in the last year. The sum of £555,000 had been paid up out of a total of £1,000,000 of Ordinary shares and £240,250 had been paid up out of a total of £250,000 of Preference capital. There was, therefore, a very large margin of Ordinary capital, and a small amount of unpaid Preference capital. In regard to the loan capital, at their last meeting he dwelt on the position of the Company and the resources they had in their powers to borrow. He on that occasion called their attention to the necessity of raising more capital to the extent of £50,000, and stated that one of the Directors, Lord Wantage, who was their largest shareholder, had agreed to advance £50,000 on mortgage of the Company's undertaking. He stated at the same time that the principal money would become due in three years, and that there must be no misunderstanding as to the character of the mortgage in the event of circumstances at the end of that time making it impossible either to raise new capital or pay off the loan in some way. Since then the further necessities of the Company, resulting from two causes—partly from expansion and partly from breakdowns and rebuilding—had involved the necessity of increasing the loan to £80,000. The loan becomes payable next March, and they were now under the necessity also of devising means of raising some more capital—not a large amount—to enable them to carry on for the next year or two. With regard to their undertaking as a going concern the accounts for the past year revealed this—that although they were not as good as they could have hoped and as might have been reasonably expected, they were a great deal better than they were in the previous year, for whereas the accounts for the year 1892 showed a loss on the working of about £4,000 in round figures, the accounts now submitted showed a profit—a minute one—but still there was no loss. The number of lamps had increased from 46,197 in 1892 to 61,924 on December 31, 1893. That was an increase of 34 per cent., which was tolerably satisfactory, although less satisfactory than it might have been but for the occurrence, in a less acute form, of some of those disturbing causes in the supply of electricity to their customers which had dogged them from the beginning. Their progress even during the past year had shown a marked improvement in remedying those diseases in various parts of the system which made the patient bad in 1892 and in 1893 not so bad, but still not in sound health. It seemed to him that the thing would turn on this—how far they could, by dint of curing these evils, establish a character for continuity and efficiency of supply. They were in a greatly improved position in connection with all the details of their business as compared with their position in 1892, and they were infinitely more secure than they were in 1891. Notwithstanding all their drawbacks, they had had, as he had said,

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an increase in the number of lamps of 34 per cent. If the payment per lamp had remained normal—if that had not been affected adversely—the results would have been correspondingly good in respect of receipts, which, however, showed an increase of only 6 per cent., the average price of the unit having been materially reduced owing to the competition among the different companies. The average receipt per unit in 1892 was 6·90d., and in 1891 it was 7d., and they would judge what a difference this made when they were dealing with a quantity of about one million of units. Their position would have been greatly different if with an increase of 34 per cent. in the number of their lights the price of them had remained them same. The cutting of the price had made the cost per unit almost the selling price. The effect had been felt all round, even by the Metropolitan, the Westminster, and the St. James Companies. Those companies were happier than the London Company in the sense that they were more developed ; and they were also happier in another sense, that their capacity of development had cost them a vast deal less than the London Company's capacity had cost. Those companies had followed in the wake of the known and had not rushed to the experimental. One of the things that was affecting them even now was that their experiment had not yet been carried out. The real secret of success in the business was the number of lamps, because the fixed charges were the same, whether the number of lamps was small or large, as the cost of production did not materially increase unless the number of the lights largely increased. There was formerly a good deal of speculation as to what a lamp ought to earn, and probably they would remember that the lamps when they contracted for them were £1 per annum. Invention, however, afterwards found out a meter, and they were bound by their Act of Parliament to sell at per meter as soon as a proper and reliable meter could be found. Naturally, their consumers preferred to pay by meter where they had some idea as to what they were paying for. Contracts were now almost entirely gone out of their business. Great care now was also taken in economising the consumption, which had become almost a mechanical proceeding. They had thus had, concurrently with the diminution in the price of the unit, a considerable decrease in the consumption of the unit. These facts were apparent in the returns of all the companies, and it therefore seemed a question whether the cutting of the rates to a point at which they scarcely paid was desirable, and whether the companies would not be driven in their own interests, and with entire justice to the consumer, to take what the law allowed them to take per unit. A cutting rate, coupled with a diminished consumption, would very soon find its level in there being nothing left for the companies. The proportion of house lighting was also increasing, and the average consumption in private houses was much less than in clubs, restaurants, and such places. The fact was that they were working out slowly the elements on which the undertaking was to be conducted for the future. He did not think it was necessary for him to deal with the details of the revenue account, which were set forth in great detail in the statement which had been presented to them. The accounts showed the minute—he might say microscopic—balance on the right side of £172 ; but this £172 must be taken in contrast with the loss shown in the previous balance-sheet of £3,914. The account was thus in round figures about £4,000 better than it was a year ago, although they had had to contend against the adverse incidents to which he had alluded, many of which would not, they believed, recur. They had now gone through nearly four and a-half months of the current year with a remarkable absence of those faults and interruptions which in former years had so adversely affected them. There was one matter which he desired to point out in the accounts, especially when the position of Director *versus* the shareholder was criticised so much, and that was the question of the apportionment in the accounts of charges to capital. This was a thing which they need not blink at all, and it was quite a mistake to do so. During 1893, as in preceding years, they had placed certain charges to capital account, with the entire concurrence of their auditors. While the business was progressing and their minds were engaged in the building up of the Company, some reasonable proportion of the general charges might be properly carried to capital. In the present case they had carried £4,000 to capital, and he for one was prepared to defend this proceeding against all comers, including the Board of Trade auditor if the latter challenged it, on the ground of it being a reasonable proceeding. It should also be remembered that they were under the obligation of keeping their accounts upon a particular model designed and approved by the Board of Trade with the view to a possible contingency—namely, the right by the Local Authority of each area at the end of a term of years, on notice, to take over these properties at their then value. A good many wise heads had been put together, with an absolute indifference as to the question of how far it affected the immediate revenue, but whether it was proper in a company, out of its revenue, to pay amounts of money from year to year, which, on an aggregate of years, would represent a very large capital sum—to the advantage of the gentlemen who, under the Provisional Orders, could eventually come in to purchase up the concern at its then value. He should advise—and no doubt his colleagues would concur in the proposition—that a legitimate appropriation to capital should be insisted upon with their eyes open, with a view to its effect upon the future, and not exclusively on the present. Sir John Pender, at the recent meeting of the Metropolitan Company, stated that the item of management charges would now disappear for the first time from the capital expenditure. For some years that company, like the other companies, had put to capital account a proportion of their general expenses ; but of course, when they began to make a considerable profit the rule might be relaxed. They had spent on capital account in the past year £33,086. As he had said, they were suffering because they started a great experiment, which, however, might even now turn out to be a great success. It had made wonderful strides in the direction of the original idea up to that moment, notwithstanding all their drawbacks, but he desired to give them an illustration and an analysis of their capital account, and certain expenditure connected with it, as compared with the expenditure required consequent upon the expansion of the business. The account was divided into two heads. One was for new machinery—that was to say, all the addition to existing machinery which was consequent upon the expansion of their business. When they had 46,000 lights they had a factor to deal with, but that number had now increased to 62,000 lights. That meant that every new customer had to be provided with a transformer, a switch, and a great variety of machines, which cost money. The necessity of providing for progress required some outlay for mains, dynamos, &c., but this was a matter which one could accept with equanimity because it meant spending money wisely, to provide for future expansion ; but what was extremely disagreeable was when they were obliged to provide a great deal of new machinery, and to spend a good deal of money to replace something which had become obsolete. The effect upon them in the past year of this had been that out of the total expenditure of £33,086, £13,176 had been for replacing obsolete machinery, which, in fact, was in their way, and it was so inefficient that it was better to sacrifice it by replacing it with new machinery than by keeping it going. That was a charge in connection with the founding of the business. One knew that many things became obsolete by the progress of science, and they then had the alternative presented to them, either of abolishing what had become obsolete or replacing it or "sticking in the mud" and making no progress. He rather pointed to this matter with the object of arguing that there was a limit to this kind of loss. They had now got a machine in work, effective for the lighting of 90,000 lamps, and at the present time the number was 65,000. This number they hoped to develop to 90,000, but what they had to take care of was that when they approached 90,000 they did not fall into danger. At present they had a sufficient reserve of force when the lighting was at its fullest development to secure them against breakdowns, but they would get upon very dangerous ground indeed when they got to between 70,000 and 80,000 lights. What they ought to do—and do very quickly—was to spend £12,000 in providing another dynamo, which would not only give them absolute security in the character of reserve, against the possibilities affecting the 90,000 lights, but it would also give them an increased capacity of 25,000 lights. This was rather an interesting point—that, bad as a thing was, and great as the waste was in effete or obsolete things, a very small amount of money added from time to time to what they had got would give them a large increase of security and capacity. They knew that in the area where they were it had not developed at all to the extent of its capacity, and, therefore, instead of searching for new fields of enterprise, they had determined that the proper thing was to cultivate and develop to its proper capacity the field of which they were in possession ; but that could not be done without money. As he had said, Lord Wantage had been good enough to find £50,000 for them on mortgage, and that sum was exhausted. His lordship then found a further £30,000, which was practically exhausted, or would be very shortly. The point was, what was to be done? They had consulted with some of the largest shareholders at a conference that was held before the general meeting, but he regretted to say that they were unable to come to any result. It would be suicidal to think of regarding the position as hopeless, and "to chuck up the sponge," because a comparatively small additional sum was required. Happily they were in the hands of a gentleman who was the largest shareholder and their mortgagee, and he did not think that that gentleman was likely to resort to extremities without affording his partners in the undertaking an opportunity of considering whether they would not attempt the rescue of the affair just at the moment when it had survived all its unknown troubles, when they were appreciated and almost cured, and just at the time when, notwithstanding all that experience, they found that the increase in the number of lamps was proceeding in a very satisfactory ratio. If they went on at the rate of 34 per cent. upon 62,000 they would very soon have got the 90,000 which they could now safely light, and the income of every 10,000 lamps additional would be for the greater part of it absolute profit. All the fixed charges would remain the same, as would also the sunk capital ; it was the mere coal and water involved in the generation of so many more units. A point which was very satisfactory, and to which he desired to refer at the request of a large shareholder, was the transmission of the current from Deptford. The shareholder in question had found abroad the idea that the ruin of the Company had been the enormous amount of current that was lost in the transmission of the current between Deptford and the distributing stations in London. Mr. Edison warned him (the speaker) about this point when he visited Deptford. Mr. Edison said he thought that the idea was a very fine one, but that they would be beaten by their wastage of current in getting it to London. At that time there were no means of determining what amount did come to London, but they now knew exactly how much current went into the mains at Deptford, and how much came out and went into the stations ; and the loss all told was about 5 per cent., and certainly did not exceed 6 per cent. This was extremely satisfactory ; but they had found out something else. The proportion of this loss of 6 per cent. was about equally divided in the current travelling in the mains and the magnetising of the large transformers at the stations. Their great drawback had been not in the magnetising of these large receptacles at the distributing stations, but in the small transformers on the premises of the consumers. This had been a very serious business, and among the items described as new machinery to replace obsolete they had had to take out transformers which were extremely wasteful, in order to put in others which were very economical. The sum of £5,000, had, however been expended in this way in the past year, and they were going on with this outlay. Already by this change the proportion of current sold had increased. If they could sell, as the low-tension companies professed to do, 75 per cent. or 80 per cent. of the current generated, they would be in a very different position, but they were now working in the improved manner he had intimated. He desired to impress upon them that the undertaking was not a hopeless one, to be abandoned in despair. It was, in fact, emerging from darkness into light, and it would be almost a scandal to let it drift for the want of a little more capital. Turning to the report he

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remarked that in the past three or four years they had insisted on the engineers of the Company—Mr. Ferranti in the first place, and then Mr. D'Alton (Mr. Ferranti's successor) and their friend Dr. Fleming—putting in black and white from year to year their version of how the thing was electrically and mechanically. He desired to impress upon them that £12,000 was absolutely necessary to ensure the continued supply of current for 75,000 or 80,000 lamps the moment they got to that point. They had now reached to 65,000, and, therefore, if the business progressed, as they hoped in the winter months it would in something like the proportion of last year, they would very soon be at danger point, and then, in consequence of a want of reserve, they might find the whole thing stopped for six hours. All outside debts of the Company, excluding the mortgage, were covered by £6,000. They required, as an outside sum, about £30,000 to carry the thing on for two years, including the new generating unit, which would be a source of safety and expansion both. They were a little embarrassed because they had no working capital, and the £30,000 included a little margin in this direction.

The DEPUTY-CHAIRMAN (Major C. B. Waller) seconded the motion.

Mr. BARHAM regarded the report as very unsatisfactory.

Mr. MULLENS doubted whether persons would provide the capital required at such a rate of interest as 5 per cent. They would have to be tempted by a higher rate—say 10 per cent.

After a few remarks from Mr. CHARLES (who thought that under the circumstances the Directors ought to give the Company their services for nothing),

The CHAIRMAN, in reply, said that Mr. Mullens had answered the material point raised by Mr. Barham, namely, that the mortgage referred to was represented by the debentures. They were issued as security for Lord Wantage's advance; they formed a first charge on the undertaking, and were payable in March, 1895, with a right of foreclosure in the event of non-payment. What they had to do between now and March next was to see whether the shareholders could agree to some plan by which a sufficient sum of money would be provided to enable them to get out of the position of being liable to be sold up by the mortgagee. Probably they would not determine that question that day. He had tried to make it clear that the misfortunes of the Company originated in their starting a great experiment, which had so far failed, but that was no reason for throwing the thing away. What they would have to do would be to consider, he supposed, something like the sensible suggestion which had been made by Mr. Mullens. If a sufficient amount of debenture stock were created to pay off Lord Wantage, or a sufficient amount were created on reasonable terms in conjunction with Lord Wantage's mortgage they could probably go on. Negotiations had been on foot with a view of living in amity with the other companies, and those negotiations were pending at the present time.

He then put the resolution, and it was carried. Subsequently he stated that the retiring Directors were Mr. Joseph Pyke and Major Waller. He had frequently had the point in his own mind whether he himself ought not to retire, and he felt that he ought to do so as far as either his comfort or his responsibility went, but he considered that to retire from a thing when it was in trouble was dishonourable. He was, however, quite prepared to retire if the shareholders wished him to, but he would not voluntarily leave the concern so long as he thought he could retrieve a position which he desired them to remember he had had no part in creating. As regarded other members of the Board, they had not deliberately lost the shareholders' money or their own, and it was to be remembered that they owned two-thirds of the whole of the capital.

On the motion of Mr. BARHAM, Mr. Pyke and Major Waller were severally re-elected, as were also the auditors subsequently.

The CHAIRMAN, in acknowledging a vote of thanks, said that no one lamented the Company's misfortunes more than the Directors; and notwithstanding the little adverse criticism to which they had been subjected, and which was natural, they would not be discouraged from pursuing a course which was most likely to retrieve past disasters.

The proceedings then terminated.

The following is the Directors' report above referred to, which only reached us three hours before the time fixed for holding the meeting:—

The reports of Dr. Fleming and the engineer, appended to this report, describe the works that have been carried out during the year, and the general condition of the Company's station and plant. During the short time the new transformers have been in use their greater efficiency has sensibly decreased the loss of current. When the whole of them are installed, a considerable advantage will arise from the increase in the proportion of saleable current to current generated. The other important new works described in the engineer's report have proved beneficial, and have materially increased the efficiency of the system of supply. The increase in the number of lights during the year amounts to about 34 per cent., and but for the general depression of trade this rate of increase, which was most marked in the first half of the year, would doubtless have been greater.

The result of the year's working shows an improvement on previous years, the revenue account showing a small balance to the good, as against a loss of £3,914. 9s. 7d. last year, and this notwithstanding the reduction of the standard charge to 6d. per unit and the severe and continuing competition in the best districts of the Company's area of supply. In view of the growing increase in the use of electricity, and of insuring uninterrupted continuity of supply to consumers, the Board recommend that a new generating unit of 1,250 H.P. be provided as speedily as may be. This, with the necessary apparatus for connecting new customers, will, however, involve a further extension and expenditure of capital. Mr. Francis Ince has retired from the Board. The Directors retiring by rotation are Mr. Joseph Pyke and Major C. B. Waller, who, being eligible, offer themselves for re-election.

Engineer's Report, dated May 1, 1894.

I have the pleasure to report that during the past year the Company's consumers have received a more satisfactory supply of electric energy; the working of the year, as a whole, showing a distinct improvement on all previous years, both with regard to the steadiness of the light, and the continuity of supply. We commenced the year with a connection of 46,197 lights; at the end of the year the number had increased to 61,924. But for the commercial depression and other disturbing causes in the latter half of year, the increase would probably have been greater. Towards the end of the year a new 300-H.P. dynamo was brought into use. This will prove a great advantage in enabling us to deal with our daylight load without starting the larger machines, and in this way a marked economy will be effected. The 10,000-volt trunk mains from Deptford to London, originally fixed to the parapet of the South-Eastern Railway, were removed and laid underground with perfect success during the summer, and without any interference with the continuity of supply. By this important work we are now protected from the accidents from which we suffered so seriously in the past; whilst the annual charges will be considerably decreased, owing to the reduction in the cost of maintenance, and the rental of wayleaves on the railway.

The distributing mains have been carried into the Parish of Chelsea, and further extensions have been made in the Parishes of St. George's, Hanover-square; St. James; St. Martin; St. George-the-Martyr; St. Margaret and St. John; St. Saviour; St. Olave and Newington; amounting in all to 2½ miles, bringing the total length of distributing mains laid to 38 miles. All the Company's mains have worked satisfactorily during the year, and the charges for repairs and maintenance have been lessened.

A filtering plant, capable of dealing with 100,000 gallons of water per day, has recently been erected at Deptford, by which we are now able to use the river water for the boiler supply, and thus to dispense with a great portion of the supply hitherto derived from the Kent Water Works Co. This will result in a saving of from £400 to £500 per annum under present conditions. New house transformers, amounting to 2,442 H.P., were purchased last year; of these, 1,477 H.P. are now in use on the circuits, leaving in stock 965 H.P., which are being put into use as speedily as possible. Owing to the delay of the manufacturers in making delivery, it was not until the last month of the year that this work could be commenced, but from the observations I have taken up to the present time I am able to say that this change will have good economical results. To replace the whole of the old type transformers now in use, a further 1,045 H.P. of the new type will be required. The generating and distributing plant is in good order, and is working to my entire satisfaction.

P. WALTER D'ALTON, Engineer-in-Chief.

Dr. Fleming's Report, dated May 1, 1894.

I have read the report of your engineer and agree with it. The replacement of the old form of house transformers by instruments of newer and more economical type has now proceeded to a considerable extent. The result of this exchange has already made itself evident, as we anticipated it would, in a decreased proportion of loss in distribution. There is every reason to believe that when this exchange is completely effected the gain in economy will show itself to the extent indicated in the report of last year. A careful process of testing each transformer for efficiency before it is employed is now adopted. Methods have also been put into operation during the last year for measuring the total daily output from the generating station, which permit the effect of improvements in the distribution plant to be clearly ascertained. A systematic record is thus obtained of the number of units generated as well as sold.

J. A. FLEMING, M.A., D.Sc., F.R.S.

Western and Brazilian Telegraph Company (Limited).

The following is the report of the Directors of this Company for the half-year ended December 31st last, to be presented at the twenty-seventh ordinary general meeting, to be held at Winchester House, E.C., on Thursday next, the 17th inst., at 12 o'clock:—

The total earnings amount to £80,338. 18s. 3d., as against £86,954. 11s. 2d., showing a decrease of £6,615. 12s. 11d. compared with the half-year to December 31, 1892. The working expenses amount to £35,592. 8s. 10d., as against £37,165. 11s. 5d., a decrease of £1,573. 2s. 7d. Including the amount brought forward from June 30, 1893 (£7,679. 4s. 7d.), and the dividend received upon the shares held in the Platino Company, the balance to the credit of the revenue account is £61,659. 9s., from which has been deducted £12,027 for debenture interest, and £7,073 for the debenture redemption fund, leaving £42,559. 9s., of which £5,000 has been placed to the reserve fund. The Directors now recommend the payment of a dividend of 7s. 6d. per share, free of income-tax on the Ordinary shares, being a dividend of £2. 10s. per cent. for the year, leaving a balance of £1,045. 6s. 6d. to be carried forward. In the case of shares which have been divided into "Preferred" and "Deferred," the 7s. 6d. per share now recommended will be payable to the "Preferred" shareholders, making up the full dividend of £5 per cent. on the Preferred shares for the year 1893.

The shareholders will remember that at the general meeting of the Company, held on May 12, 1892, the Directors reported that they had made an arrangement with the Brazilian Submarine Company, that in consideration of this Company duplicating at once certain sections of the line, the Brazilian Submarine Company guaranteed this Company a payment of £6,000 per annum. This began from June 7, 1892. The Brazilian Submarine Company have raised the contention that under this agreement they have acquired the right to control the tariff of both Companies, for the purpose of meeting competition. This Company was advised by Sir Horace (now Lord Justice) Davey and by other eminent counsel who have been consulted, that the Brazilian Submarine Company has acquired no

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such right and has no such such power, and that this Company is entitled to deduct she annual sum of £6,000 from the joint purse. Under these circumstances, the Directors have taken credit for this sum in the accounts, and they are advised that the legal proceedings which this Company has been compelled to institute in the matter will, before the next meeting, in all probability be settled. They do not, therefore, propose to deal separately with the amount on the present occasion.

In consequence of the "Viking" having been in commission for a portion of the half-year under review, the full economy to be ultimately realised by the substitution of the new "Norseman" to replace the two ships formerly in commission has not yet been reached. The Directors have not written down the ships laid up, because, looking at the large amounts paid from revenue for capital purposes for the new ship and the loop lines, and the uncertainty as to the sum that may be realised for the disused ships on sale, they think that this matter should remain in suspense until the sale, subject to the requisite adjustment between revenue and capital being then made.

The shareholders are aware that the exceptional state of affairs in Brazil, referred to in the last report, continued until quite recently. The rate of exchange has also been much depressed.

The fourth annual drawing of the "A" and "B" Debentures, amounting to £14,200, have been drawn and have been paid off at par.

The Pacific and European Company's land line, connecting Buenos Ayres with Valparaiso, was opened for traffic on March 19th last.

The retiring Directors are Lord Richard H. Browne and Mr. C. W. Earle, who offer themselves for re-election, as do also the auditors, Messrs. Turquand, Youngs, Bishop and Clarke, and Messrs. Deloitte, Dever, Griffiths and Co.

NEW COMPANIES. STATUTORY RETURNS, &c.

BRITISH ALUMINIUM COMPANY (LIMITED).—This Company was registered on May 7th with a capital of £100,000, in £10 shares, to carry on any business relating to the winning and working of minerals, the production and working of aluminium or sodium and other alloys, and the production, use and sale of electricity and electric power, for lighting, heating, motive power or otherwise.

CALIFORNIAN ELECTRIC POWER AND MINING DEVELOPMENT SYNDICATE (LIMITED).—This Company was registered on April 28th, with a capital of £30,000 in £1 shares, to construct or maintain electric power or lighting works, telegraphic or telephonic systems, lines, cables and works, railways, tramways, and other means of communication, &c., in California and elsewhere.

LANCASHIRE RUBBER COMPANY (LIMITED).—This Company has been registered with a capital of £70,000 in £5 shares, to acquire the business of a rubber manufacturer now carried on by the Lancashire Rubber Company, and to carry on business as manufacturers of and dealers in rubber and rubber goods generally.

CALIFORNIA GAS, WATER, AND ELECTRIC LIGHT COMPANY SYNDICATE (LIMITED).—The annual return of this concern, which has just been filed, states that 1,475 shares out of an nominal capital of £2,000 in £1 shares, has been taken up, the full amount called, and all calls paid.

CAMBRIDGE ELECTRIC SUPPLY COMPANY (LIMITED).—The second annual return of this Company, made up to March 20th, has been filed. 2,775 shares of £10 each, out of a nominal capital of £50,000, were taken up and allotted. On each of these a call of £8 has been made, resulting in the total payment of £22,200.

CHAMBERLAIN AND HOOKHAM (LIMITED).—The annual return of this Company made up to April 25th has been filed. The nominal capital is £100,000, divided into 5,000 "A" shares of £10 each and a similar number of "B" shares of the same denomination, and of these, 1,000 "A" and all the "B" shares have been taken up, the latter being considered as fully paid. Upon the "A" shares a call of £3. 10s. per share has been made, resulting in the payment of £3,500.

CHARING CROSS AND STRAND ELECTRICITY SUPPLY CORPORATION (LIMITED).—According to the annual return of this Company, made up to March 6th, and recently filed, the whole nominal capital, of £150,000, in £5 shares, have been taken up, the full amount called, and the total amount paid.

CHATHAM, ROCHESTER, AND DISTRICT ELECTRIC LIGHTING COMPANY (LIMITED).—The annual return of this undertaking, made up to April 3rd, and recently filed, shows that 3,890 shares have been taken up out of a nominal capital of £50,000, in £5 shares. Of these, 1,863 have been issued as fully paid, upon 2,000 the full amount has been called, while upon the remaining 27 shares a call of £2 per share has been made, resulting in the payment of £10,051. 10s., and leaving the sum of £2. 10s. as yet in arrear.

CITY OF BATH ELECTRIC LIGHTING AND ENGINEERING COMPANY (LIMITED).—The third annual return of this Company made up to March 21st, was recently filed. The nominal capital is £60,000, divided into 5,500 ordinary shares of £10 each, and 50 Founders' shares of £100 each. Of these 3,384 of the former, and all of the latter have been allotted, and of these 2,250 Ordinary, and the 50 Founders' shares have been issued as fully paid. Upon the remaining 1,134 Ordinary shares the full amounts have been called and paid.

COUNTY OF LONDON AND BRUSH PROVINCIAL ELECTRIC LIGHTING COMPANY (LIMITED).—The annual return of this Company, made up to June 6, 1893, was not filed until April 9, 1894. Out of a nominal capital of £800,000, in shares of £5 each, 200 shares have been taken up. On each of these a call of £4 has been made, resulting in the payment of £800.

CROSSLEY TELEPHONE COMPANY (LIMITED).—The annaul return of this concern, made up to December 30th, was recently filed. The Company has a nominal capital of £100,000, divided into 5,000 "A," 12,500 "B," and 2,500 "C" shares of £5 each. At the time of compiling the present return, 607 "A," 120 "B," and 350 "C" shares have been subscribed for and allotted, and the full amount called, resulting in the payment of £5,385.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).—The annual return of this Company, made up to February 28th, has been filed. The whole nominal capital of £220,000, divided into 16,000 Ordinary and 6,000 Preference shares of £10 each, was taken up, the full amount called, and all calls paid.

DICK, KERR AND CO. (LIMITED).—The annual return, made up to April 12, 1894, and recently filed, states that the whole capital of £160,000, divided into 16,000 ordinary and 16,000 Preference shares of £5 each, has been taken up, and the full amount called and paid on the Preference shares, while the Ordinary were all issued as fully paid.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—The annual return of this Company, made up to April 3rd, was recently filed. The nominal capital is £95,000, divided into 13,000 Ordinary and 6,000 Preference shares of £5 each. 12,931 Ordinary and 6,000 Preference have been taken up, and the full amount called on the latter class, while £4 per share has been called on the Ordinary shares, resulting in the total payment of £81,724. For subsequent capital arrangements, see *The Electrician*, April 20th, p. 705.

DIRECT UNITED STATES CABLE COMPANY (LIMITED).—The annual return of this Company, made up to February 6th, has recently been filed. 60,710 shares of £20 each, of a nominal capital of £1,300,000, were taken up, and all of these have been issued as fully paid.

CITY NOTES.

AFRICAN TRANSCONTINENTAL TELEGRAPH COMPANY (LIMITED).—The second ordinary general meeting of this Company, which was to be held yesterday at the Company's offices, 19, St. Swithin's-lane, was adjourned till Thursday next, at noon, a quorum of shareholders not being present.——In connection with the alleged conflict between this Company's party and the Portuguese, the Governor-General of Mozambique states that the official advices from the Governor at Tete contain no reference whatever to any hostile action by the English gunboats. The Governor believes the whole story to be a canard, and says that the telegraph line to the frontier is being actively constructed by the Portuguese.

CHINA AND JAPAN TELEPHONE COMPANY (LIMITED).—A meeting of this Company was held on the 2nd inst. The proceedings were formal, the Directors' report and accounts being adopted, and the retiring Directors and Auditors re-elected. The Directors' report showed that the revenue for the year ended December 31st, after charging debenture interest, amounted to £435. 15s. 6d., which was transferred to profit and loss account, which now amounts to £920. 18s. 10d., which was carried forward. The year's working showed a less favourable result than the previous one, although the gross income of the Company in China has further improved. This was due chiefly to the continued decline in the value of the dollar and the consequent increased loss on remittances from China.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended May 6th were £886, as against £793 in the corresponding period of 1893, being an increase of £93. The total receipts for the half-year amount to £16,400, as against £16,154 for the corresponding period of 1893, an increase of £246.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this Company for April, 1894, amounted to £20,000, and from January 1st to April 30, 1894, £83,000. In the corresponding months of 1892 and 1893, the amounts were £82,800 and £84,000 respectively.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY (LIMITED).—This Company notify that the laying of the second section—viz., between Labuan and Hong Kong—of their alternative Singapore-Hong Kong cable has now been completed and the line opened for traffic.

HASTINGS AND ST. LEONARDS-ON-SEA ELECTRIC LIGHT COMPANY (LIMITED).—This Company announce the issue of shares to the extent of its authorised capital. The working of the Company has assured the payment of dividends on subscribed capital of 5 per cent. in 1890, 7½ per cent. in 1891, 5 per cent. in 1892, and 5 per cent. in 1893. The demand for electric current in the district served by the Company is increasing beyond the Company's power to supply, and it has become absolutely necessary to enlarge the present station, provide additional machinery, mains, and other necessaries. To carry out these extensions £10 shares are issued at par, payable £2. 10s. on application, £2. 10s. on allotment, and the balance in calls of £2s. 10s. each at two months' notice. Applications must be made by the 12th inst. The prospectus says nothing of the amount of the issue, and is, generally, more than usually vague.

HOBART ELECTRIC TRAMWAY COMPANY (LIMITED).—The traffic receipts for the month of April were £1,174.

STOCK EXCHANGE NOTICES.—The Stock Exchange Committee have ordered £150,000 Five per Cent. Debentures, Nos. 1 to 1,500, of the Telegraph Construction and Maintenance Company (Limited) to be quoted in the Official List. Application has been made to the Committee to appoint a special settling day in and to grant a quotation to a further issue of 8,000 Seven per Cent. Cumulative Preference Shares in Crompton and Co. (Limited).

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WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended May 4th (after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited), were £2,924.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the two weeks ending April 30th were £2,490, as compared with £3,604 for the corresponding period of last year.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share	Last Dividend	Name	Previous Week's Price, May 2.		Price Wednesday, May 9.		Rate per Cent. Yielded. £ s. d.	Dividend Due	Business Done During Week Ending May 9. Highest	Lowest
			TELEGRAPHS.								
£1,134,640	Stock	9/0	Anglo-American	43	45	43	45	5 5 6	Jan., Apr., July, Oct.	..	--
£2,932,680	Stock	18/0	Do. Preferred	80½	81½	80½	81½	5 16 7	" "	81½	80½
£2,932,680	Stock	5/0	Do. Deferred	7¾	8½	7¾	8	..	..	7¾	7½
£184,500	100	4%	African Direct Telegraph 4% Deb.(Reg.&Bearer)	101	104	101	104	3 16 11	January and July ..	..	..
180,000	£10	3/0	Brazilian Submarine	12	12½	12	12½	5 4 0	Mar., June, Oct., Dec	12¼	12 3/16
£18,700	£100	5%	Do. 5 per Cent. Bonds	100	103	100	103	4 17 1	January and July ..	..	—
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	108	112	108	112	4 4 10	June and December	—	—
10,000,000	$100	$1¾	Commercial Cable Capital Stock	146	150	140	146	4 16 7	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	12	13	12	13	6 3 1	February and August	--	..
6,000	10	10%	Do. Preference 10 per Cent.	18	19	18	19	5 5 3	" "	..	--
12,931	5	1/7½	Direct Spanish (£4 paid)	2¼	3¼	2¾	3¼	4 16 8	April and October ..	3	--
6,000	5	10%	Do. Preference 10 per Cent.	8¾	9½	8¾	9½	5 8 1	" "	..	..
60,710	20	2/0	Direct United States Cable, 1877	9½	9¾	9½	10	6 0 0	Jan., Apr., July, Oct.	9⅞	9 9/16
400,000	10	2/6	Eastern	14⅞	15⅛	14⅞	15⅛	4 5 11	" "	15 1/16	14⅞
70,000	10	6%	Do. 6 per Cent. Preference	16	16½	16	16½	3 12 9	" "	16 3/16	16
£1,294,100	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	115	118	114	117	3 8 5	May and November	115½	114½
£105,900	100	5%	Do. 5 per Cent. Debentures, 1899	107	110	107	110	4 10 11	February & August	..	--
250,000	10	6/6	Eastern Extension	15⅜	15⅝	15⅜	15⅝	4 9 7	Jan., Apr., July, Oct.	15⅝	15½
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	114	117	114	117	3 8 5	February & August	..	..
£62,700	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs 1900	103	106	103	106	4 14 4	January and July ..	10 ¾	..
£108,700	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	103	106	103	106	4 14 4	" "	.	—
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	104	107	104	107	3 14 9	February & August	105	..
£200,000	£25	4%	Do. 4% Mauritius Sub. Debs.	105%	108%	105%	108%	3 14 1	May and November	106½	..
180,227	10	2/6	Globe Telegraph and Trust	8¾	9	8¾	9	5 0 0	Jan., Apr., July, Oct.	9 1/16	8 15/16
180,042	10	6%	Do. 6 per Cent. Preference	15⅛	15⅜	15⅛	15⅜	3 18 1	" "	15⅜	15 5/16
150,000	10	7/2	Great Northern	21½	21¾	21½	21¾	3 15 11	Jan., April, and July	21 5/16	21½
£200,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	104	107	104	107	4 13 6	March & September	..	--
17,000	25	12/6	Indo-European	45	47	45	47	5 6 5	May and November	--	..
37,548	10	4/0	London Platino-Brazilian	4	6	4	6	..	" "	--	—
£100,000	100	6%	Do. 6 per Cent. Debentures	106	109	106	109	5 10 1	March & September	..	—
£160,000	£100	4%	Pacific European Tel. 4% Guar. Debs. "Red 1942	102	105	102	105	3 16 2	..	..	—
11,839	8	4/0	Reuter's	5½	6½	5½	6½	..	April and October ..	..	—
3,381	£100 Cert.	25/0	Submarine Cables Trust 6 per Cent.	111	116	111	115	5 4 4	" "	..	..
15,609	10	5/0	West African Telegraph	3	5	3	5	..	January and July ..	..	—
£249,900	100	5%	Do. 5 per Cent. Debentures	100	103	100	103	4 17 1	March & September	..	..
30,000	10	2/0	West Coast of America	2½	3	2½	3	..	January and July ..	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	105	109	105	109	7 6 10	June and December	-	..
33,321	10	1/0	West India and Panama	1¼	1½	1¼	1⅝	..	..	1½	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10½	11	10½	11	5 9 1	May and November	10¾	10 11/16
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9	10	9	10	6 0 0	" "	..	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	109	112	109	112	4 9 3	June and December	..	..
64,242	15	4/6	Western and Brazilian	7½	7¾	7½	8	..	May and November	7¾	7½
33,129	7½	4/6	Do 5 per Cent. Cumulative Preferred	6	6½	6½	7	..	..	6⅞	6⅝
33,129	7½	4/6	Do. 5 per Cent. Deferred	2	2½	2	2½	..	..	..	..
£178,200	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	106	109	106	109	5 10 1	February & August	..	—
£222,700	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910.	106	109	106	109	5 10 1	" "	--	—
$1,214,000	$1,000	7%	Western Union 7% 1st Mtge (Building) Bonds	110	115	110	115	6 1 9	May and November	..	—
£169,000	£100	6%	Do 6 per Cent. Sterling Bonds	100	104	100	104	5 15 5	March & September	..	—
			TELEPHONES.								
44,000	5	10/0	Chili Telephone (fully paid)	1¼	2¼	1¼	2¼	..	—	..	—
224,800	10/0	8½d.	Consolidated Telephone Const. & Maintenance	1/16	1/16	1/16	1/16	..	May and November	..	—
171,504	£1	6d.	Oriental Telephone and Electric (fully paid)	⅜	¾	⅜	¾	..	Yearly	..	—
484,597	5	2/6	National	4¾	5	4¾	5	5 0 0	June and December	4 15/16	4 13/16
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	15	16	15	16	3 15 0	" "	15½	15
15,000	10	6%	Do 6% Cumulative 2nd Pref. (fully paid)	14½	15½	14½	15½	3 17 5	" "	..	..
119,234	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	5⅝	5⅞	5⅝	5⅞	4 8 11	..	5⅝	5½
925,017	£100	4½%	Do. Deb. Stk. 4½%	115	117	114	116	3 17 7	January and July	115⅞	115
58,000	5	1/0	United River Plate	1½	2	1½	2	—	" "	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	90	100	90	100	5 0 0	" "	—	—
			ELECTRICITY SUPPLY COMPANIES.								
40,000	£10	..	City of London Electric Lighting (fully paid)	12	13	12	13	—	—	..	..
20,000	10	6/0	Do. 6 per Cent. Cumulative Pref. (fully paid)	13¼	13¾	13¼	14	..	—	13 15/16	13¼
19,900	£5	..	Electricity Supply Co. for Spain	..		..		—	—	—	—
£150,000	£5	..	Electricity Supply Company Ordinary	..		..		—	—	—	—
£50,900	£100	5%	Do. 5 per Cent. Debentures, 1900	..		..		—	—	—	—
8,222	£5	—	House to House Electric	..		..		—	—	—	—
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	..		..		—	—	—	—
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..		..		—	January and July	—	—
30,000	£5	1/9	Liverpool Electric Supply (£4 10s. paid)	5⅞	6¼	5¾	6¼	..	—	—	—
15,000	£5	2/6	Do. (fully paid)	6¼	6¾	6⅜	6½	..	—	..	—
111,000	5	..	London Electric Supply	⅜	¾	⅜	⅜	—	..	..	—
49,900	£10	5/0	Metropolitan Electric Supply (fully paid)	7	7½	7½	8	3 2 6	..	7¾	7⅝
£100,000	Stock	5%	Do. 5% Debs. (Bonds of £10, £20, & £40)	106	109	108	111	4 10 1	June and December	..	—
6,452	£10	..	Notting Hill Electric	4½	5½	4½	5½	—	—	—	—
19,980	£5	4/6	St. James' and Pall Mall	6¾	7¼	6¾	7¼	..	—	—	—
29,000	£5	7%	Do. 7 per Cent. Preference	8	8½	8	8½	4 2 4	—	8 5/16	8
59,900	5	2/6	Westminster Electric Supply (fully paid)	5¾	6¼	5¾	6¼	3 4 0	—	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
90,000	3	1/6	Brush Electrical Engineering	2¾	3	2¾	3	6 0 0	—	2 15/16	2 13/16
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative.	2⅝	2⅞	2⅝	2⅞	5 1 1	—	2½	2 7/16
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	103	111	108	111	4 1 1	March & September	109⅝	..
20,000	5	2/6	Crompton and Co., 7 per Cent. Cumulative Pref.	3½	3¾	3½	3¾	..	January and July	..	..
12,139	5	..	Edison and Swan United	—		—		—	—	—	—
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	..		..		—	—	—	—
120,000	2	..	Electric Construction	¾	1	¾	¾	..	—	⅝	..
12,845	2	..	Do. 7% Cumulative Pref.	1¼	1¾	1¼	1¾	..	..	..	—
91,195	2	10/0	Elmore's Patent Copper Depositing	¾	¾	¾	1	—	—	..	—
29,000	5	..	Fowler-Waring Cables (fully paid)	¾	1½	¾	1¼	—	—	..	..
50,060	10	15/0	India Rubber, Gutta Percha &c., Works	23	24	23	24	5 4 2	February & August	24	23
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102	104	102	104	4 6 7	March & September	103	—
11,334	£10	6/4	International Okonite Ordinary	1	2	..		—	—	—	—
16,000	£10	—	Do. 8 per Cent. Preference	..		..		—	December and June	—	—
20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	—	⅛	—	⅛	..	..	—	..
78,949	5	3/6	Swan United (£3. 10s. paid)	2	2½	2	2½	7 0 4	May and November	2⅛	—
37,350	12	36/0	Telegraph Construction and Maintenance	39	41	39	41	5 17 1	March and July	40	39⅝
£150,000	100	5%	Do. 5 per Cent. Bonds	..		104	107	4 13 6	January and July	—	—
37,514	£5	—	Woodhouse and Rawson Ordinary (£3. 15s. paid)	—		—		—	—	—	—
41,098	£5	—	Do. Preference (fully paid)	—		—		—	—	—	—
			RAILWAYS AND TRAMWAYS.								
£630,000	Stock	½%	City and South London Railway	27	32	28	30	2 1 8	May and November	29½	28½
87,500	£10	1%	Liverpool Overhead Railway	7½	7¾	7¾	8	—	—	—	—

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④ THE ELECTRICIAN:

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NOTES.

In our Correspondence column an interesting reply from Dr. Hopkinson to our leading article of last week will be found. His belief that algebraic methods have been useful for discovery more frequently than geometrical, and that the work being once done, it is often easy to cast it into a geometrical form, points to the need for a clearer understanding of the relation of mathematics to engineers. Let mathematicians, by all means, use algebraic methods, but let engineers be provided with something more intelligible. Dr. Hopkinson is perfectly right in thinking that the methods of the calculus are feared and shunned by engineers, and the reason is simply that some have no heads for algebra, and others have not time to keep their algebra in working order. Algebraical mathematics is largely a matter of practice in transformations and recollection of standard forms of differentiation and integration. Some minds are utterly unalgebraical, as some are unmusical. To appreciate, to remember, and to intelligently use an algebraical method is as impossible in some cases as the recollection and humming of a tune. A very considerable proportion of the intelligent and educated public are unable, perhaps happily, to reproduce a single bar of a popular tune with which the rest of the community has been saturated. Cambridge need not, of course, go out of its way to accommodate totally unalgebraical people with geometrical instruction, for such people do not, of course, take up mathematics as a study.

Some one ought and some one must provide engineers who are either constitutionally or by want of practice unalgebraical, with geometrical methods. Dr. Hopkinson himself has made most valuable contributions, and others have from time to time used geometrical methods or have translated their algebraical work into a geometrical form. But we want more than this—we want well-recognised alternative systems. Dr. Hopkinson says that mathematicians should be ambidextrous equally ready with algebra and geometry. Would that they were! We should then have no cause to complain, and if the calculus could be taught geometrically it would be neither feared nor shunned. A very fair proof of our contention that graphic analysis is not recognised, taught, and studied, is the absence of text-books on the subject. A few engineer's tricks for calculating moments of inertia and a book or two on graphic statics, and that is all. We are very glad to find that Dr. Hopkinson takes so liberal a view of the question. If we have misread his interesting Address, and were in error in supposing that algebraical methods were held to be of supreme importance, and that geometry was comparatively ineffectual, others have probably taken the same view, and have been induced to do so by such expressions as "Formulæ must be used," "Here, again, it is difficult to see how the differential equation and its solution can be evaded."

A short time ago we had occasion to comment on the great waste of steam which results from condensation in steam pipes. Mr. Crompton, in his recent Paper, proposes to get rid of this waste by giving the steam some 8 to 10 per cent., or more, of superheat immediately after it leaves the boilers. While admitting that this would more or less completely prevent condensation in the pipes, we cannot see that any increase of economy would take place. Surely, if a certain number of yards of hot pipe radiate a certain number of thermal units per hour, it is immaterial if this heat escape from saturated or from superheated steam. The waste of energy would be as great in the latter as in the former case; indeed, it might be greater, owing to the higher temperature of the pipes. The only advantage would lie in the absence of condensation, thus preventing the carrying of water into the cylinder; but a much more economical plan would be to pass the steam through a separator. The only really efficient way to prevent loss of heat by radiation from the steam pipes is to have them well lagged with non-conducting material, and, if possible, to shut them down at the boiler end whenever they are not in use.

As for the advantage of supplying the engines with superheated steam, we very much doubt if this is necessary in the case of high-speed electric-light engines. Mr. Willans, in his Paper on "Steam Engine Trials," in 1888, showed that the amount of wetness of the exhaust steam of his engine was entirely due to the work done by the steam during expansion in the cylinders; and that the cylinder condensation which took place on admission was immediately followed by total re-evaporation of the condensed steam. This was with an unjacketed engine supplied with saturated steam. Many engineers are alarmed at the occurrence of wetness in exhaust steam, and think that it shows that initial condensation is going on. Very often they ought rather to rejoice, as the wetness shows they are getting their money's worth out of the steam.

The proposal made by Mr. Geipel, during the discussion, to produce superheated steam by wire-drawing 200lb. pressure of

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boiler steam down to 150lb. pressure in the pipes, does not strike us as being a satisfactory mode of procedure. To begin with, one would be at the expense of raising high-pressure steam in order to throw away 25 per cent. of its pressure in wire-drawing, involving useless expense and risk in the boilers. But the chief objection lies in the fact that the wire drawing would probably not superheat the steam at all, owing to the wetness of the steam; or, if it did superheat it a degree or two, the effect would be completely lost before the steam had gone 10ft. along the steam pipes, on account of the rapid radiation losses which would in any case occur. Superheating by wire-drawing is a very pretty lecture-room paradox. Engineers are inclined to forget that the properties of real steam, as it occurs in a boiler house and engine room, are considerably different from the properties of what we may call "Regnault" steam. The former is always a mixture of steam and water, in spite of its passage through the best form of separator; and it requires only a very small percentage of wetness to prevent superheating, even though the steam may have received as much as 25 per cent. of wire-drawing.

The enforcing of the ten-minute rule in the discussions at the Institution of Electrical Engineers has been attempted at the last few meetings, but the very praiseworthy endeavour to cut down rambling remarks has been frustrated to some extent by the mode in which this attempt has been made. The Chairman has anxiously watched for a suitable moment, when the rambler paused for breath, to ring the bell, and has asked if the meeting desired that the speaker should be longer heard. An uncertain amount of confused noise has been taken for the applause of those who wish for more. Dissent is impossible except by hissing or cries of No! A show of hands would be much better, the vote being given as a simple arithmetical quantity, and the Chairman can estimate the ratio of hands to total members more easily than the absolute value of the energy expended in joules or foot-pounding. An automatic alarum would really be the more dignified signal, for it would save the Chairman the difficult task of chiming in without interrupting a sentence.

The Paper by Mr. Appleyard read at the Physical Society last week dealt with two subjects, the behaviour of dielectrics under pressure, which ought to interest cable men, but will probably fail to do so, and of heterogeneous compounds of gutta-percha and brass filings. The latter present some points of purely scientific interest in connection with oscillatory discharges, but have a practical bearing in connection with the construction of high resistances. Dr. Fleming showed some rods of a mixture of plumbago and clay at the Society of Arts not long ago, and said that they were satisfactory, but nothing more has been heard of them, and instrument makers would, no doubt, like to keep up the idea that nothing but expensive coils of fine wire are suitable for resistances of hundreds or thousands of ohms. Plumbago slides are offered in a deprecating way as good enough for medical men, and cheap pencil-line-on-ground-glass megohms are to be bought. Plumbago and plaster of Paris can be made up into resistances, but what is wanted is some thoroughly trustworthy mixture. Seeing that the temperature coefficient of carbon is negative, while that of metal powder is positive, a negligible coefficient seems attainable.

In our issue of May 26th last year we described the Agthe and Kallmann systems of automatically notifying and localising faults occurring on the huge three-wire network existing in Berlin. Elsewhere in the present issue we give in abstract a Paper recently read before the Elektrotechnischer Verein by Dr. Passavant, in which he has something to say about the actual working of these methods of continuously controlling the insulation of the Berlin system of mains. During the past nine months fourteen faults have in this way been signalled, localised, and at once removed. Dr. Passavant does not tell us anything about false alarms and very little about faults not signalled, but the figures actually given with regard to the latter point show the Agthe and Kallmann devices to be extremely reliable. Out of nine failures that occurred on the main cables five were signalled; of the four unsignalled faults two occurred on circuits not yet provided with signalling apparatus, and two were too small to start the alarm. This record, and the fact that the apparatus has had a year's actual trial in Berlin, will perhaps induce some of our own central station engineers to give the idea a thought. Nowhere does the dictum that prevention is better than cure apply with more force than where interruptions of an electric supply are concerned.

Like the posters that now disfigure so many of our fields and woods, cacophonous cacotechnies, such as the "bega-farads" and "quegohms," to which we made some allusion in a recent leading article, are, fortunately for the continued existence of the Anglo-Saxon idiom, calculated to excite opposition as well as arrest attention. Such, unfortunately, is not the case with the humbler flights of the practical man. It is to his attempts to be at once picturesque and pithy that we owe the monstrous regiment of "boosters" and "buzzers," "naked conductors," and "triple-petticoated insulators." One of the latest admissions to this somewhat mixed society is the "milker," whose useful functions and simple nature were recently set forth in our columns by Mr. Arnot. At first glance the "milker's" relationship, if any, to the other members of the society was difficult of elucidation. We felt satisfied that he could have nothing in common with the boastful "booster," but hazarded the conjecture that he was, perhaps, first cousin to that pink of propriety, the "triple-petticoated insulator," when a brighter brain than ours solved the mystery by dogmatically asserting that a "milker" was obviously only a species of "feeder."

Society of Arts.—The *conversazione* of the Society of Arts is fixed to take place at the Imperial Institute, on Friday evening, June 22nd.

Obituary.—Mr. Arthur Edward Robinson, chief of the Electro-Chemical staff at the Electric Construction Company's works at Bushbury, Wolverhampton, expired, after a brief illness, on Saturday, the 5th inst. Mr. Robinson was only 34 years of age.

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Cable Interruptions:

	Date of Interruption.
Cayenne-Paramaribo	Oct. 25th, 1893.
Bissao-Bolama	Nov. 24th „
Brest-St. Pierre (P.Q. Co.)	Mar. 29th, 1894.

Finsbury Technical College.—A students' conversazione will be held at the Technical College, Finsbury, E.C., on Thursday, May 24th, at 7 p.m. A lecture on "Polarised Light" is to be given by Prof. S. P. Thompson, while Prof. Meldola will describe "The Camera as a Scientific Weapon."

An Electrical Standardising Laboratory for Austria.—It is announced that the State Normal Standards Commission of Austria has decided to establish an electrical laboratory for standardising purposes in connection with the new buildings which are in course of erection for the Commission.

Utilisation of Water Power in Switzerland.—A firm at Aaran has just secured a concession to construct a canal in connection with the Rhine, by which no less than 15,000 H.P. will be made available. It is stated that the large aluminium works at Neuhausen have already contracted for 10,000 H.P.

Electric Radiation.—Our readers will be glad to hear that Prof. Oliver J. Lodge has a treat in store for his audience, at his lecture on "The Work of Hertz," at the Royal Institution, on June 1st. He promises to show a number of interesting, indeed, we may say, rather surprising, experiments on electric radiation.

Bristol.—Recently the Mayor of Bristol, together with the High Sheriff and several other prominent citizens of that ancient city, paid a visit to the Bristol telephone exchange, for the purpose of "inaugurating a new switchboard." We may soon hear of a new station voltmeter being inaugurated by a Prince of the Royal blood.

Electric Power Transmission in Austria.—An electric power transmission plant on the "Drehstrom" system has recently been put down by Messrs. Siemens and Halske, of Berlin, in connection with the Linz Waterworks. The electrical energy is transmitted at 2,000 volts pressure to the pumping station, a distance of about 4½ kilometres.

Water Storage of Power.—The Lynmouth electric supply station is driven by water from the Lynn, but the amount of available water does not always correspond with the load on the station. Consequently, a storage reservoir has been erected on an eminence, having a capacity sufficient to contain two or three days' supply of water. The reservoir, in fact, corresponds to the millpond in an ordinary water-mill plant.

Dynamo Nomenclature.—*Dynamo dimorphe* is the name by which *L'Industrie Electrique* is of opinion that a dynamo giving out continuous currents on one side and two-phase currents on the other should be known. The same journal announces that M. Hospitalier will to-day give an address to the Société Française de Physique, entitled "Générateurs et Transformateurs Polymorphiques d'Energie Électrique et leurs Applications Industrielles."

Royal Society.—The following 15 candidates have been selected by the Council of the Royal Society, to be recommended for election into the Society:—Mr. W. Bateson, Mr. G. A. Boulenger, Dr. J. R. Bradford, Mr. H. L. Callendar, Prof. W. W. Cheyne, Mr. R. E. Froude, Prof. M. J. M. Hill, Prof. J. V. Jones, Mr. A. E. H. Love, Mr. R. Lydekker, Mr. F. C. Penrose, Dr. D. H. Scott, Rev. F. J. Smith, Mr. J. W. Swan, and Mr. V. H Veley.

Technical Education.—The Master, Wardens, and Commonalty of the Society of Merchant Venturers of the City of Bristol have decided that their technical school shall henceforth be known as the Merchant Venturers' Technical College. In this connection the following nominations have been made: Principal and Professor of Chemistry, Mr. J. Wertheimer, B.Sc., B.A.; Professor of Mechanical Engineering, Mr. J. Munro, M.I.Mech.E.; Professor of Electrical Engineering and Applied Physics, Mr. W. Wilson, M.A.

Exports of Telegraph Wire and Apparatus.—The export trade of this country in telegraph wire and apparatus connected therewith, shows a little more activity than it did last year, although it is still a good way behind the trade of 1892. During the first four months of this year the value of the exports amounts to £452,018 as against £435,434 in the corresponding period of 1893, and £543,962 in the first four months of 1892. The exports last month amounted to £186,739, out of the £452,018, as against only £43,475 in April, 1893.

Telephony v. Traction.—It is reported that the Bell Telephone Company of Canada has brought an action against the Montreal Street Railway Company to recover damages for expenses incurred in placing return wires on its lines, the former use of the earth being rendered impossible by the interference caused by the electric railway circuits. The contention of the Telephone Company appears to be that it has obtained, by long usage, a vested right to the use of the earth for the purposes of its business, of which the action of the Railway Company has deprived it.

Fire Alarms.—Owing to the Post Office method of unearthing "earths" by pricking their wires, the single-wire telegraph fire-alarm circuits of the London County Council, which run in the same ducts as the Post Office wires, are frequently put in this way to earth, with the result that a false alarm ensues. One of the disadvantages of using telephonic fire alarms is, it has been pointed out, the necessity of using double-wire circuits. Under the conditions which obtain in London, however, this disadvantage would be converted into a positive advantage, since line-prickers would no longer make firemen's lives a misery with false alarms.

Electrolysis in Sugar Manufacture.—We are assured, says *La Lumière Electrique*, that sufficient success attended the electrolytic experiments made last season in connection with the manufacture of beetroot sugar to warrant their renewal this year. In addition to the experiments at French factories, some three-and-thirty German firms tried various electrolytic processes. The presence of one part of salt prevents the crystallisation of four parts of sugar, and the idea of certain electrolytic processes is to eliminate the saline constituents of the juices by electrolytic osmosis. In other processes no diaphragm is used, and the aim is to destroy the organic salts and generate alkaline carbonates.

Tinning Cast Iron.—A French company is said to have adopted a process of tinning cast iron by first covering it electrically with a coating of nickel and iron or cobalt and iron. One kilogram of sulphate, nitrate, or chlorate of nickel is mixed with 3 kilograms of the sulphate of iron and 1 kilogram of citric or tartaric acid; or 1·2 kilogram of sulphate, nitric, or chlorate of cobalt with 3 kilograms of sulphate of iron; this is dissolved in 100 litres of water, to which a sufficient quantity of a caustic alkali is added to neutralise the solution completely; a little bisulphate of potash, soda, or ammonia may be added to increase the conductivity. The cast iron is immersed, and a current is passed having a density of about 50 amperes per square metre of surface to be coated; about 7 volts are required.

Reduced Charges for Electricity.—The Kensington and Knightsbridge Electric Lighting Company announce that after July 1st next electricity supplied by them will be charged for at the rate of 6d. per unit, instead of 8d., as previously. A further economy the Company state can be effected by the use of higher efficiency lamps than those in general use at the present time. Such lamps (of various makes) can be purchased at the Company's Office. A certain number of lamps out of each case received by the Company are tested to ascertain that they are up to the required standard.——It is also announced that the Westminster Electric Supply Corporation have decided to reduce the price of electricity, after Midsummer, for motive power, cooking and heating to 4d. per unit where the supply is taken through a separate meter.

Train Electric Lighting.—It is reported that the London, Brighton and South Coast Railway Company has finally decided that their electrically-lighted trains are more serviceable than those lighted either by gas or oil. For some time, all three systems of train lighting have been tried upon this railway. The electrically-lighted trains not being required to be hauled to the charging station, as is the case with those illuminated with

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gas, they are always ready for immediate use, and are estimated to render about 15 per cent. more service than the others. The first cost of gas, for a train of ten coaches, including the buildings and producer plant, is stated to be £700; that of oil, £120, while electrically-lit trains cost £400. The yearly cost of maintenance is, with gas £120 per train, with oil from £70 to £130, while with the electric light it is only £50 per train.

The Habit of Making Notes.—It is one of the merits of technical colleges, says *Engineering*, that they have taught engineers how to experiment and how to record. They have diffused the judicial frame of mind which takes note of every piece of evidence, whatever be its complexion. It is curious, however, that the men they turn out do not seem able to carry into business operations the same methods that they apply to matters of measurement. They will measure angles, deflections, and temperatures with the greatest minuteness, but very often they cannot explain how a job is getting on. Lately we heard an engineer declaim against the inability of his assistants to write intelligible reports concerning the matters under their charge. There is scarcely anything that recommends a young man engaged on outside work to his chief so much as explicit reports which show, not only how everything is getting on, but also what preparations are being made for difficulties or contingencies that may be expected to arise. It is not sufficient—at least not until a reputation has been made—for a man in this position to do all that is necessary to carry on his job; he must also keep the person on whom the ultimate responsibility falls informed of what has been done, and also of the plans he has formed for the future.

Wood Flywheels.—Commenting on the frequent occurrence of flywheel accidents in the United States, the *Engineer* observes:—"Flywheels of ordinary flywheel materials have struck such terror into the hearts of some American builders that they are making them of wood. One mill engineer writing to an American paper says:—'Why should men who would not dream of using cast iron in the tension member of a bridge use such an untrustworthy metal in the rim of a flywheel, where it is subject, not only to much higher tension, but more sudden changes of load? Since the bursting of the flywheel here, on October 15, 1891, we have abolished cast flywheels, and now have three wooden-rimmed ones, the first being 30ft. in diameter, with 110in. face, replacing the wrecked one, and the other two but slightly smaller. We have also built one 14ft. in diameter, with a 30in. face, and rim 12in. thick of plate steel, each plate being ½in. thick, 30in. broad, and extending half way around. This mass is riveted through and through, and I think it would be impossible to run it at a high enough speed to burst it. Its normal speed is 93 revolutions per minute, and it acts as a flywheel for a 1,500 H.P. tandem compound engine. All these wheels are giving entire satisfaction, and I for one want nothing more to do with cast-iron flywheels.' We wonder how they would get on with wood flywheels in a rolling mill where large cast wheels are often brought up in a revolution or two when running at over 100 per minute, and still remain able to do another round turn? Cast steel pulleys are now being used for high peripheral speeds, and have been found to be very safe.'

Opening of the Cambridge Engineering Laboratory.—This laboratory was formally opened, as announced, last Tuesday afternoon, by Lord Kelvin. Upwards of £5,000 has been subscribed, including £1,000 from the late Chancellor, the Duke of Devonshire, and, in addition, valuable presents of plant and appliances have been given. The University contributed £1,000. The Vice-Chancellor, in a brief speech, said that the occasion on which they were assembled was a novel one, the opening of a building to be devoted to the teaching of engineering. Some had doubted the wisdom of the University in attempting this new study. To Prof. Ewing's exertions and indefatigable zeal was the erection of the building due. Lord Kelvin, in the course of his address, justified the addition of the teaching of engineering as part of the University curriculum, and maintained that true education consisted in providing the most efficient means for the equipment of persons for the battle of life; and although the old system of scientific education possessed great merit, yet for a profession like engineering it required to be supplemented by a method of teaching such as the laboratory would supply. The establishment of an engineering school at Cambridge had already drawn to the University a number of earnest, hardworking students, who, but for it, would not have joined the University. Their presence could not but benefit the whole University, while the *status* of the profession would be raised by the introduction of men who had the advantage of University culture. Prof. Kennedy, who was introduced as the parent of engineering laboratories, also spoke as to the advantages to be derived from the movement. Sir Frederick Bramwell, who humorously described himself as one of the mechanicians of the baser sort, said he was an example of the sort of person who had not had the benefit of a University education. He did not think he could ever have passed an examination, for he could never remember anything that would have been required of him by an examiner at the right moment. He had some little fear whether the danger did not exist of the future supply of engineers exceeding the demand. Their numbers had enormously increased of late years, but he was very sorry to say that the demand for their services was decreasing.

Manganese Steel.—Mr. Hadfield, in a Paper read before the Iron and Steel Institute, gave some interesting information about this material. A bar cemented in the ordinary manner became strongly magnetic compared with its ordinary condition, but being kept several months, the coercive power was lost, showing it to have been only feeble. In order to see the effect of forging and water-quenching, the same sample, now magnetic, was re-heated, forged, and water-quenched in the usual manner. To the author's surprise the sample then became equally as non-magnetic as in its original state. In order to further test this fact, a bar of manganese steel 15in. long, ¾in. wide, and ½in. in thickness, of usual non-magnetic quality, was cemented. It became magnetic. Half the bar was heated, forged, and water-quenched, the other half left in the state as received from the cementation furnace; the former, that is, the forged and water-quenched portion, was non-magnetic, whilst the other, or cemented portion of the same bar, was considerably susceptible to magnetic influence: thus a curious combination of magnetic and non-magnetic qualities was obtained *on the same bar*. Naturally enough, it might be thought to cementation was owing the entire change of properties noticed; but from the behaviour of other specimens not cemented, but merely heated for a long, continuous period, and which also lost their non-magnetic qualities, the author feels sure that the change is rather a question of continuous heating (probably changing or decomposing the particular form of carbon or carbide) than an increase or decrease of carbon such as produced by cementation or annealing. The heat treatment must be continuous for a considerable time, and probably also must be accompanied by a very slow cooling, such as would naturally occur either in the case in question or in the cementation process. This is specially mentioned, because merely heating manganese steel once or more for a short time, even to very high temperatures, close upon the welding point, will *not*, so far as can be detected, change its non-magnetic character. It was then thought it would be interesting to see what would be the effect of decarbonising manganese steel. It was naturally expected that this would be a troublesome operation. The annealing of this manganese steel was certainly more difficult of accomplishment, but by treating a thin bar, 3¼in. wide by $\frac{3}{32}$in. in thickness, the object was attained, the carbon being reduced to as low as 0·06 per cent., or, in other words, a removal of 94 per cent. of the amount originally present was effected. The sample being thin was naturally much scaled. The latter was removed, and the bar was found to possess very considerable magnetic qualities or susceptibility. The same experiments were then carried out as with the cemented samples. A strip now magnetic was heated to various temperatures, then forged and water-quenched, but in no case did it again become non-magnetic, as with the cemented or annealed samples. It was now persistently magnetic, though according to the analysis apparently no change in the chemical composition had occurred except as regards carbon.

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MOTIVE POWER AND GEARING.*

BY E. TREMLETT CARTER.

(*Continued from page 38.*)

Furnaces and Boilers.

Furnace Combustion.—When burned in a boiler furnace, fuel requires much more than the theoretical weight of air to effect its complete combustion, even when the air is supplied under perfect conditions. The reason for this is, that if only the theoretical amount of oxygen is supplied in a stream to the fuel, a great deal of the oxygen will pass through the grate without coming into contact with the fuel, owing the dilution of the oxygen by the products of combustion. To remedy this, and to ensure the contact of a sufficient weight of oxygen against the fuel particles, excess of air is always supplied to the furnace. In a slow draught the excess of air must be greater than in a rapid draught, because in the former the products of combustion loiter about the fuel and insulate it from the oxygen more than they do in a rapid draught. The greater part of the air is supplied between the fire-bars; but it is usually the practice to supply a little air, either continuously or at intervals, over the grate. The over-grate air will be regulated by the liability to produce inflammable gases over the grate, and should be directly proportional to the rate at which such gases are produced. With perfectly steady stoking, however, even with fairly bituminous fuels, over-grate draught is not necessary, provided a large amount of air be passed through the grate. The actual amount of air necessary for the best results, with any given furnace burning any given kind of fuel, should be found by trial, *i.e.*, by adjustment of the dampers, or otherwise the force of the draught, as the case may be. In fact, this is the only satisfactory way to determine it within a close approximation, and theoretical calculations on this point are of little practical value. On an average, ordinary coal stoked by hand in the usual ways requires about 24lb. to 25lb. of air per pound of fuel, during the steady burning, and about 10 to 15 per cent. more on putting a thick charge on the fire. The volume of this weight of air at ordinary temperatures will be about 320 cubic feet. With careful mechanical stoking it is possible to effect economical combustion with from 16lb. to 18lb. of air per pound of coal of average quality. If too little air is supplied imperfect combustion results, the gases will not be properly heated, and both the economy and steaming performance of the boiler will suffer. On the other hand, if too much air is supplied the furnace gases will be cooled by the great amount of cold air, and precipitation of smoke and soot will occur, while much of the heat will be carried uselessly away by the extra chimney gases. Cold air is usually supplied to the fuel, but in some instances an economy of from 5 to 10 per cent. of fuel has been obtained by supply air at from 150° to 300°F.

Stoking.—Ideal stoking may be said to consist in keeping a perfectly regular and even thickness of fuel over the grate; in varying this thickness according to the steaming requirements of the boiler, so as always economically to keep a steady head of steam; and in so gradually supplying fuel to the area of combustion as that there shall be no sudden evolution of combustible gas when it reaches that area. Uniform thickness is desirable on account of the necessity for uniform passage of air through the grate. If air passes in one place in excess, and in another place insufficiently, imperfect combustion must result. Only by having an even fire can the air be led to stream uniformly through it.

Thickness of Fire.—Generally speaking, it is easier to maintain a uniform stream of air in a thick fire than in a thin fire, for the variations in thickness are of less importance in the former than in the latter. The actual thickness must evidently be determined by the draught and the weight of coal to be burned per hour. Very thick fires can only be burned where a great pressure of draught is available. For a given weight of coal, a thick fire means a small grate area; and this will lead to the amount of heating surface exposed to the radiation of heat from the fire being small. As will presently be seen, it is well to expose a considerable amount of surface to this radiation, so that very thick fires are only used where compact grates are necessary. The following may be taken as representing average practice, assuming the boilers to be at their normal steaming rate. With moderate chimney draught, unassisted by forced draught, a thickness of from 3in. to 6in., equal to about 4½lb. to 9lb. of coal per square foot per hour, may be allowed; with rapid chimney draught, or where a moderate assistance is given by forced draught, the practice is from 6in. to 12in. or 15in. thick, equal to about 9lb. to 20lb. or 22lb. of coal per square foot per hour; while, where very high forced draught is used, as in locomotive practice, a thickness of 3ft. to 3½ft. may be allowed, corresponding to from 100lb. to 150lb. of coal per square foot per hour. These figures, however, are modified very much where small coal or coke is used; in either of these cases a larger area of grate being allowed. The fires also will be thicker at reduced loads.

Hand-Firing.—The methods of stoking may be divided into two classes: hand-stoking or firing, and mechanical stoking. These again have their sub-divisions. There are three common methods of hand-firing—(1) the coking system, (2) the spreading or sprinkling system, and (3) the alternate system. In all three the fuel is supplied at intervals, and never continuously; and the fire-door must be opened for the purpose. As a consequence, the thickness of fire must vary, not only according to the steaming but also according to the decree of the being who handles the shovel. This decree is rarely dictated by the wisest judgment, and the boiler suffers in consequence. Another result attending hand firing is that whenever the fire door is opened a rush of cold air will enter by it and chill all the heating surfaces, causing strains through contraction, and diminishing the boiler output by depositing soot and cooling the surfaces. The irregularities consequent on infrequent and improper hand firing are the chief source of avoidable loss in boilers. On the coking system, the fuel is first thrown on to a dead plate, or portion of the grate in which there are no perforations for the admission of air. Here the volatile matter is distilled by the heat of the fire, sufficiently slowly to ensure its meeting with enough oxygen for its combustion. After coking on the dead plate the fuel is pushed on to the firebars, where the solid portion is directly supplied with air. This is undoubtedly the best method of hand firing with fuel which contains much volatile matter. On the spreading system, the fuel is shovelled straight on to the fire-bars, the attempt being made to distribute it evenly. The alternate system consists in alternately charging fuel on the right and on the left half of the grate. This is a modified form of coking system, for the side on which the last charge was thrown will have a thicker fire, and will receive less air through the bars than the other side, so that coking will take place on this side.

Mechanical Stokers.—On the broad general principle that wherever possible, in machinery, the human element should be eliminated, and should be replaced by automatic machinery, as well as in the light of actual experience, mechanical stoking is far superior to hand firing. In mechanical stokers the fuel is supplied to the grate continuously, not at intervals, and there is no need for a fire-door to be opened for the purpose. The rate of supply can be adjusted to suit the steaming rate, and can almost as economically be adapted to low steaming rates as to the normal rate; while, owing to the evenness of the fire and the constancy of the temperature of the heating surfaces, the combustion is more perfect and the evaporation of water more steady—as well as being actually greater—than where the fire is fed irregularly. Only a class of finely-divided fuel, such as slack or coke breeze, can be supplied by mechanical stoking; but as this fuel is cheaper per ton than round coal, and as quite as high an evaporation per pound of fuel can be obtained from it, this fact is not a disadvantage against mechanical stokers. There are two classes of such stokers: the coking stokers and the sprinklers. In the former the fuel is fed on to the front of the grate, and is gradually worked backwards to the bridge end, where the ash and cinders fall into the ash-pit. Motion is usually given

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to the bars in order thus to produce a steady travel of the fuel. In the sprinklers the fuel is scattered over the whole grate; but this class of stoker, though adapted to the use of very dry fuels, has not been generally adopted for electric power station work.

Vicars' Mechanical Stoker.—The extensive use of the Vicars' mechanical coking stoker in electric power stations, as well as in other classes of works, and the remarkable results obtained through its use, make it worth while for electrical engineers to pay special attention to this apparatus and justifies its full description in this treatise. In the accompanying pair of illustrations, Fig. 13 gives an end elevation, and Fig. 14 a longitudinal section of the latest pattern of Vicars' stoker fitted to the front of a Cornish boiler, this form of boiler having been selected for simplicity of drawing. With a Lancashire or other double-furnace boiler there would be two such stokers fitted to each boiler. The illustrations are drawn to scale, for a 7ft. boiler shell. The action of the stoker is as follows. Small coal is stored in the hopper, H, which, together with the other parts, is supported on the cast-iron frame, S. The fuel drops through

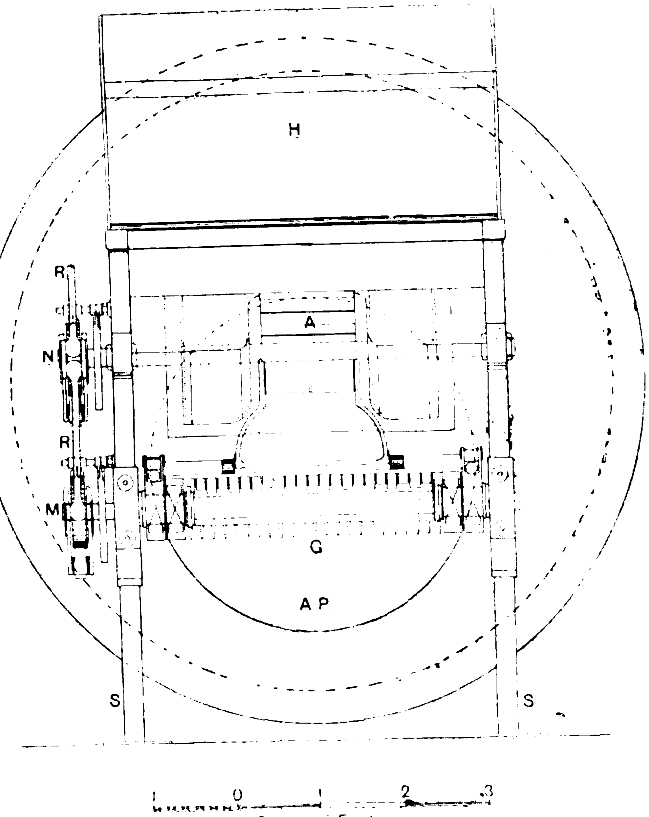

Fig. 13.

two openings in the bottom of this hopper, into two cylinders, one on each side of the fireplace. In each cylinder a piston is maintained in reciprocating motion, by means of the ratchet motion and cams at N. The out-stroke of the piston, or plunger, allows fuel to drop into the cylinder from the hopper; and the in-stroke of this piston forces the fuel from the open end of the cylinder on to the dead-plate, D P, where it is coked before dropping on to the fire-bars. The grate, G, consists of two sets of fire-bars, arranged alternately; and, by means of the ratchet and cam motion at M, the following motion is communicated to the bars:—Firstly, both sets are pushed inwards, carrying the fuel towards the bridge; then one set of bars is drawn back, while the other is stationary; and finally the second set of bars is drawn back, while the first set remains stationary. Then the whole cycle is repeated. At each in-stroke of the fire-bars, coal is carried forward; and by the out-stroke of each separate set the clinker tends to be broken up. If the fuel is highly bituminous there will be little or no loss of fuel through dropping into the ash-pit, A P, through the air spaces. The necessary motion is communicated to the mechanisms M and N, by the rod R, which receives a reciprocating motion up-and-down from an eccentric on a shaft; the shaft running the length of the battery of boilers, and actuating all the stokers. By varying the speed of this shaft, which requires only a trifling amount of power to drive it, the stoking rate of all the boilers can be varied simultaneously, or stopped altogether; and, by means of adjustments on the mechanisms, M and N, it is possible to separately adjust for each separate stoker the number of charges given to the fire, up to 240 per hour, and the amount of play of the fire-bars to-and-fro, up to 4in. Air is freely supplied to the fuel through the grate, as well as through a perforated air-plate over the grate at A; this plate being provided with a long slot for the introduction of a slicer without opening the fire-door. Fuel is usually supplied to the sets of hoppers by means of a trough running over the tops of the boiler fronts, in which trough there is a spiral conveyor, actuated by the same engine which propels the shaft for driving the stokers. The trough is supplied with charges of fuel from one point; and the most economical plan is to have the boiler-house so arranged that the fuel can be shot down from the stores to the conveyor,

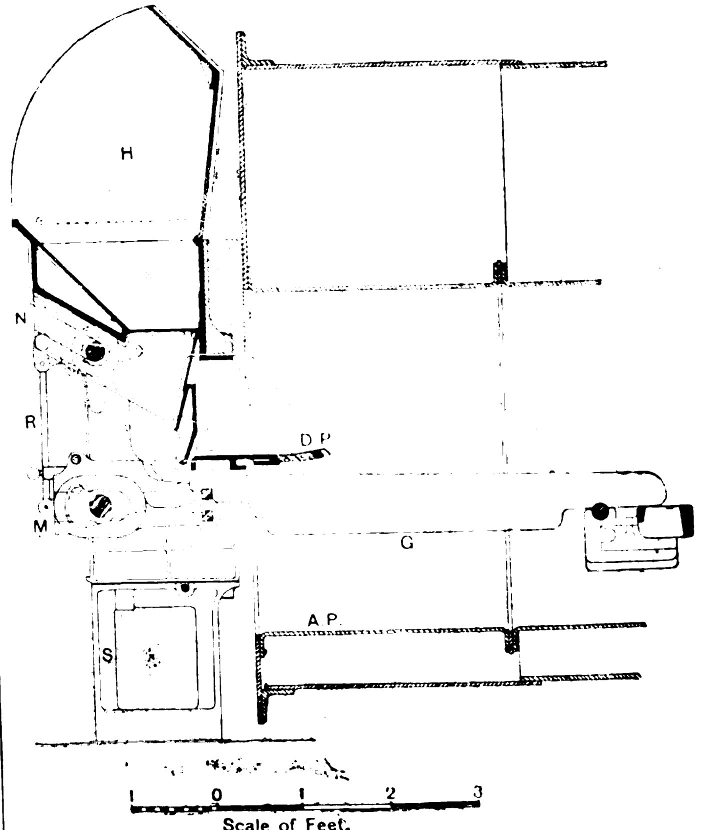

Fig. 14.

i.e., to have the boilers below the level of the stores. In several stations in which the author has made some inspection of these stokers, the fuel is raised to the conveyor automatically by means of buckets fixed to an endless chain, the elevator being worked by the auxiliary engine which drives the rest of the coal-handling plant.

This stoker will deal with highly bituminous slack without producing the least smoke, and will often with such fuel give a higher evaporative efficiency per pound of fuel than where good Welsh coal is stoked by hand. Clinker cannot form over the fire bars, owing to their perpetual reciprocating motion; so that a steady and uniform draught is maintained through the grate. Messrs. T. and T. Vicars have, through the courtesy of their representative, Mr. George S. Howatson, kindly supplied the author with particulars, given on the next page, of two sets of trials of their stoker, in the one as against hand firing with forced draught, in the other as against hand firing with induced draught.

At a large sewage pumping station, where the author has inspected a battery of 10 Lancashire boilers (8ft. by 30ft.) fitted with these stokers, not the slightest smoke can be seen

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issuing from either of the two chimneys, although the weekly consumption of inferior bituminous slack amounts to about 250 tons; and the same may be said of every one of the factory chimneys where Vicars' mechanical stokers are used, which the author has from time to time had the privilege of inspecting. As examples of electric power stations, among these the Liverpool Overhead Railway generating station, and the electric supply stations at Manchester, Derby and Bristol, may be mentioned. In every case the author has found that an inferior and gassy quality of slack, sometimes even smudge, is in regular use, giving a higher boiler performance with considerably less cost of fuel than could possibly have been the case had the firing been done by hand. Since writing the above, the author has received a letter from Mr. Faraday Proctor, the Corporation Electrical Engineer at Bristol, in which he observes that the mechanical stokers have proved "most satisfactory, and even at fairly heavy loads smoke from the chimney is not visible." The fuel used is Welsh small nuts, but sufficient load has not been put on the station to test the smokelessness at full load. As a labour-saving device the mechanical stoker also calls for some notice. While it undoubtedly saves labour which would be necessary in manually handling and stoking the fuel, it introduces labour on account of the manipulation of the auxiliary engine, elevator, and conveyor, as well as in adjusting the feed of the stokers and the play of the bars, besides which some extra repairs—very trifling, however—will be necessary. In some stations it has been found that these items of labour-cost balance one another; in others, such as at the Liverpool Overhead Railway generating station, where there is a boiler plant of six Lancashire boilers, a net saving in labour has been effected by the use of mechanical stokers, amounting, at the station just named, to two men.

Place	Royal Paper Mills, Wandsworth.		Vauxhall Water Works.	
System of stoking	Hand.	Vicars'	Hand.	Vicars'
Draught	Forced.	Forced.	Induced.	Induced.
Date of trial	24/6/90.	23/6/90	13-19/4/86	21-27/4/86
Type of boilers	Lancs.	Lancs.	Cornish.	Cornish.
Number of boilers	1	1	4	4
Size of boilers	30ft. × 7ft.5in.	30ft. × 7ft.5in.	28ft. × 6ft.	28ft. × 6ft.
Diam. of furnace	2ft. 9in.	2ft. 9in.	3ft. 6in.	3ft. 6in.
Grate area (total)	33 sq. ft.	22 sq. ft.	84 sq.ft.	45·6 sq. ft.
Duration of trial	10 hours	10 hours	168 hours	168 hours.
Class of coal used	Small Welsh	Bituminous slack.	Welsh	Bituminous slack.
Price of fuel per ton	15/-	13/-	16/6	13/-
Coal consumed during trial	7,168lb.	5,936lb.	84,000	205,632
Coal per sq. ft. of grate per hour	21·7lb.	27lb.	6lb.	26·9lb.
Total evaporation	5,020lb.	5,330lb.	4,332lb.	10,100lb.
Evaporation per lb. of coal	7lb.	8·93lb.	8·65lb.	8·25lb.
Cost of coal per 100lb. of water evaporated	1·128d.	0·775d.	1·02d.	0·880d.

(To be continued.)

CONDENSATION IN STEAM-ENGINE CYLINDERS.

Two very interesting contributions to the literature of steam-engine theory have recently made their appearance, and help to elucidate a very recondite subject—the initial condensation of steam in the cylinder; and, by implication, to throw some light on the value of the steam jacket. Apparently this question, which has by no means been brought to a finality in either case, is one about which the highest authorities are at disagreement. Indeed, it seems as though no general solution of the question will be made; but that it will have to be dealt with separately, and on different lines for each separate class of engine. The first of these contributions is a selected Paper on "Experiments on the Condensation of Steam in Cylinders of Iron and other Metals," by Mr. Bryan Donkin, M.I.C.E., and is published in the *Proceedings* of Institute of Civil Engineers, Vol. CXV., p. 263. Probably no more competent authority on this subject, than Mr. Donkin, could be found; and electrical, as well as other engineers, will value this the latest extension of his well-known researches on the subject. We may remark in passing, however, that the conditions of Mr. Donkin's experiments much more nearly approximate to slow-moving pumping-engines than to high-speed electric light engines; the number of fillings and emptyings of his experimental cylinders being of the order of between 20 and 50 per minute. The cylinders used were of cast-iron, phosphor-bronze and glass; and arrangements were made whereby the ratio of cylinder capacity to the surface exposed to the steam might be varied. Experiments were made with both condensing and non-condensing working; and the special objects in view were the determination of (1) the variation of temperature throughout the thickness of the liner; (2) the weight of steam condensed per square foot of exposed surface; (3) the variation of the depth of heat-penetration into the cylinder walls at each steam filling, when the surface temperature was varied. It was found that when steam was admitted into an unjacketed glass cylinder, copious condensation occurred, in the form of large drops on the cylinder walls; while, when the cylinder was jacketed, the condensation was small and in the form of a fine mist or film. Instantly on release, the drops of water were seen to be in violent ebullition; and at the end of the exhaust the cylinder walls were dry, in the case of the jacketed cylinder, though there remained detached drops of water upon them where no jacket was used. It was further shown that within a certain distance from the inner surface of the cylinder, a pulsation of temperature synchronised with the fillings and emptyings of the cylinder; and that the depth of metal thus varyingly affected was greater in the unjacketed than in the jacketed cylinder.

Mr. Donkin observes that "It is now generally recognised by steam engine authorities that for the maximum economy in any engine the exhaust should be steam only, and not a mixture of steam and water; on the other hand, it should not be allowed to escape superheated, or again there will be a loss." If this principle is really established, the question of the value of the steam jacket is instantly settled in favour of the jacket. For it is impossible to have unjacketed expansion of saturated steam, even in a perfectly non-conducting cylinder, without liquefaction. But, after all, *is* this principle established? Are we indeed so sure that the steam jacket (or its equivalent, the superheater) is a necessary adjunct to the steam-engine? Looking at the case of high speed electric light engines, we find in the Willans engine an engine with neither a jacket nor a superheater, an engine which does not exhaust steam alone but a mixture of steam and water, and yet an engine which, supplied with a given pressure of steam and exhaust, will work as economically as any equally rated jacketed engine working between the same pressure and exhaust. Speaking of the Willans engine reminds us that the late Mr. P. Willans was by no means in favour of providing for a pure steam exhaust; and that he has naïvely observed that, in an ideal engine, steam would go in at one end and water would trickle out at the other. However, this is more a question of working liquefaction than of initial condensation; though it serves to show that water in the exhaust is not inherently objectionable. Incidentally, we may mention that an interesting Paper by Mr. Donkin, on "Heat Losses from Dry and Wet Cylinder Walls Exposed to a Vacuum, &c.," appears in the recently-issued *Proceedings* of Institute of Mechanical Engineers, No. 4, 1893.

The second Paper on this subject which we notice, read at the recent meeting of the Institute of Naval Architects by Mr. D. Croll, has suggested that the indeterminate element in cylinder condensation lies in the roughness of the cylinder-cover and piston surfaces, and points out that the heat absorbing area of surface might be considerably increased by a granulated, unfinished state of surface. The lesson to be learned, if this is so, is that all surfaces exposed to cylinder steam should be brought to a bright polish. Cylinder condensation, occurring as it does to an increased extent at reduced loads, is an important factor of ineconomy in electric power stations where the engine plant is not greatly sub-divided; and it is a matter calling for the attention of electrical engineers to seek to minimise it. As has been shown by Mr. Willans, the steam jacket is of little or no use for this purpose in the

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class of engine which is best adapted to power station loads; but it might be worth while to try if machined and buffed cylinder covers and piston faces would help to save the steam by reducing initial condensation. It is worth remarking that the higher the speed of revolution for which an engine is designed, the less will be the condensation due to surface changes of temperature, while in rotary engines, such as the Parsons steam turbine, no condensation on this account can take place, though, unless the steam is superheated, liquefaction will arise from other causes.

NOTES ON THE WORKING OF THE BERLIN ELECTRICITY SUPPLY.*

The author began by remarking that the first part of his Paper contained an addendum to the Paper read last year by Dr. Kallmann, giving the results of the use on the Berlin Supply system of the apparatus therein described. The purpose of the two systems is to announce and localise any fault which may occur in the insulation of the mains in such a manner that the failure may be corrected before any serious disturbance of the supply takes place.

To briefly recall the principle of these arrangements will not be out of place. The first, that of Herr Agthe, is to use the pilot wires of the two outer mains of the three-wire network as signal wires for the automatic announcement of any disturbance; they are connected, namely, to the pole of the dynamo opposite to that which is connected to their conductor by a lead wire in the feeder junction box, and in the station pass round the coils of a relay. If by some damage done to the cable the pilot wire and main come into contact, the relay in the station rings violently, excited at 200 volts, and the fuse wire goes in the junction box; the relay announces which feeder the fault is on, and, therefore, in what district it has occurred.

The second system, invented by Dr. Kallmann, utilises the differences of potential set up in the ground by an earth on the mains. The pilot wires of the middle-wire are utilised, being earthed in as many places as possible, and connected through the feeder junction boxes through relays in the station again to earth. Every earth contact of the outer conductor means raising or lowering the potential of the earth in its vicinity, thus setting up a current in the pilot wire, and setting the corresponding relay in action, thus localising the fault.

All the stations of the Company, except the Markgrafenstrasse station, which only has the first of these systems, are fitted with both these alarm systems; and these during the last nine months have fourteen times signalled faults which have at once been removed. These alarms, chiefly given by the Agthe relays, included the following sources of leakage: three faults in house connections, six cases of water in the cable boxes, and five faults in the mains themselves. All cases where the leakage was only on the pilot wire are omitted.

The causes of these failures are interesting. Taking first the house connections, failures here are nearly always due to damp damaging the cables and junction boxes in damp cellars, especially in the Spandauerstrasse, where at times an alkaline moisture exudes from the walls which gradually soaks all wood and destroys its insulating properties; the current so set up destroys the wood completely. This source of failure, discovered by the alarm system, can be corrected by keeping the conductors and main switches off the walls. Penetration of water into junction boxes is a more serious affair. The electrolytic action set up not only decomposes the water but also the box itself, which is sometimes completely destroyed. In order to signal the presence of quite a small quantity of moisture the following plan was devised. In every junction box the wire connecting the pilot wire screws is bared in one place, and a piece of ebonite tube pushed over it; and as soon as the bottom of the box gets covered with moisture the relay, excited by 100 volts from the short circuit from pilot-wire to earth, rings until insulation is restored.

Of nine failures on the cables proper during the past year, five have been signalled by these apparatus. Of these nine only two were true failures of insulation, the others were generally due to accidental blows with a pick. Two of the unsignalled failures were on circuits having no pilot wires, and the other two were too small to set the signals in action. Thus the most frequent cause of damage is from outside, and not from failures of the cable itself. Although the signalling apparatus has meant increased expenditure, the money is well spent in keeping the cables in such good condition, and the author considers the apparatus indispensable.

* Abstract of a Paper read before the Elektrotechnischer Verein, by Dr. Passavant. See also *The Electrician*, Vol. XXXI., May 26, 1893, p. 103.

Leaving the question of alarm signals, the author takes up the question of power supply in Berlin. 358 electric motors, totalling 1,200 H.P., are now on the mains, 60 H.P. more are announced as ready to come on, and 50 H.P. more, at least, are in contemplation. In 1892-93 some 238,000 kilowatt-hours of energy were sold for power purposes, and in the first eight months of the current year, the total has reached 376,000. In the current year the total energy sold for motors will amount to about 10 per cent. of the whole supply. These motors are divided about as follows:—

———	Motors.	H.P.
Lifts	64	370
Ventilation and heating	103	130
Printing and paper manufacturing	78	287
Metal industries	24	106
Wood and leather works	6	30
Butchers	10	42
Washing, spinning, and weaving	35	94
Various	38	131

This large development of motor supply is due to the action of the Berliner Elektricitäts-Werke, which set out with the idea that a large power supply was desirable, and fixed their tariff at such a point as to encourage its development, the price being fixed in 1891 at 24pf., or 3d. per kilowatt-hour, about 40 per cent. of the price for lighting, and having been lately reduced to 2½d. The result of this policy has been to increase the summer all-day load from practically nothing to some 2,500 amperes. This load does not increase any of the working expenses, except the coal bill, and this is fully covered by the price charged. Curves given in the Paper show that, contrary to the universal experience with lighting, the number of hours a day run by each horse-power connected is increasing more or less steadily—from 1·25 in 1892 to somewhere near 1·8 now—thus showing that the motors are becoming less of a luxury or curiosity, and are used for factory supply in larger numbers. The author concludes with a few remarks on motor design, calling the attention of designers to the fact that consumers do not care to pay for power supplied to motors when running light.

PHYSICAL SOCIETY.

At a meeting of this Society on May 11, Walter Baily, M.A., Vice-President, in the chair, a mathematical communication on

"Electromagnetic Induction in Plane, Cylindrical, and Spherical Current Sheets, and its Representation by Moving Fields of Images,"

by G. H. Bryan, M.A. Part I., "General Equations," was read by Dr. C. V. Burton, who also explained some of the parts in greater detail. After mentioning that the magnetic field due to induced currents in thin conducting sheets placed near moving magnetic poles could be represented by moving trails of images of those poles, the author goes on to say that, in the Paper, the surface conditions which hold at the surface of the sheets are deduced directly from the fundamental laws of electromagnetic induction: 1. "The total current across any enclosed portion of a surface which always contains the same particles is equal to 1/4 π of the line integral of the magnetic force round the curve bounding the surface;" and 2. "The rate of decrease of the surface integral of magnetic induction across any enclosed surface space which always contains the same particles is equal to the line integral of electromotive force round the curve bounding the surface." By working with the scalar magnetic potential instead of rector potential the investigation is simplified. In addition to the above laws the author makes the usual assumptions that displacement currents in the dielectric as so small as to be negligible, and that the induced currents are distributed uniformly through the thickness of the sheet. On these suppositions the surface conditions satisfied by the potentials at the two sides of plane, sylindrical, or spherical sheets are determined, and, with an additional limitation as to the thickness of the sheet fulfilling certain conditions, extended to current sheets of other forms. In the latter part of the Paper a synthetic determination of the images in a plane sheet is given and expressed in the form of a definite integral.

In reading the Paper to the meeting, Dr. Burton pointed out several misprints in the proof.

Prof. MINCHIN showed that equation (1) of the Paper ($\Omega_2 - 4\,\Omega_1 = \pi\,\phi$ of constant, where Ω_2 and Ω_1 are the magnetic potentials at the two sides of the sheet, and ϕ the current function), would be deduced by purely mathematical reasoning, instead of being based on the laws of electromagnetic induction. Moreover, it was true for any functions whatever, and did not depend on ϕ being the current function. Equation (2) $\left(\frac{d\,\Omega_2}{d\,z} = \frac{d\,\Omega}{d\,a}\right)$

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followed immediately from the fact that the magnetic force was continuous. The latter part of the Paper might be simplified by integrating the linear partial differential equation (15) $\left(\frac{d^2\Omega^1}{dz\,dt} - R\frac{d^2\Omega^1}{dz^2} = -\frac{d^2\Omega^1}{dz\,dt}\right)$ in the ordinary way, for the form was one for which the auxiliary equations are well known.

Dr. BURTON, in reply, said he thought Mr. Bryan's reason for developing the equation from the laws of electro-magnetic induction was to give his next work a physical rather than a mathematical basis.

A Paper

"On Dielectrics"

was read by Mr. ROLLO APPLEYARD. In testing the insulation resistance of celluloid by having a sheet pressed between the metal plates, the author noted that the resistance, which was very high, *decreased* as the time the testing battery was left on increased. The "electrification" (using the word to indicate the rate of diminution of galvanometer deflection) was therefore *negative*. The resistance also diminished greatly with increase of battery power, and a considerable amount of hysteresis was observed, the resistance at any given voltage, after a minute's electrification, depending on the previous history of the specimen. On making contact with the surfaces of the celluloid by mercury instead of by solid metal the abnormal results disappeared, little or no resistance—hysteresis or "electrification"—being present, and only a small diminution of resistance with increase of voltage. For a 6 mil. sheet the resistance between opposite faces 5½in. diameter was of the order 30 megohms, and one specimen broke down at 1,200 volts. The celluloid condensers used in the experiments were found to discharge slowly at first, and after a certain time the deflections of the galvanometer became reversed, and attained a steady negative value. This the author attributes to an E.M.F. of about 0·0006 volt between the mercury and celluloid.

Similar experiments on gutta-percha tissue showed no such E.M.F., and the "electrification" was normal. The resistance usually attained a maximum for voltages between 600 and 800. Although the tissue had a thickness of only 2 mils. (0·002"), it stood a pressure of 1,200 volts, and offered a resistance between circular faces of 5½in. in diameter of about 3,000 megohms.

The opaque white spots seen in celluloid under the microscope led the author to test the behaviour of mixtures of conducting and insulating materials. A strip of gutta-percha was warmed, and coarse brass filings scattered over it as thickly as possible. In spite of this the resistance was practically infinite, even when tested with 750 volts. A number of rods were made from mixtures of brass and gutta-percha in various proportions, and on testing these it was found that if the weight of filings exceeded about twice that of the gutta-percha, the resistance of a rod 20in. long ¾in. diameter was small (sometimes a fraction of an ohm), whereas a slightly smaller proportion yielded rods having resistances measured in thousands of megohms. Such rods were found to be affected by oscillating discharges in a manner similar to Prof. Minchin's "impulsion" cells and M. Branby's tubes of filings. Experiments were also made on the behaviour of such rods when subjected to high alternating pressures. This caused small local arcs to form along the rods, but did not permanently destroy their high resistance.

In connection with Mr. Appleyard's Paper, a

"Note on the Behaviour of Certain Bodies in Presence of Electromagnetic Oscillations."

by Prof. G. M. MINCHIN, M.A., was read by Mr. ELDER. Referring to the employment of impulsion cells, metallic films, &c., for detecting the nodes of electromagnetic vibrations, he says that so far the physical state of such bodies are too variable to be of service. Metallic services, formed by embedding fine metallic powders in films of gelatine, shellac, or sealing wax, are, as described in a previous communication to the Society, found to act as insulators, but become conducting when subjected to strong electromagnetic disturbances. After a current has once passed through such a film, its resistance is changed by very feeble impulses, whereas previously it failed to respond to strong ones. On breaking contact by removing the electrode from the surface, the film loses its conductivity, the time necessary to do this depending on the hardness of the matrix. The resistance of a film containing tin powder, measured between the rounded tips of two platinum wires 1cm. apart, varied under the electromagnetic impulses, from ∞ to 130 ohms. In conclusion the author points out that with films and tubes the whole phenomenon relates to change of resistance, whereas impulsion cells may have currents from external sources passing through them whilst in either the sensitive or insensitive states.

Mr. BRIGHT and Mr. ENRIGHT asked questions as to the electrification of gutta percha and the bridge connections in the resistance tests of the semi-conducting rods respectively, to which Mr. APPLEYARD replied.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

TO-DAY) FRIDAY, May 18th.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Students' Meeting at 28, Victoria-street. The following Paper will be read:—"Notes on Gas-Engines," by P. W. Paget.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "The Splash of a Drop and allied Phenomena," by Prof. A. M. Worthington, F.R.S.

SATURDAY, May 19th.

ROYAL INSTITUTION.

3 p.m. Tyndall Lecture: "Colour Vision," by Capt. Abney, F.R.S.

TUESDAY, May 22nd.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "The Modern Microscope; an Instrument for Recreation and Research," by the Rev. N. H. Dallinger, F.R.S.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Ballot for members. The following Papers will be read and discussed: (1) "Recent Types of Ferry Steamers," by Andrew Brown, M.Inst.C.E. (2) "The Birkenhead Ferry Boats, 'Wirral' and 'Mersey,'" by Charles Jones.

SOCIETY OF ARTS.

8 p.m. Applied Art Section. The following Paper will be read:—"Decorative Art in connection with Elementary Education," by Selwyn Image, M.A.

WEDNESDAY, May 23rd.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. The following Paper will be read:—"Liquid Fuels," by G. Stockpleth.

THURSDAY, May 24th.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary Meeting. Continuation of discussion on "The Cost of Electrical Energy," by R. E. Crompton, M.Inst.C.E.

FRIDAY, May 25th.

ROYAL INSTITUTION.

9 p.m. "Evening Discourse: The Development of the Astronomical Telescope," by Sir Howard Grubb, F.R.S.

Street Nomenclature.—A writer in a recent number of the *Chemical News* enumerates some of the streets, avenues, and public squares in Paris, named after eminent scientific men. In some instances the streets thus designated are appropriately placed near learned institutions with which the investigators' names were associated; in others, the names of men engaged in the same branch of science are grouped within small areas. It is pointed out that the "Jardin des Plantes is bounded by streets named respectively, Cuvier, Buffon, and Geoffroy St. Hilaire; while in the immediate vicinity are the streets Lacépède and the Place Jussieu. Elsewhere in Paris the following names occur:—Lamarck, Linnæus, de Saussure, and Humboldt. Near the École de Médecine runs the street Dupuytren, and in the same quarter the eminent physician Velpeau is honoured. Near the Hospital La Salpêtrière two English physicians lend their names to streets, Harvey and Jenner. In the neighbourhood of the Arc de Triomphe occur the names of the astronomers Copernicus, Galileo, Kepler, Euler, and Newton; elsewhere we find the streets Huyghens, Laplace, and Herschell. Mathematicians and physicists have not been forgotten, as shown by the occurrence of the following street names:—Biot, Pascal, Lalande, Lahire, D'Alembert, Dulong, Arago, Monge, Legendre, Ampère, Fresnel, Becquerel, Galvani, Volta, Franklin, and Faraday. Ampère, Galvani, and Faraday are near each other. Philosophy is represented by Descartes, Auguste Comte, and Bacon; engineering by Vauban, Watt, Stephenson, and Fulton; useful inventions by Bernard Palissy and Guttenberg; exploration by Christopher Columbus and Magellan. Chemists have received, however, a larger share of the honours than any other single class, not even excepting men of letters. Thus we find streets named after the French chemists Bayen, Berthollet, Cadit, Chaptal, Darcet, Daguerre, Gay-Lussac, Lavoisier, Langier, Orfila, Parmentier, Payen, Raspail, Réaumur, Rouelle, Thénard, and Vauquelin; the Swede, Berzelius; and the Englishmen, Davy, Faraday, Priestley, Cavendish, and Watt."

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PRIORITY.

SOME little time ago a New York contemporary published a series of articles from the pen of Miss MARY A. HENRY—extracts from which appeared in these columns at the time—setting forth the bases of her father's claim to be called the first and true discoverer of "magneto-electricity." In attaching such paramount importance to mere priority, Miss HENRY did no more than give her adhesion to the widely-accepted and influentially-supported doctrine that questions of the kind should be settled solely by the date of publication, without, as HELMHOLTZ says, "considering the ripeness of the research."

Encouraged, probably, by the success of her former literary effort, Miss HENRY has more recently undertaken the task of assigning to JOSEPH HENRY his proper place in the history of the electro-magnetic telegraph. The place allotted is, it is, perhaps, needless to say, the first. A perusal of this second series of articles, now appearing in the *Electrical Engineer* of New York, would, no doubt, show that this second claim has been made good. But the discovery of the "intensity" electro-magnet is in a very different category to that of the phenomena connected with the interactions of electric and magnetic circuits. The "intensity" electro-magnet is the very soul of the electric telegraph, and was recognised as such from the commencement. Had the Princeton Professor been possessed of the modern mania for patenting the results of his laboratory investigations, the files of the United States Patent Office would have been enriched by at least one intrinsically valuable invention, and the patentee possibly by an untold tale of dollars. The importance of priority the moment a philosopher descends to inventing is obvious; it is the all-in-all, the alpha and omega of the trade, and cannot be over-estimated. The inventor's attachment to priority has, in short, a purely business basis, and need not, therefore, be objected to as irrational. The pocket argument, however, does not apply to the discoveries of pure science. The hot haste of the patentee we can under-

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stand, not so the pot-hunting of the physicist. Whence comes this feverish eagerness to be first, which is so characteristic of latter-day research, always to its detriment, and often to the delight of the Philistine, ever glad to see the philosopher come down from his pedestal and display to the world at large a few of the failings of common men? Does it come from that "rage for fame" which "attends both great and small," and makes men think it "better to be damned than mentioned not at all"?

Now the articles which dealt with the conflicting claims of MICHAEL FARADAY and JOSEPH HENRY, albeit in excellent taste, the author refusing to allow her close relationship to one of the candidates to intervene at the expense of her fairness and courtesy, left the impression that the true significance of each of the many factors that go to make up the ultimate value of a scientific discovery had been somewhat misapprehended; a failing, indeed, common to most literature of the kind. Stress was rightly laid upon the widely different conditions under which FARADAY and HENRY worked: the one in a well-equipped laboratory, with ample leisure, and amidst books and stimulating society; the other only able to devote a few weeks every summer to research, and living out of the world in a small town 150 miles from New York. But the real objective of Miss HENRY's incursion into the fields of technical literature, the idea with which proof was piled on the top of proof *ad demonstrandum* and *ad nauseam*, was to secure a verdict for JOSEPH HENRY—to make it known unto all whom it might concern that the dark horse away out in the American backwoods had passed the winning post at least half a head in front of MICHAEL FARADAY. In the investigator himself a wish to be first may perhaps be excused by reason of the inherent defects of the human mechanism, but in settling the precise position of a niche in the Temple of Scientific Fame, the undue weight that is attached to mere matters of date is wholly without excuse. It has no foundation in reason, and should have none in sentiment. The assiduity of the scientist-historiographer tends greatly to foster this belief in the supreme importance of being first. A day amongst the dry-as-dust files of the Patent Office, a visit to the British Museum library, the possession of a moderately-sized collection of old volumes, and you have all the ingredients necessary for the unearthing of the real genuine No. 1, who somewhere in the dark ages of Science was the only son of a widowed mother, learnt three languages by sitting up late at night, and imbibed science in lieu of beer during the dinner hour. If this exhumed No. 1 be finally admitted within the pale of science, after due discussion and examination of his claims, the names of the discoverer of the discoverer and of the discoverer of the discovery will in all probability have become so linked together that, like twin stars, they will for ever revolve around each other in the scientific firmament, and be reckoned of equal magnitude.

About two things, and two things only, should history concern itself in dealing with the personal equation of a scientific discovery, and these things are its intrinsic value and the manner in which it was made. As it is, intrinsic worth counts, indeed, for something; but opportuneness, date, and mode of publication, and practical possibilities count for much more. That one man had a clearer idea of what he was aiming at, or a more intelligent perception of the true meaning and bearing of what he had found, will avail him but little in face of the fact that someone else stumbled upon the same object, it may be, quite four-and-twenty hours before. It is the knowledge of this that leads so many to sacrifice thoroughness and lucid exposition in their desire to "take date." Hence comes the modern custom of publishing, step by step, the blind gropings of the laboratory:—"Certain experiments which I have been making on the electrolysis of aniline have casually led me to suspect that there is a fundamental flaw in the Newtonian theory of gravitation; more anon (April 1st). Further experiments have convinced me of the absolute correctness of my conclusion; I have now only to test the accuracy of my electrostatic voltmeters, &c. . . . Regret to say that a redetermination of H and g in my laboratory has revealed grave inaccuracies, vitiating conclusion jumped to on April 1st, so can only take date for my 'suspicion.'"

Notwithstanding this rage for taking date, two and two, we doubt not, will continue to the end of time to make four, and the truth to be that the honour awarded to a discoverer ought in no way to be lessened, because, totally unknown to him, someone else has carried out an investigation on parallel lines, and has anticipated his conclusions. The intellectual triumph is the same in either case, and the waste of thought and experimental skill are due to the defects of the system. It does not follow that a man is entitled to "all the honours of war" who shuts himself up, and deliberately ignoring the work of his scientific ancestors and contemporaries, magnanimously gives to the world results long since common property. An indispensable preliminary to the solution of every scientific problem ought to be to make oneself acquainted with the results of previous work in the same field, but in these days of verbiage and voluminousness an investigator who would exhaust the literature of his subject before commencing his own attack runs a risk of never beginning—of not seeing the forest for the trees. After all, to quote from HELMHOLTZ once more, "All this literature of untried and unconfirmed hypotheses has no value in the progress of science. On the contrary, the few sound ideas which it may contain are concealed by the rubbish of the rest; and one who wants to publish something really new—facts—sees himself open to the danger of countless claims of priority unless he is prepared to waste time and power in reading beforehand a quantity of absolutely useless books, and to destroy his readers' patience by a multitude of useless quotations." In the past a lack of proper means of intercommunication led to much wasteful working on parallel lines. To-day the danger is that this absurd ambition to publish first "without considering the ripeness of the research," in order to secure the equivocal advantage of priority, leading as it does to the publication of an immense amount of "untried and unconfirmed hypotheses," will equally result in wasteful working on parallel lines. The volume of the stream of scientific literature must of necessity continue to grow so long as men continue to burrow into nature. Let us, however, dry up one perennial source of printed inanities by setting a right estimate on the minor question of date.

REVIEWS.

Water or Hydraulic Motors. By PHILIP R. BJÖRLING. (London: E. and F. N. Spon. New York: Spon and Chamberlain. 1894.)

The author of this little book tells us, in his preface, that he has been induced to write it because "all the books previously published are too abstruse in mathematics, and not practical;" and he assures us that "deep, and in many cases useless, calculations are avoided." We, therefore, passed on to read the book, with the anticipation of something very practical; and we may perhaps have expected to find some royal road which is a short cut to the intricacies of mathematical treatment. We cannot say that either of these expecta-

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tions were realised, and especially in regard to the latter, we have been but confirmed in our conviction that there is no satisfactory short cut or royal road to the study of hydraulic or any other branch of mathematical engineering. In his haste to cut away all appearance of mathematical equation and form from his pages, the author has inflicted upon his readers such rigmaroles as the following:—"The loss of energy then equals the weight of the water multiplied by the square of the higher velocity in feet per second, divided by 64·4, and the result multiplied by the number of times the column is arrested per minute, minus the weight of the water multiplied by the square of the lower velocity in feet per minute, divided by 64·4, and the result multiplied by the number of times the column is arrested per minute." Almost breathlessly we exclaim, How much better and more neat this would have been if in the shape of a little formula! Can any "higher mathematician" solve it in its present form? Again, in his extreme desire to make the principles of hydraulics appear simple and non-mathematical, the author makes them simpler than they really are, and thus misleads where he professes to instruct. Thus, in an early chapter on "Hydraulics Relating to Water Motors" we find the statement that "the wetted surface in the motor should be small, as friction is proportional to that surface," a statement which, when taken by itself, and without qualification in regard to the velocity and section of the flow, is a completely erroneous principle of design. This chapter, which professes to introduce the reader to the elementary principles, is nothing more than a badly arranged collection of mere assertions, without the slightest attempt at proof; and many of these assertions are either completely wrong or are limitations of the truth. A serious defect in the chapter, and indeed in all the theoretical chapters, is the absence of any definitions of the hydraulic terms used. A curious feature of the chapter is the "table of square and cube roots, advancing by *half-inches*;" as also is the absence of any table of 5th powers.

The author is more correct and more happy in the later chapters, in which, for the most part, he confines himself to a series of descriptions of water-wheels, turbines, and water-pressure engines. His descriptions, too, are well illustrated with numerous drawings, which have the merit of being something more than mere pictures. The illustrative part of the work is, indeed, one of its best features, and considerably compensates for defects in other respects. The author has, perhaps, been too careful to perpetuate older types of machinery, and not careful enough to give due proportion to the later and more efficient types; but that, in an elementary and unscientific work which this claims to be, is perhaps a pardonable defect. Water-wheels and turbines are treated of in about 110 pages, the remaining 144 pages being concerned with hydraulic rams and water-pressure machinery. The separate chapter on "Circumferential-flow Turbines" is based on a questionable classification; and of the types selected for illustrating this class two are inward-flow turbines and the other is an outward-flow turbine. The sole ground upon which we can recommend this work is that it contains a number of illustrated descriptions of water motors, old and new; but the work is untrustworthy as a treatise on the principles either of the construction or of the action of these engines.

Electroplating. By J. W. Urquhart. Third Edition. (London: Crosby Lockwood and Son. 1894.)

While the preface disclaims for this book any concern with electro-metallurgy, it professes that it has been brought fully up to date. No reference whatever is made to Mr. J. W. Swan's method of obtaining high-current density in copper plating or to the silver-cadmium alloy. Eleven pages at the end of the book relate to the use of dynamos, and contain very insufficient information about current density and voltage. The book should be entirely rewritten on modern lines.

Electric Light Installations. By Sir David Salomons. Vol. II. Seventh Edition. (London: Whittaker and Co. 1894.)

This volume consists of descriptions, with many illustrations, of various kinds of machinery and apparatus, including several obsolete and nearly obsolete examples. It is not confined, as was the author's original work, to private house work, but touches on supply stations, mining, &c., but in a very superficial manner. The subject is treated neither from the amateur, the professional, the critical, or the scientific point of view. It is promised that Vol. III. will more particularly deal with the method of working, so that the detailed information which some might naturally look for in this book, will be found in the one that follows. It is, therefore, impossible to regard the present volume as other than a set of illustrations of a forthcoming work.

THE RELATION OF MATHEMATICS TO ENGINEERING.*

BY JOHN HOPKINSON, F.R.S.

(*Concluded from page 43.*)

Submarine telegraphy yields some interesting examples of the application of the higher mathematics. When a cable across the Atlantic was first seriously entertained, the first point to be settled was, how many words a minute could be sent through such a cable. This was the most practical question possible. Upon the answer depended the prospect of the cable paying commercially if successfully laid. The matter was dealt with by Prof. Thomson,† of Glasgow, now Lord Kelvin. He showed that the propagation of an electric disturbance in a cable could be expressed by a partial differential equation, and that the solution of this equation under certain conditions applicable to practice could be expressed either by a definite integral or by an infinite series. The values of these were calculated, and hence before an Atlantic cable was laid at all it was known how long it would take a signal to reach the opposite shore, and how much its intensity would be diminished in transmission. Referring to Fig. 5, abscissæ represent time, reckoned from the time of making contact at the sending end of the cable, ordinates the currents at the receiving ends, curve (1) gives these currents when the contact at the receiving end, after being made, is continuously maintained. It will be observed that for a time a there is hardly any current at the receiving end, that then the current rapidly increases, and attains to half its final value after a time equal to about $5a$. Curves (1) . . . (7) show the currents at the receiving ends when the contact is made at the sending end maintained for times a, $2a$ . . . . $7a$ respectively, and then broken. Looking at curve (1) one sees how small is the amount of current and how long it lasts compared with the time during which contact is made. The time a depends on the length and character of the cable; it is equal to $kcl^2 \log_\varepsilon \frac{4}{3} / \pi^2$, where k is the resistance per unit length, c the capacity per unit length, and l the length of the cable. The knowledge of what is the commercial value of a cable depends on a knowledge of the value of a, and this cannot be obtained without knowing the differential equation $ck\frac{dv}{dt} = \frac{d^2v}{dx^2}$,‡ to which I have referred, and its by no means simple solution either as a definite integral or as an infinite series. So far as I know, this piece of higher mathematics cannot be evaded by any mere elementary treatment. The transmission of disturbance in a cable is quite different from the transmission of sound waves in air, which move with constant velocity. If the cable be doubled in length, it takes four times as long for the signal to pass through it instead of just twice as long, as would be the case if it were a proper wave motion. In fact the time of passage between the making of contact at the sending end of the cable and the beginning of the resulting disturbance at the receiving end, varies as the square of the length of the cable. The mathematical theory is exactly the same as that of the transmission of heat in a plate, one surface of which is suddenly exposed to a temperature different to the temperature of the plate. This is constantly occurring in the application of mathematics—one piece of mathematical work serves for many physical problems having apparently little in common. Fourier long ago discussed the heat problem, little dreaming that his analysis would be just what was wanted for ascertaining how fast signals could be sent across the Atlantic by a system of telegraphy which in his days had not even been projected in its simplest form. The same differential equation also gives the theory of the transmission of telephonic messages through cables; but the solution is then easier, and tells us exactly why it is so much more difficult to speak through 100 miles of cable than through 1,000 miles of overhead line.

* The "James Forrest" Lecture, delivered before the Institution of Civil Engineers, May 3rd.

† "Mathematical and Physical Papers," Vol. II., p. 61. Sir W. Thomson.

‡ v is the potential, t the time, and x the distance from the sending end of the cable.

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As I have just stated, the differential equation of the disturbance in the cable is $c k \frac{d v}{d t} = \frac{d^2 v}{d x^2}$. A musical note of period T spoken into the cable through a telephone is properly represented by $A \sin \frac{2 \pi t}{T}$; the disturbance in the cable will be—

$$v = A e^{-x \sqrt{k c \pi / T}} \sin \left(\frac{2 \pi t}{T} - x \sqrt{k c \pi / T} \right),$$

as may be easily verified by differentiating. This equation tells us everything. It tells us the rate at which the waves diminish with the distance. This rate increases with the resistance, with the capacity and with the frequency. If the capacity is at all considerable the diminution is rapid. The velocity of the waves is not the same for all frequencies, as is the case with waves in air, but varies as the square root of the period, so that if two notes were sounded the high note would arrive after the low notes, and the resultant effect would be entirely destroyed. Here, again, it is difficult to see how the differential equation and its solution can be evaded.

Though the history of the telegraph dates only from a little more than 50 years ago, it is ancient in comparison with the other great applications of electrical science, which have received their development during the last 15 years. Here again mathematics which are not quite elementary have played their part. In the theory of transformers we find another illustration of the need of knowing how formulæ are obtained if they are to be correctly applied. The early transformers were made with unclosed magnetic circuits; there was an iron core, but the lines of magnetic force passed through air for a considerable part of their path. In this case a complete mathematical theory was not very difficult. But speedily closed magnetic circuits were found to be

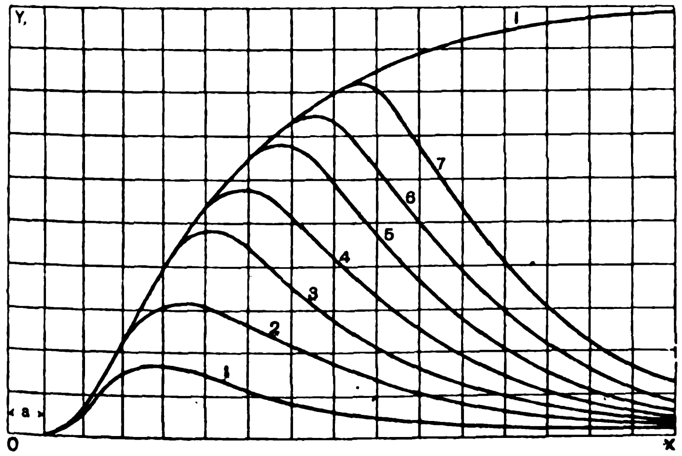

Fig. 5.

better, and the relation of magnetic induction and magnetic force became all important. If anyone were to apply mathematical formulæ, which were true for the earlier transformers, to the later ones, his results would be inaccurate. Indeed a wholly different method of attack on the problem was needed, taking account of the facts as they are, and applying results which were true of older apparatus to cases essentially distinct.*

The employment of alternating currents has brought into use, as a necessity for understanding the actually observed phenomena, a great deal of mathematics. Why is the apparent resistance of a conductor greater for an alternating current than for a direct current? And by resistance I do not mean the quasi-resistance due to self-induction.† The mathematical electrical theory is ready with an answer; it is ready, too, to tell us how the difference depends upon the frequency of the current and on the size of the conductor. In the case of a cylindrical conductor the solution involves a knowledge of Bessel's functions. We learn that if the current has a high frequency, or if the conductor be large, there will be very little current in the centre of the cylinder, and that therefore for any practical purpose the centre of the cylinder might just as well not be there; the current is largely confined to the part of the conductor near to its surface. The currents at different depths in the conductor attain to their maximum values at different times; those near the surface of the cylinder occur before those at some distance from the surface. The mathematical conditions are expressed by the same equation as is used to express the disposition of heat in a cylinder the surface of which is submitted to a periodic variation of temperature. Anyone who had thoroughly mastered the heat problem would be quite prepared to deal with the problem of currents in a conductor. It cannot be too often repeated, any piece of pure mathematics which finds one application to a physical problem is almost sure to find, in exactly the same form, applications to other problems which superficially are absolutely distinct. The differential equation in this case is $k c \frac{d v}{d t} = \left(\frac{d^2 v}{d r^2} + \frac{1}{r} \frac{d v}{d r} \right)$, the similarity of physical condition to the problem of linear propagation of heat is close, but the mathematics differs materially owing to the presence of the term $\frac{1}{r} \frac{d v}{d r}$ in the equation. Mathematics deals with the relation of quantities to each other without troubling as to what the physical meaning of the quantities may be. Hence it is that the mathematical treatment of two such problems as the distribution of currents in a cylindrical conductor and of heat in a cylinder is identical, whereas the treatment of the distribution of heat in a cylinder is quite distinct from the treatment of the distribution of heat in a sphere or in a solid bounded by two parallel planes.

A curious phenomenon was observed in the large alternate-current machines at Deptford when connected to the long cables intended to take the current to London. The pressure at the machines when connected to the conductors was, under certain conditions, actually greater than when not so connected. The phenomenon is one of resonance very analogous to the heavy rolling of ships when the natural period of roll is about the same as the period of the waves.* The period of the alternating-current corresponds to the period of the waves, the self-induction of the machine to the moment of inertia of the ship, the reciprocal of the capacity to the stiffness of the ship, and the electrical resistance of the conductors to the frictional resistance to rolling. The mathematics in the two cases is then the same. The effect was predicted long before it was observed in a form calculated to cause trouble.

A problem which is still agitating electrical engineers is that of running more than one alternate-circuit dynamo machine connected to the same system of mains. Before the matter became one of practical concern, it was considered in this room, and it was shown mathematically that it was possible to run independently-driven alternators in parallel but impossible to run them in series. That is to say, that if two alternators were connected to the same mains they would tend to adjust themselves in relation to each other so that their currents could be added, but that if an attempt were made to couple them, so that their pressures should be added, they would adjust themselves so that their effects would be opposed.†

Perhaps of all engineering problems which have received their solution in the last hundred years, that of the greatest practical importance is the conversion of the energy of heat into the energy of visible mechanical motion. The science of thermodynamics has advanced along with the practical improvement of the steam engine. By its aid, particularly by the aid of the so-called second law, we know what is possible of attainment by the engineer under given conditions of temperature. I must not trench on the subject of one of my successors, but I may point out that our knowledge of the second law of thermodynamics was first developed by means of mathematics, and that to-day its neatest expression is by means of partial differential coefficients. The two most notable names in connection with the development of the second law of thermodynamics in harmony with the first are those of Kelvin and Clausius; both dealt with the subject in a mathematical form not comprehensible to those who have not had substantial mathematical training.

Illustrations such as these might be multiplied almost indefinitely. They show that the advancement of the Science of Engineering has been aided in no inconsiderable measure by the labours of mathematicians directly applying the higher mathematical methods to engineering problems. They show, too, one way in which respect for a formula may be dangerous, one way in which it is true that mathematics may be a bad master. In St. Venant's problems we have an example in which the use of older results of limited application in cases where the assumptions on which they rest are not true will mislead. The examples show the proper remedy; it is a more complete application of mathematical methods. The error is just one which a man will make who has the power to use a formula without a ready understanding of how it is arrived at. A practical man, ignoring mathematical results, might or might not escape the error of supposing that a triangular shaft would break at the angles under torsion; the half-educated mathematician would certainly fall into the snare from which complete mathematical knowledge would deliver him. You can only secure the services of that good servant, mathematics, and escape the services of a bad master by thoroughly mastering the branches of mathematics you use. The mistake caused by the wrong application of mathematical formulæ is only to be cured by a more abundant supply of more powerful mathematics.

* *Proceedings* of Royal Society, February 17, 1887.
† Lord Rayleigh, *Phil. Mag.*, Vol. XXI., p. 381.

* Institution of Electrical Engineers, November 13, 1884.
† Minutes of Proceedings Inst. C.E., April 5, 1883; Institution of Electrical Engineers, November 13, 1884.

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There is another drawback to the use of results, taken, it may be, out of an engineering pocket-book by those who are not prepared to understand how they are reached and on what foundations they rest. The educational advantage is lost. The close observation which enabled the earlier engineers to proportion their means to the ends to be attained was no doubt very laborious, and the results could not be applied to cases much different from those which had been previously seen, but the effect on the character of the engineer was great. In like manner, to thoroughly understand the theory of an engineering problem makes a man able to understand other problems, and in addition to this precisely the same mathematical reasoning applies to many cases. The mere unintelligent use of a formula loses all this ; it leaves the mind of the user unimproved, and it gives no help in dealing with questions similar in form though different in substance.

But even the use of mathematics by competent mathematicians is not without drawbacks. Mathematical treatment of any problem is always analytical—analytical, I mean, in this sense that attention is concentrated on certain facts, and other facts are neglected for the moment. For example, in dealing with the thermo-dynamics of a steam engine, one dismisses from consideration very vital points essential to the successful working of the engine, questions of strength of parts, lubrication, convenience for repairs. But if an engineer is to succeed he must not fail to consider every element necessary to success ; he must have a practical instinct which will tell him whether the instrument as a whole will succeed. His mind must not be only analytical, or he will be in danger of solving bits of the problems which his work presents, and of falling into fatal mistakes on points which he has omitted to consider, and which the plainest, intelligent practical man would avoid almost without knowing it.

Again, the powers of the strongest mathematician being limited, there is a constant temptation to fit the facts to suit the mathematics, and to assume that the conclusions will have greater accuracy than the premises from which they are deduced. This is a trouble one meets with in other applications of mathematics to experimental science. In order to make the subject amenable to treatment, one finds, for example, in the science of magnetism, that it is boldly assumed that the magnetisation of magnetisable material is proportional to the magnetising force, and the ratio has a name given to it and conclusions are drawn from the assumption, but the fact is, no such proportionality exists, and all conclusions resulting from the assumption are so far invalid. Wherever possible, mathematical deductions should be frequently verified by reference to observation or experiment, for the very simple reason that they are only deductions, and the premises from which the deductions are made may be inaccurate or may be incomplete. We must always remember that we cannot get more out of the mathematical mill than we put into it, though we may get it in a form infinitely more useful for our purpose.

Engineers no doubt regard their profession from very different points of view ; some think it a mere means of making money ; some regard it as an instrumentality for benefiting the race, whilst others again delight in it as an interest in itself, and delight in it most of all when new knowledge is added to that which we know already. It is just the same with the medical profession ; some attend patients for the guineas they receive, some give a very high place to motives of benevolence, whilst others love it as a field where new knowledge may be found and the delight of discovery enjoyed. In regard to the first class of engineers, I have no doubt a little skill in managing a board of directors or impressing a committee of Parliament will be much more useful than a great deal of mathematics. Let him manage his board and buy his mathematician, and it is very probable he will make much more money than the mathematician or any other person of skill whom he may employ. But we cannot all of us make money in this way. In the future it is likely that educated men will have to work harder and receive less, and it is a great thing if their work can be made itself a joy, and surely this can best be by a thorough understanding of the reason of all they do by the feeling that they have full competence to form their own judgments without depending much on the authority of others. This can only be, in the words of Sir John Herschel, by a "sound and sufficient knowledge of mathematics, the great instrument of all exact inquiry, without which no man can ever make such advances in any of the higher departments of science as can entitle him to form an independent opinion on any subject of discussion within their range."

After all, in any department of applied or pure science, the highest satisfaction comes from accomplishing that which no one has done before, from disclosing what no one hitherto has known. If a department of the arts or sciences ceases to advance and becomes simply the application in known ways of known principles to obtain known ends, that department has lost its charm till the time comes for a fresh advent of change and development. To effect such advances it is easy to show that mathematics is a most necessary instrument. Here it is no drawback that the mind of the discoverer is too analytical ; he may deal at his pleasure with one aspect of a problem, and it does not detract in any way from the value of his solution that he does not touch on incidental matters. Some of you who love the interest of continual advance in our science and practice, may look forward with a shade of sadness to a possible time when all is done or known which can be done or known, and the work of the engineer shall be merely applying principles discovered by his predecessors. In such a state, when the experience of the older generations shall control the practice of to-day, the free use of mathematical methods may be effectually superseded by the application according to rule of mathematical formulæ. But it would be a much less interesting condition than the constant change of to-day, when the practical experience of ten years ago is in many departments rendered worthless by later discoveries. But we need not fear that such a time of petrifaction will come so long as, whilst reverencing the discoverers who have added to our knowledge, we endeavour to replace their methods by better, and expect that those who come after us will, in their time, improve upon ours. Our knowledge must always be limited, but the knowable is limitless. The greater the sphere of our knowledge the greater the surface of contact with our infinite ignorance.

TESTING FOR GROUNDS ON INCANDESCENT CIRCUITS.*

BY AUSTIN S. B. LATCH.

After reading Mr. G. L. Thayer's article on "Grounds on Incandescent Circuits," in the *Engineer*, of April 11th, I send you a method I have used for about five years, and think it will commend itself to your readers, as no lights are disconnected in locating the ground. With slight modifications, the system can be adapted to alternating, as well as direct current, and either isolated or central stations. I devised the method from some experiments made by Mr. M. M. Waddell, of the Waddell-Entz Company, and myself, at the Edison station, in Detroit, in our attempt to locate grounds on the underground system by other than the "cut and try" method.

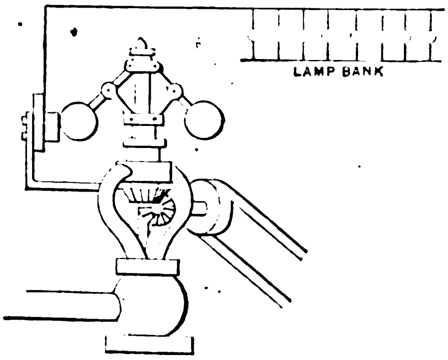

FIG. 1.

The mechanical stokers in that station are run by a small engine, with the ordinary ball governor. We used this governor to interrupt the current from a bank of lamps, as shown in Fig. 1. An iron arm is fastened to the governor frame ; this carries a block of wood, on which is a metal strip. The governor balls strike this strip and thus complete the circuit to ground through the engine. This gave an interrupted current through the system, from the ground to the station, and, by carrying an induction coil with a telephone receiver over the wires, we were able to follow in the direction of the ground.

My method is a modification of this. I divide the system into sections, and with auxiliary bus bars can test each section without putting out the lights. After locating the section I would try the inside wiring with the device shown in Fig. 2. This consists of an induction coil with a receiver connected to the fine wire terminals and a non-inductive resistance with an interrupter. The primary of the induction coil has screw clamps for terminals so that it can be connected to each side of the cutout. The resistance coil R is connected from the other wire to ground. By removing the plug or fuse strip the current will pass through the induction coil. If the ground is in the building there will be a heavy induced current in the receiver ; otherwise only a slight hum caused by the direct current. If the ground is in the building a few more such tests will easily locate the ground. Should the ground be found on the outside underground wiring it can be located without danger of producing fire ; so putting on a load at

* From the *Electrical Engineer* of New York.

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the station the indicators will show which feeder it is near. A junction-box can now be opened knowing that not more than one other will need be.

The first thing I do after opening the box is to test the feeder for ground, disconnecting of course. If it is in the feeder I disconnect both in the station and junction-box ; then connecting the terminals together in the junction-box I measure by the ordinary sliding-bridge method, as shown in Fig. 3. This is simply a Wheatstone bridge, and the point in the wire loop where the galvanometer is connected when the needle comes to rest will divide the loop just as the ground divides the feeder.

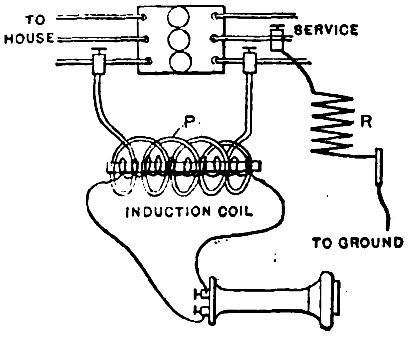

Fig. 2.

Should the ground be in the mains I use the same method as in inside testing, only using a heavier interrupted current, since the ordinary current is heavier. After locating the main and disconnecting so that it feeds from one end only, I put as heavy current through the ground as is safe without burning the smallest service, should the ground be in it. I now measure the voltage across this load and simultaneously at the services. The voltage across the load will be the same as that of the two services on each side of the ground. This is shown in Fig. 4. A, B, C, D, E, F are ser-

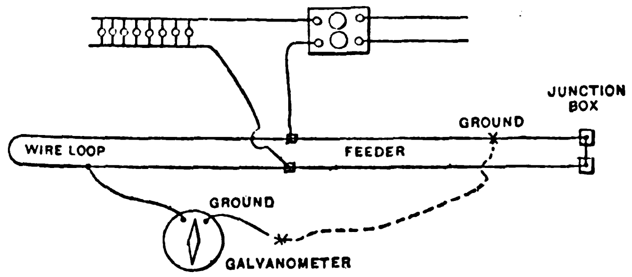

Fig. 3.

vices ; the voltage at M across the resistance is the same as at F and possibly a little less than at E since the current in passing through to the ground and back to K will produce an appreciable drop in the wire from K to the ground ; but the services F, G, H, will remain the same as M, as the testing is made when the load is light.

With the induction method 5 amperes is a large current and usually 2 or 3 is enough, depending on the normal current in the line. If the ground be in a cord or fixture this current will blow

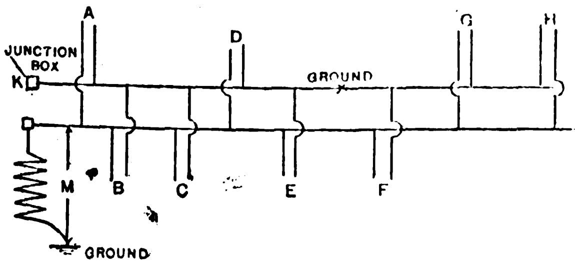

Fig. 4.

the fuse without any danger of fire, I do not advise a lamp bank for a testing resistance as it will attract attention, while a non-inductive resistance coil will give the appearance of connecting a telephone on the line "to hear the flow of the current. With overhead lines only the inside tests need be made as a good inspector usually knows his faulty spots and where to look first.

This may seem to be a long, roundabout method if the cut and try method has been used. But usually with two men, and often only one, I can locate the ground as soon as two men will by the "guessing process." Even if it took twice as long or cost twice as much, I would still advise the above method, I believe too much emphasis cannot be put on the importance of uninterrupted service either isolated or central station. One disconnected service costs ten times the apparent saving even if disconnected only for a moment, and it may cost a good customer. I believe the principal cause for the opinion of instability in electric lighting is due to the habit of employés indiscriminately disconnecting customers for testing purposes.

Of course we are avoiding grounds now by our better methods of wiring, both inside and out, than were employed five, or even three years ago ; still we have them, and that shows we cannot be too particular in watching our insulation resistance records. On arc circuits Rudd's method is the best ; but for Edison or other multiple arc systems I think a modification of Mance's method for measuring a resistance containing a potential difference, or else using two voltmeters at once, is to be preferred. I do not think much of measuring the resistance when the wires are idle but want the condenser effect.

COST OF ELECTRICAL ENERGY.

The following is an abstract of the discussion which has taken place on Mr. Crompton's Paper on the "Cost of Electrical Energy" (see *The Electrician*, April 27th, *et seq.*). Speakers who have returned their proofs revised have their remarks prefaced by an asterisk.

Mr. RAWORTH, in opening the discussion, said he imagined Mr. Crompton's was the most comprehensive Paper upon the question of works cost and management that had ever been laid before the Institution. In fact, it seemed to him to include very nearly the whole education of an electrical engineer. Mr. Crompton was endeavouring to show the possibility of reducing the cost of electricity to 3d. per unit to the consumer, and he arrived at the figures he had given them by first of all reducing the capital, and secondly by increasing the output, and thirdly by using better engines, boilers and dynamos. At first he (Mr. Raworth) thought the figures as to capital expenditure were scarcely justified, but on looking over the matter he found Mr. Crompton was perfectly justified, for at Bradford and Newcastle they already delivered eight units per sovereign of capital expenditure ; the next best were St. James's, six units, and St. Pancras, five units per sovereign. Then came Bournemouth, Westminster and Charing Cross, who delivered four and a-half, the Metropolitan, Kensington, and Liverpool gave four, and last of all came Preston and Oxford with two. Of course, it was too bad to try to apply the moral in these cases, because stations were so remarkably various. There was one very important point Mr. Crompton had made in connection with coal. It might be remembered that, some year or two back, Mr. Crompton put forward a table in which he connected all the prices per unit for coal expenditure by putting them through the sieve of their British thermal units and bringing them all up to one level, and showing what the cost per unit of coal would be in each station if the value were duly corrected. He (Mr. Raworth) then put out the hydrogen, which, although it counted perfectly well in the table, did not count in the boiler. He saw now that Mr. Crompton had fallen in entirely with his view, and had corrected his own views on that point. With regard to the boiler question, he quite agreed with Mr. Crompton, although it was quite contrary to what every boiler maker would tell them, that Babcock-Wilcox boilers did *not* give wet steam. Now he would go to the question of engine efficiency. Mr. Crompton was one of the first to put the theory of direct coupling into practice, and they owed him very great credit for the example he had shown in that direction. He could assure Mr. Crompton that they who had to build alternating current plants would have followed his example long since if it had been possible, but in the early days of the alternating current industry they could not get the money to do it, and in the second place they did not see their way to do it, because, as they all knew, they could not run an alternator at any speed they liked ; they had to run it at a speed which was in accordance with the periodicity of the system they had chosen. Therefore they had to find some other means of driving, and they took to rope driving, which had been pretty generally adopted, but they had found out—in fact, they knew all the time—that the sooner they could get rid of the ropes the better, because they were losing something like 6 per cent. all the time they were running—not 6 per cent. of the load only, but 6 per cent. solid loss. Therefore as soon as they could see their way to do it they would abandon rope driving and come on to direct driving also, so if Mr. Crompton would give them further statistics he hoped the alternating-current plant figures would come out very much better than they had done now. Coming to engine losses, Mr. Crompton was a great admirer of the Willans engine, and rightly so, for it had stood the industry in very good stead, and he himself admired it very much indeed. But when Mr. Crompton said the Willans engine was more efficient from the point of view of mechanics, he was under a wrong impression. He knew very well that the efficiency obtained was 89½ or 90, which was very good, but it was owing to the fact that makers of ordinary double-acting vertical engines never had the apparatus for testing their engines that the idea arose that this efficiency claimed for the Willans and Robinson engine was the top one. He could get—and anybody could get—from the ordinary vertical double-acting engine 92 per cent. ; it could easily be got, there was no trouble whatever about it, no special arrangements. The reason the idea had grown up that the Willans engine was so much more efficient than ordinary engines was that the ordinary engines which had gone through many and accurate tests had usually been horizontal

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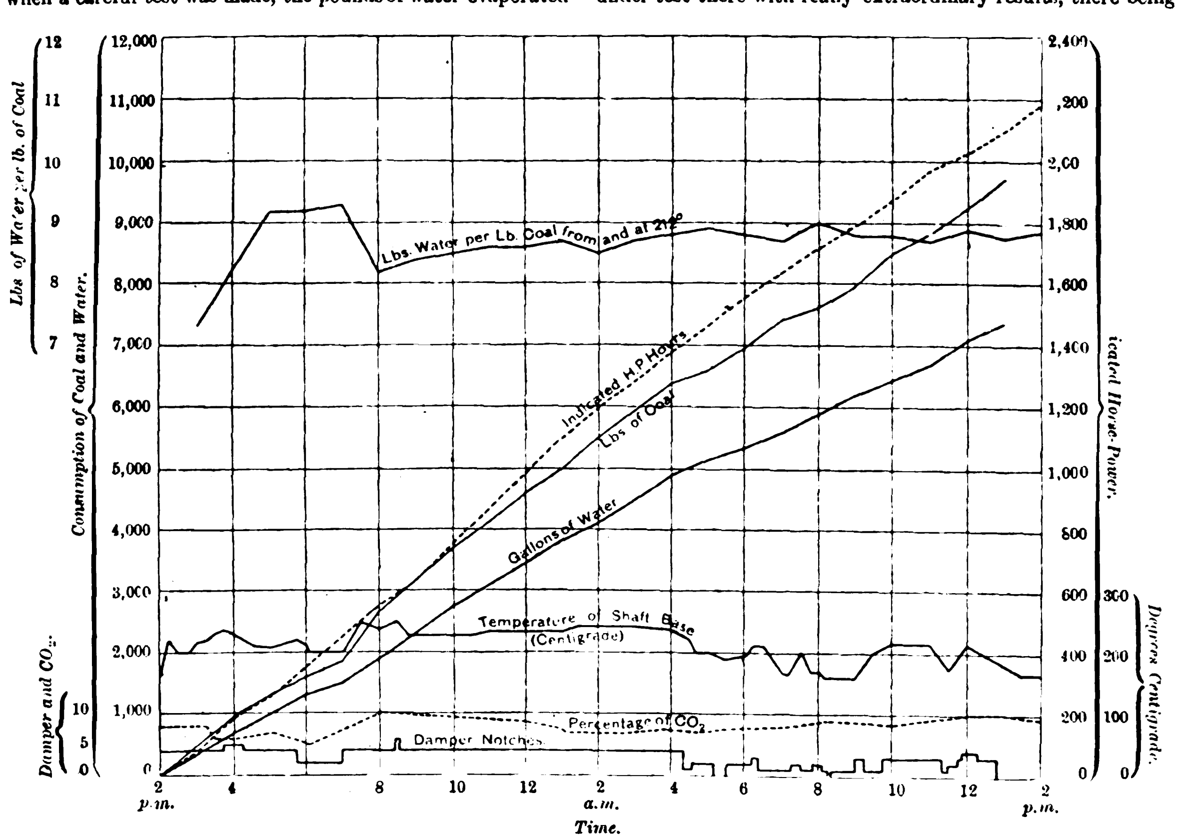
engines, and in those cases they had to deal with mechanical drag, a piston weighing tons, moving backwards and forwards at the rate of 500ft. or 600ft. a second, sliding on the bottom of a cylinder, and that made it almost impossible to get a higher efficiency, and made the Willans engine so much ahead of ordinary engines. But he would point out that the Willans and Robinson engine was extremely efficient on the down stroke only; on the up stroke it lost its efficiency, because when going back it was doing no power. Therefore, if they could make it double acting, probably its efficiency would go up to 95 per cent. He thought Mr. Crompton had fallen into one pretty serious error in regard to the efficiency of distribution where it referred to alternating-current systems. In central stations they simply took amperes multiplied by volts for their outgoing. As a matter of fact it was much less than that. The alternating-current systems were used in districts which were not to be compared with the districts where continuous currents were used. Taking Bournemouth as an instance, there were miles upon miles of wires in all directions; in fact, they could scarcely see from one house to another. Compare this with St. James's, where the work was not much different from lighting up a large hotel. Therefore, without large local knowledge it was almost impossible to form an accurate conclusion.

The discussion was then adjourned.

THURSDAY, MAY 10TH.

At the adjourned discussion on Thursday evening, May 10th, Mr. CROMPTON first drew attention to a diagram (*see* Figure) giving the results of a 24-hour test of a boiler at the Chelmsford power station. It showed that when a careful test was made, the pounds of water evaporated



per pound of coal rose to a little over 9; that was to say, the same boiler and the same apparatus which on the year's run come out at 5·2, under the careful conditions of the test got as high as 9. That was the class of test he recommended to be taken at frequent intervals in stations in order to enable the engineer in charge to know what their plant was capable of doing on the 24-hours' cycle. There was no doubt that, if at Chelmsford they took the same pains throughout the year as on that particular occasion, they would get for every day in the corresponding period of the year as good a result as on that occasion.

*Major-Gen. WEBBER said he was at a loss to know upon what system, especially in the metropolis, Mr. Crompton had framed his estimates. For instance, in Kensington, the three companies had a capital expenditure of £3 per lamp. Did Mr. Crompton believe that he was going to reduce that £3 to £1. 6s.? Did he forget that, of the 60 miles of streets which would be the ultimate area which would have to be lighted in Kensington, only about 4 miles had mains along both sides? Did he forget that the total plant of the three companies had only a capacity of 2,300 E.H.P. output, and did he believe that when that reached 13,500 E.H.P. output, which was the probable requirement of Kensington in a few years, he would then have come down to a capital expenditure of £1. 6s. per lamp? He (the speaker) did not think he did, and therefore wished to ask him where his ideal station would be. The speaker then criticised the mode in which the author of the Paper had collected his data, and the use he had made of them. The speaker was of opinion that the engineers who supplied data should have a hand in the compilation of the tabular statements. Chelsea was one of the most mixed stations in this country. The Paper which he (Gen. Webber) read two years ago described that station, and stated that, while accumulators were the main source of supply, there was also a distribution between transformer-motors and accumulators, showing a maximum loss of 30 per cent.; the supply by transformer-motors having a loss of very little more than 15 per cent., and the direct-current portion of the supply having a loss between the terminals of the dynamo and the consumers' terminals of 10 per cent. Therefore he did not think it was quite right to include the Chelsea system as not being one of those mixed systems purposely left out of the report for purposes of comparison. He thought the term "efficiency of distribution" was altogether a misnomer. It might be efficiency of copper. If Mr. Crompton had left out all the information regarding companies with which he was not acquainted, no one would have complained. He sympathised greatly with the engineers of the stations dealt with, because those of them who declined to fill in the returns must have disapproved of its form.

*Mr. MARK ROBINSON said: He hoped Mr. Crompton's prediction as regards the 2·5 of coal per unit might be realised. The prediction rested on three factors, amongst others; first, the evaporation by the boiler of 12lb. of water per pound of coal; secondly, the consumption by the engine of only 12lb. of steam per indicated horse-power hour; and thirdly, only a small amount of friction. With regard to the boilers, all he would say was that the figure of 12lb., or 10lb. in ordinary work, including all losses, was beyond the present practice. With regard to the dryness of steam from water-tube boilers, his own Company had lately taken up a water-tube boiler, from which they hoped great things, and from which they knew they got dry steam. They had had one under test there with really extraordinary results, there being about ¼ per cent. of moisture only. Mr. Crompton said his experience of Babcock boilers was that they were able to force them very much beyond their original capacity, and they had still given dry steam. They had had just the same experience with the Niclausse boiler, which at its proper rate of evaporation, gave less than ¼ per cent. of moisture in the steam. It was then worked at considerably more than twice its rated capacity, and still gave less than 1 per cent. of moisture. They had tested a Babcock boiler about the same time, and with practically the same result. The figures mentioned for the consumption of steam (12lb.) had been reached, he believed, by the Sulzer engine. One could wish that the results had been corroborated by concordant results from a good series of progressive trials, or, at least, that they had been the means of many trials. The undoubted competence of the observers in the case of the Sulzer trials commanded, however, their fullest respect and acceptance. Mr. Willans's best experimental figures at Thames Ditton were about 12·8lb., and the best guarantee they had ever given was 13·5lb. for a mill engine of 500 I.H.P., though this probably allowed a very good margin. He had no doubt they could, by carrying expansion much further and by jacketing to the utmost and carrying out every refinement possible, bring the high-speed engine down to the same figure as the Sulzer engine; but in doing so they would have to make a bigger engine, with larger cylinders and pistons and more ring friction, and, of course, at much more cost. With a larger ring friction they would get smaller brake efficiency in the engine and smaller combined efficiency in the plant. He was afraid the combined efficiency of 86 to 88 per cent. upon which Mr. Crompton relied would not be forthcoming. That was the point he wanted to bring out; they could not eat their cake and have it too. They must

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not take the smallest steam consumption *and* the smallest friction, and expect to get both in the same engine. Mr. Raworth at the last meeting said the brake efficiency of the Willans engine was 89½ to 90 per cent., and he went on to say that every other vertical engine had the same or more, and he named 92 per cent. That was very well, but he would like to know how it was arrived at. He did not think it was safe to say, because one had taken a friction card with an engine running light, and it showed only 8 per cent. of the full power, that the brake efficiency was 92 per cent. In the case of the Willans engine it probably was so; but he thought the Willans engine differed in that respect from ordinary engines. Mr. Raworth stated that if the Willans engine were double-acting it would have considerably less friction in proportion to power developed; but that meant ring friction, and ring friction was practically constant at all loads. There were four principal kinds of friction, it appeared to him, which an ordinary engine suffered from. In the first place, there was the friction of rings—piston rings—and valve piston rings. That certainly was practically independent of the load. Then, secondly, there was slide-valve friction, which in most engines rose rapidly with the load; but from that the Willans engine was of course exempt. Thirdly, there was the bearing friction, which, when the brasses were bathed in oil, seemed by the trials they had made not to rise with the load, but which they believed, in the case of double-acting engines, or, at any rate, where the bathing in oil was not so complete, *did* increase with the load. Fourthly, there was another friction loss, increasing with the load, where the pressure on the brasses was not all in the same direction, but involved alternate pull and push, as in ordinary engines—what the Americans called "lost motion"; of its rate of increase they knew nothing, but they believed it existed, and at any rate the single-acting engine was free from it. Thus it would appear that the single-acting engine had only sources of friction which were approximately constant, whereas that with which Mr. Raworth compared it had also causes of friction which increased with the load. Therefore, he was not able to accept friction cards as conclusive upon brake efficiency. The mean of a number of engine tests made on Willans engines which were new and stiff, and which would certainly give better results afterwards, came out at 90·6 brake efficiency. Those tests were made with a brake arranged on what was usually known as Mr. Halpin's plan, and they believed the figures were reliable. Mr. Crompton had made an excellent practical suggestion in one small matter, the use of a pressure gauge on the steam chest. If people knew how useful such an arrangement was they would always use it.

Mr. W. GEIPEL said he hoped to show that Mr. Crompton had been altogether too modest. He (Mr. Crompton) said, in speaking of the item of first cost, "we engineers have nothing to say in controlling these figures." He (the speaker) did not for one moment agree with this. The reduction of the cost of electricity supply stations was very largely indeed the business of engineers. In his opinion the present high price of electric supply was due mostly to an insufficient consideration having been given to this question of first cost. It was certainly not always judicious to incur every possible expense in providing for saving in coal and labour and stores without regard to the consideration of outlay. For example, costly chimneys were frequently erected when a less outlay in this respect would suffice, or condensers and economisers were erected capable of dealing with the maximum load, the consequence being that a large portion was utilised but a mere fraction of the year. Was it not the function of an engineer to so lay out the capital that the cost of interest, depreciation, and the working expenses were together a minimum? Mr. Crompton did not say precisely how he arrived at his first cost of 2s. per unit sold per annum; but if his basis were the 20 per cent. load factor to which he alluded further on, his figures meant a cost of £175 per kilowatt. It was his opinion that the first cost might frequently be less than one-half this figure, not certainly on the low-tension direct-current system, upon which he feared Mr Crompton had based his figures, but with the more modern alternate-current system, using high-tension feeders, supplying by transformers a low-tension network. He did not see why the improvements which were being made in the efficiency, and the reduction of the cost of alternators and transformers, should not enable them in future to arrive at a figure of £60 per kilowatt under favourable circumstances. He was not so sanguine, however, as Mr. Crompton upon one or two points. A 20 per cent. load factor was not often recorded in central stations in this country. Even 15 per cent. was considered good. He did not see how coal could possibly be reduced to 2½lb. per unit, but believed 4lb. might be reached, even with English coal, which could be obtained at 7s. and less per ton, making the cost of coal 15d. per unit. He was afraid that the figure Mr. Crompton had given, namely, 12lb. of water evaporated per pound of coal, was one the attainment of which would gladden the hearts of legions outside the electrical profession. He was aware that, under specially favourable circumstances, with the best fuel and conditions, and deducting ashes, this result might be attained on occasion, but he had not yet found anything approaching this in practice, even under circumstances much more favourable than those which obtained in central station working. In fact, further on in the Paper, a lower figure, namely, 10lb., was spoken of. At the same time, there could not be a doubt that there was room for improvement, and perhaps he might be permitted to mention two methods of setting boilers which he had designed with a view to reducing the losses due to the radiation from boilers. One was applied to the Babcock-Wilcox boiler, which, as they were aware, was enclosed by a large amount of brickwork, absorbing, as Mr. Crompton pointed out, a proportional amount of heat. In order to reduce this he had introduced a thermal insulator in the form of an air-space in the middle of the side walls, so that the outer half did not absorb as much heat as heretofore. This setting had been applied to the boilers at the Huddersfield and other electricity works, and had, he understood, been since adopted by Messrs. Babcock at another place with good results. The other method related to cylindrical boilers of the Lancashire and similar types which he arranged as follows:—The gases, after passing through the boiler and under, were diverted into a main flue, which led on to the economiser; from this they passed by a large side flue round each boiler consecutively to the chimney; so that whatever number of boilers happened to be out of use at any time, they were kept warm by the waste gases from those in use. He did not agree with Mr. Crompton that the Lancashire boiler was unsuitable in all cases for electric lighting purposes, nor that its efficiency compared so unfavourably with other boilers. The comparison given between the marine boiler at Glasgow and the Lancashire by Bryan-Donkin was certainly unfavourable to the Lancashire, but of all boilers the Lancashire was most unsuited for burning coke. It would probably be found that with bituminous coal the results would be reversed. Mr. Crompton spoke of a difficulty in utilising the hydrogen constituents of the coal. Might he suggest that, provided there was an excess of the proportion of hydrogen above that required for combining with the oxygen already in the coal there should be no difficulty with a suitable furnace in utilising the heat of combustion? He thought it had been demonstrated that bituminous coal could be burnt under proper conditions without causing smoke, while the results of tests of the flue gases, so far as he knew, did not show unoxidised hydrogen to any extent. There was this advantage with the bituminous or flaming coal, namely, that the heat was less confined to the grate. In other words, it enabled a more gradual use to be made of the boiler-heating surface. At the same time, he quite agreed with the author that anthracite coal had many advantages. He merely pointed out that there were numerous districts in this country where bituminous coal could be used with far greater economy than anthracite or Welsh coal. The great point which accounted for the suitability of the Babcock boiler, was in the small quantity of fuel required for raising steam, which was largely due to the small proportion of water contained in the boiler. He was inclined to believe that there were cases where it would be advantageous to use a combination of Lancashire and Babcock boilers where bituminous coal was cheap, using the Lancashire continuously, and the Babcock for the top parts of the coal curve. He was sorry to see that Mr. Crompton recommended the use of boiler fluids, &c., to keep the scale and sediment from affecting the surfaces; he was of opinion that the boiler was not the proper place to effect the deposit of mud and scale. The better cure was the removal of the impurities from the water before it entered the boiler. The reserve power afforded by the forcing capabilities of the Babcock boiler was of enormous importance, for it enabled the passing over of the peak of the load curve with a smaller quantity of boilers, and though at the moment of forcing there might be some loss of efficiency, it was probably more than counterbalanced by the saving in steaming further boilers, to say nothing of the saving in capital outlay in having less boilers to provide. He was glad to see this forcing advocated by Mr. Crompton, and was of opinion that it might often be worth while providing blowing apparatus to be used during the heavy load period, which after all presented a mere fraction of the whole year. Mr. Crompton referred to the average efficiency of the existing alternating systems as 66 per cent., but this was largely due to the use of separate transformers. The result of banking transformers was, however, making enormous improvements in this respect, and in Mr. Crompton's table this was instanced by the 82 per cent. of the City of London Company. He was glad that Mr. Crompton advocated superheating the steam. He had for several years been an advocate of this practice, but instead of resorting to the use of superheaters, of which Mr. Crompton rightly points out the difficulty, why not evaporate the steam at a higher pressure, using reducing valves on each boiler? There was no difficulty in working a Babcock boiler at 200lb., and if steam at this pressure were reduced to 150lb. pressure in the steam pipes they would at once have approximately the 8 per cent. superheating mentioned by Mr. Crompton. The loss in the steam pipe was undoubtedly of the most serious nature, and every precaution should be taken to subdivide the steam pipes into sections controlled by valves, so that only that portion of the steam pipe which was absolutely necessary at the time being was used. Mr. Crompton spoke of the use of surface condensers, as entailing the working out of several very difficult problems connected with the thorough filtering of the oil contained in the exhaust steam. Why use oil in the cylinders at all? It was a common practice in the Mercantile Marine, and Mr. Raworth never had a drop put into his cylinders, condensing or noncondensing. This was a very simple solution of the difficult problem. He confirmed all Mr. Crompton said as to the wastefulness of direct-driven feed pumps. His attention was first called to this about six years ago, when he made two six-hour tests. Since those tests his Company had designed a pump driven by spur gearing from a high-speed engine, from which very much more economical results were obtained.

*Mr. SCHÖNHEYDER said: He had intended to make some remarks about Mr. Crompton's statement as to the poor efficiency of Lancashire boilers, but there were other gentlemen in the room who would make them better than he could. He would only say that, in making such a statement, Mr. Crompton ought to have put a note stating the rate of evaporation in pounds of water per square foot of heating surface per hour; without that it was impossible to say whether the boiler was economical or not. The other point to which he wished to refer was in respect of water-meters. It was evidently of great importance that the water should be measured for electric light stations, and Mr. Crompton had been good enough to refer to his (the speaker's) meter. Mr. Crompton stated that it had given him fairly satisfactory results. He (the speaker) had lately arranged improvements whereby all the seven rollers and their pins were entirely done away with, and he believed he had now got over all the difficulties in measuring hot water.

Mr. ROBERT HAMMOND said: They ought to be grateful to Mr. Crompton for his prophecy of a selling price of 3d. per unit. It had been said it was a pity that he had mentioned such a figure, because those outside would be distressed to find that whilst waiting for the 3d. they

were being charged 5d., 5½d., 6d., and so on. He did not share those views. He thought the more they could make outsiders feel that this industry had a basis whereon it could compete directly with every other illuminant, the sooner their fortunes as electrical engineers would be made. With regard to the 3d., however, it certainly was an alarmingly low figure; 3d. per unit on 5,000,000 units was £62,500 per annum; and perhaps Mr. Crompton in his reply would inform the members how many towns in England at the present time had gas companies with such a revenue. In all these comparisons they too often forgot the question of output. It was impossible with any justice to compare the costs of two companies without taking the question of output into consideration first and last. He thought the plan of finding out what the extra cost of the extra output was from one twelvemonths to another did give them a bit of a guide towards the soundness of the working cost of the works. If it were possible, having attained a certain output, whatever it might be, to increase it by 10, 15 or 20 per cent., with only an increase in cost of 2½, 5, or 7½ per cent., then those works would be in an extremely sound condition. Mr. Geipel referred to the average of some half-dozen or dozen of the companies in a certain list, and drew the attention of the members to the very great difference existing between the ideal figures of Mr. Crompton and the actual figures being obtained. There came in the question of output. The basis of Mr. Crompton's Paper was some huge concern. The next point was that Mr. Crompton omitted depreciation. Mr. Crompton's reply no doubt would be that he had made ample provision for maintenance. That was a doctrine he would very much like to hold, but he dared not, for he could not shut his eyes to the fact that even if there were no depreciation there was an "antiquation" element to be considered. Mr. Geipel said that possibly they might reach the ideal capital outlay of £60 per kilowatt. It happened that at Leeds, where they began with only 250 kilowatts last year, and where the success had been so abnormal that they would finish this with 900 kilowatts, their cost would be below £60 per kilowatt. If electricity was going to be supplied at 3d. per unit it must be by means of the by-products, or, what came to the same thing, by the uses of the plant in those hours, 21 or 22 very often out of the 24, when the lighting was not called for.

Mr. M'LAREN said that he was not an electrical engineer, but a maker of engines for driving electrical machinery. The question of the cheapness of the production of electric light depended to a very large extent upon the motor by which that light was produced. The crux lay in the coal consumption, and in order to reduce the coal consumption it was necessary to have an engine which would use a small quantity of coal for the power that was given off. Now, in the published tests of engines the information was very often incomplete, if not misleading. They very often read of the tests of particular boilers, and they were very interesting, so far as they went, but they did not afford engineers sufficient information to enable them of themselves to choose which was the best boiler for the purpose of driving an electrical machine. A boiler might give a very good result in evaporation when tested by itself and by the water that was pumped into it, and by the steam that was given off from it; but if that steam was largely saturated with water the evaporation which was ascertained by the test would be very misleading. On the other hand, there were engine tests which were conducted irrespective of the boiler which supplied the steam. Those tests might be very satisfactory, but if the engineer who was putting down an electrical installation was guided solely by the figures which were put before him in that way he might be very far astray when he came to put his boiler and engine down. The only true criterion was to test the engines in connection with the boilers they were intended to work with. The figures might look very pretty for the boiler and very pretty for the engine, but when they came to be tried together they might be very far out. With regard to the question of steam generators, he agreed with the author of the Paper in so far as the locomotive type of boiler was concerned, but he disagreed with him in regard to the amount of evaporation which he put down as the ordinary evaporation of a locomotive boiler. They had found in their own experience that the evaporation of locomotive boilers was a great deal nearer 10 than 7, at which it was put down in the Paper. They had had in tests of their own locomotive boilers as much as nearly 12 evaporated from and at 212deg. He had no hesitation in undertaking that in the ordinary way, with a well-constructed boiler, they could depend upon an evaporation of from 10lb. to 11lb. of water per lb. of coal from and at 212deg. The evaporation of many boilers, especially of water-tube boilers, with all due respect to Mr. Robinson, was in many cases an unknown quantity owing to the wetness of the steam which they frequently gave off. Then the Lancashire boiler was very much over-rated, because they found as a rule that the gases were generally discharged at 700deg. (?), necessitating the use of a very expensive economiser, for unless the boiler was accompanied by an economiser the efficiency as a steam producer must be very low indeed. He accounted for the great economy at Oxford by the fact of the engines being triple-expansion slow-running and surface-condensing. He thought it was a very great mistake to put down high-speed engines to drive electric plants. He did not expect that to go down readily, but he was quite sure, if he might be allowed to prophesy, that the future electric lighting engines would not be high-speed small engines. They might just as well put an express locomotive on with small cylinders and small wheels to drive the express trains, and run it to death. With regard to the cost of maintenance, they knew something about single-action engines; he was not speaking of any particular engines, but of single-action engines generally. He knew some makers of engines of that class of engine would undertake to keep them in repair at rates very far beyond what would be required to keep slow-running engines in repair, and it was in the maintenance as well as in the economical production of steam and the economical use of it, in his opinion, that the cost of electric lighting was going to be reduced.

Mr. M'LEAN said: Mr. Crompton had criticised the Oxford system in one or two points. He said that under the head of "Stores used in the Generating Works" the decrease had been very noticeable during the last few years of working, and in the case of Kensington Court it had reached as low a figure as 0·025d. per unit sold, adding that no doubt a lower figure would be reached as the output and load factor improved. In a note in *The Electrician* Mr. Crompton was reported to have said, in speaking of the efficiency of distribution, that the Oxford figures came in at a late period, but that the results were very encouraging; in fact, were almost too good to be true, especially in regard to the use of stores as shown in Table VII. In that table Mr. Crompton gave 0·03 as his ideal; Kensington Court had reached that low figure. Why should he discredit the statement that they had reached the figures given at Oxford, which were still 50 per cent. above his ideal? It was no argument that because no other station had got so low Oxford had not, and he was quite prepared to substantiate his statement. It might interest Mr. Crompton to analyse their sheet of daily working; it was 4ft. 6in. long. They were very small people down at Oxford, but they held the record in one or two items, and he was glad to have had the opportunity of coming there and substantiating his statements.

Mr. BURNETT said he was only in a position to speak on the boiler question. He did not think Mr. Crompton was quite right when he said, that in judging of the comparative value of fuels they should always remember that it was far less difficult to obtain a high boiler efficiency from steam coals than from those which contained a larger percentage of carbon in the form of coke. There must be a grate to suit the quality of fuel used. He sympathised with Mr. Crompton in what he said about the mechanical disadvantage of locomotive boilers, and he thought Mr. M'Laren slightly misunderstood Mr. Crompton in regard to that. He did not think he found fault with the efficiency of locomotive boilers, but with the difficulty of dealing with the low grates in putting in the fuel and banking the fires, and certainly the ordinary locomotive fire-box type was not the best. It was pretty well acknowledged that the Babcock and Wilcox boilers could do, and had done, good work with Welsh coal, and he thought the great radiation which Mr. Crompton feared, would not be serious in a range of boilers, but only with a single boiler. He did not think, however, that it had been established that they were the best for efficiency. When used with bituminous fuel they were certainly not the best. He was greatly surprised that Mr. Crompton had so lightly passed over the more or less difficult problem of cleaning the boiler. The next step boiler engineers must take must be to analyse the merits of their boilers at different speeds and rates of evaporation, just as Mr. Willans did with his engines.

The discussion was here adjourned until May 24th.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *May* 4, 1894.

Electric Traction.—The New York Legislature at its closing Session passed a Bill offering a prize of $50,000 for the most economical system of street railway traction. The object of the Bill is to take up the recent sham competition of the New York City Metropolitan Traction Company, and it now awaits the Governor's signature. Mr. E. H. Johnson, well known in England in connection with the placing of the Edison patents there in the early days of electric lighting, has been experimenting during the winter with an electric street railway underground system, and has just made some of the details public. The system—the joint invention of Mr. Johnson and Mr. Robert Lundell, the inventor of the Lundell dynamo and motor—consists of short lengths of a centre contact rail, from which the car takes current by means of a sliding brush, and to which current is fed when contact is successively made by means of mechanism in underground boxes, which is actuated by an electromagnet in the bottom of the car. Each car has a storage battery to "pick up" when necessary the line current, and also for emergency use and to pass over crossings if thought desirable.

The "Goebel Defence."—The United States Circuit Court of Appeals for the Eastern District of Wisconsin has handed down an opinion in the Oconto lamp case which finally, it is thought, disposes of the celebrated "Goebel defence." The opinion refers to the struggle of the scientific world from 1854 to 1880 with the problem of the subdivision of the electric light, and states that the mind cannot readily assent to the assertion of Goebel that he had in the meantime solved the problem, and yet made no attempt to claim the benefit until after the Edison lamp had for years been on the market. Several patents taken out by Goebel are referred to, and the conclusion arrived at that it is unbelievable that one so careful of his rights with respect to trifling matters should evince utter disregard of his interests in a matter of such great moment as his alleged invention of the incandescent lamp.

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CORRESPONDENCE.

THE RELATION OF CAMBRIDGE MATHEMATICS TO ENGINEERING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have generally made it my practice not to reply to reviews of anything I may write. If I do so in relation to your review of my lecture at the Institution of Civil Engineers, it is because I do not think your reviewer does justice to my university, not because I am in any way personally annoyed. Is it the fact that geometry is taboed by Cambridge mathematicians? Maxwell, you admit, used geometrical methods freely, and you might have added to the illustrations you give his book on heat wherein the subject is treated in the text geometrically, and the corresponding analysis is hinted at in footnotes. Lord Kelvin's method of electrical images is essentially geometrical, and from his work many other examples could be collected. Tait gives the theory of the damping of oscillations a geometrical form. To come to a humbler example, my own work whether on characteristic curves or on alternate currents, is more frequently handled by geometrical than by algebraic methods. Geometrical methods have at Cambridge a specially protected position. But my belief is that as a fact algebraic methods have been useful for discovery more frequently than geometrical. The work being once done it is often easy to cast it into a geometrical form. The point may be illustrated by a story which was current years ago at Cambridge. In old times the geometric methods of Newton were alone admitted in the Senate House. An eminent candidate had read the French Algebraic methods, but he dare not, under dire penalties, introduce them to the examiners. What did he do? He worked out his problems algebraically first and then translated his algebra into geometry. And that is frequently done in the larger world, discoveries are often first made algebraically, and are afterwards translated into geometry.

Mathematicians should, indeed, be ambidextrous—equally ready with algebra and geometry. If in my lecture I have rather insisted on the uses of the calculus it was because I thought that its methods were unduly feared and shunned by engineers, not because either I or other Cambridge mathematicians disliked or shunned geometrical methods.—Yours, &c.,

J. HOPKINSON.

A UNIVERSAL SHUNT BOX.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Perhaps you will allow me to point out that the slip referred to by Mr. Sullivan in your issue of to-day occurred only in the proof of the Paper and in the Press reports of this proof; it will not be found in the Paper itself, as already printed in the *Journal* of the Institution of Electrical Engineers.

May we not claim that, as it is much easier to divide in one's head by 10, 100, and 1,000 than by 9, 99, and 999, the slip points to another advantage possessed by the universal shunt-box?—Yours, &c.,

T. MATHER.

May 11, 1894.

METHODS OF MEASURING SELF-INDUCTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the letter from Dr. Sumpner, which you published last week, he is aggrieved that I do not mention to whom the first method I described of measuring self-induction is due, and then, with strange inconsistency, claims it for himself. I should prefer to describe it as Maxwell's method, modified by Dr. Sumpner. The method is such an obvious modification of Maxwell's that it seems to me hardly necessary to change the title. Dr. Sumpner attributes the second method—rightly, I believe—to M. Joubert.

The object of my Paper was not only to explain shortly these methods, which have been used for years in many physical laboratories both at home and abroad, but also to show in a simple manner how they could be applied to measure mutual induction, and to give an extension of Prof. C. Niven's formulæ.

There are those who, advisedly or not, desire to have their names associated with all the work they do. But, surely, in this case, where the method in question is identical with that of Maxwell, except that, instead of spending time in reducing the deflections of the galvanometer to zero, the obvious suggestion is made that two readings be taken, and the zero reading got by simple interpolation, it cannot be right to name the method after the man who introduces such a small modification.—Yours, &c.,

ALEXANDER RUSSELL.

Faraday House, Charing Cross-road, W.C., May 16, 1894.

IMPOSSIBLE PRICES

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have before me a report in a local paper of a lecture delivered by Mr. Raworth, of the Brush Engineering Company, at the Guildhall, Winchester, on Tuesday, the 8th inst., in which he is stated to have said, "He was aware of the objections as to the initial cost of fitting up premises with electricity, and he did not think under the most favourable circumstances it could be fitted into private houses for less than 17s. 6d. per lamp, but in the case of shop windows and in hotels it could be done for half the price."

Now, what I wish to point out to you, Sir, is this, that considering the enormous amount of jerry wiring, &c., which is being carried on all over the country at the present time, at a very cheap rate, by plumbers and others who really have no claim to know anything of our profession, is it not a mistake that a man representing a company of the standing of the Brush Company should get up in a Guildhall and tell the people of a country town that they can get their wiring put in at a price at which most assuredly it can only be done in large towns, and that under very favourable circumstances? Surely we ought to be able to look to our leading firms to keep up the good quality of work, otherwise the production of inferior work will seriously endanger the standing of our profession in the estimation of the public.—Yours, &c.,

H. D. PARMITER.

Manchester, May 16, 1894.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

The 1894 Edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK IS NOW READY. This valuable book contains 1,000 closely-printed pages, and several new and useful features have been added. The price of the Directory and Handbook is 7s. 6d. Postage in the United Kingdom, 9d.; abroad, 1s. 4d.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," being four Lectures delivered before the Royal Institution in April-May, 1894, by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is in preparation, and will shortly be published.

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. (abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application to the Publisher.

"ELECTROMAGNETIC THEORY," by Oliver Heaviside, is now ready, price 12s. 6d. (abroad 13s.). Prospectus on application.

"THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application to the Publisher.

"DRUM ARMATURES AND COMMUTATORS."—This book, written by Mr. F. Marten Weymouth, is also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"INVENTIONS, RESEARCHES AND WRITINGS OF NIKOLA TESLA," by T. Commerford Martin, may be obtained from the Publisher of *The Electrician*, and a copy will be forwarded post free on receipt of 16s. 6d.

"HOW TO WIRE BUILDINGS."—Copies of this work, by Augustus Noll, will also be sent by the Publisher post free on receipt of 6s.

TENDERS ACCEPTED.—The tender of Messrs. W. and J. Robinson and Co. has been accepted by the Bootle Town Council for the supply and erection of the electric light installation in the public buildings for the sum of £3,224, subject to Mr. T. L. Miller, of Liverpool, being employed to superintend the installation.

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TENDERS RECEIVED.—The Lighting Committee of the Wolverhampton Town Council recommend the acceptance of the tender of Messrs. Bailey, Pegg, and Co., of Brierley Hill, for the supply of 36 arc lamp posts at £5. 15s. each and five arc lamp brackets at £2. 15s. each.

——— Seven tenders have been received by the Lighting Committee of the Brighton Corporation for the supply and erection at the central station of two motor-alternators, with switchboards and instruments, and for the supply of 12 transformers and 60 meters. The highest figure is £5,147, the lowest £1,731. 17s. (?), the latter from the Electric Construction Company (Limited), which is recommended for acceptance. The tender of the British Insulated Wire Company (Limited), for supplying the alternating cable required for Preston and North-East Brighton, together with the necessary joints and disconnection boxes, at £3,579. 6s., has been also recommended for acceptance.

APPOINTMENT.—Mr. Arthur Ellis, A.I.E.E., has been appointed Clerk of the Electricity Works by the Southport Corporation to superintend the laying down of the cables and of the fitting up of the central station equipment.

VACANT APPOINTMENT.—The Corporation of South Shields require the services for a few months of an engineering draughtsman as assistant to the electrical engineer, for the purpose of preparing plans and generally assisting him. Some further particulars are given in our advertisement columns; and applications must be sent in not later than noon of Monday, the 28th inst., to Mr. J. Moore Hayton, Town Clerk, Court-buildings, South Shields.

LIQUIDATIONS.—A petition has been presented for the compulsory winding up of Marchant, Young, and Co. (Limited), and is down for hearing on the 23rd inst.

SALES BY AUCTION.—Mr. Bradshaw Brown announces the sale by public aution of the stock-in-trade and loose machinery which is to be sold by order of the receiver and manager in Woodhouse and Rawson United (Limited), at Cadby Hall Works, Hammersmith-road, London, W., on Tuesday and Wednesday, May 22nd and 23rd, at 11 for 12 o'clock. Further information will be found in our advertisement columns, and all particulars can be obtained of the auctioneer, Billiter-square-buildings, E.C., and the Estate Offices, Millwall, E.

——— Several important sales by auction are announced in our advertisement columns by Messrs. Wheatley Kirk, Price, and Goulty. On Wednesday next, the 23rd inst., at the North Stafford Railway Hotel, Stoke-on-Trent, the valuable freehold land, buildings, engines, boilers, machinery, and plant of the Union Foundry, Kidsgrove, Staffs., is to be brought to the hammer. The time fixed for the sale is 3 for 4 p.m. prompt. On Tuesday, the 29th inst., and following days, an important sale of new and secondhand machine tools, plant, electrical fittings, instruments, and apparatus will take place on the premises, 39, Commercial-road, London, E.

SALE BY PRIVATE TREATY.—One of the oldest and best known machine tool-making concerns is, owing to the death of a partner, offered for sale by private treaty by Messrs. Wheatley Kirk, Price, and Goulty, of whom full particulars can be obtained either at the offices in London or Manchester.

INSTRUCTIONS FOR WORKING PLANT.—The Brush Electrical Engineering Company has issued a pamphlet of instructions for working dynamos, alternators, "Brush engines," &c.

PERSONAL.—Mr. E. R. Dolby, C.E., desires us to state that he has been appointed consulting engineer to Messrs. C. H. Glover and Co., of the Hatcham Saw Mills, for the electric power transmission plant and crane to be installed at the mills. Mr. Dolby has also in hand consulting work for the London Missionary Society, &c.

REMOVAL.—Messrs. King and Co. notify that they have removed from Rosebank Electric Works, Edinburgh, to the Leith Electric Works, Leith. The telegraphic address is changed from "Electric, Edinburgh," to "Electric, Leith."

——— Messrs. Davis and Soper, agents to the Johannesburg Lighting Company (Limited), have removed from 6, Great Winchester-street, to 54, St. Mary-axe, London, E.C.

ALUMINIUM SOLDER.—A recent issue of the *Iron Age* of New York contains an article describing a series of tests of a new aluminium solder now being introduced by the Alsite Aluminium Company. Among the tests made were butt welds of sheets and plates which, under tension, showed the soldered joint to be so well made that rupture took place in every instance outside the joint. Strips connected by butt soldering were twisted in the vice without opening the seam, and soldered tubing has been successfully drawn recently. The surfaces to be soldered are cleaned by dipping in a hot solution of soda or potash, then dipped into nitric acid, rinsed in hot water and dried. Sometimes the surfaces are cleaned by filing the edges to be joined. The parts to be soldered are heated as hot as can safely be done without melting. During the entire operation the metal is kept as hot as possible, and it is completed when the solder becomes distinctly white or the aluminium assumes a reddish hue.

"SNOWFLAKE" COMPOSITION FOR INCANDESCENT LAMPS.—Mr. V. Fabris, of 171, Drummond-street, Hampstead-road, London, has patented a new coating for incandescent lamps. The composition, which is called "Snowflake," possesses, it is claimed, the advantage of diffusing the light in a softer and clearer manner than by frosting or other coatings. The process also lends itself to many pleasing varieties of patterns and designs. It is also claimed that greater strength is given to the fixing of the bulb to the rim of the lamp. A variety of lamps coated with the composition are on view at the above address.

MANGANESE.—A contract has recently been entered into between the owners of the Manganese Mines of Tchiatoura (Caucasus) and the firm of Messrs. G. Pincher and Co., of Hamburg, for developing the working of the Caucasus Manganese Mines. This firm obtain a monopoly for the sale to European and American steel works. The estimated output to be annually delivered will be about four million poods (pood = 36·1lb.).

THE BRISTOL TIME CHECK.—Messrs. King, Mendham and Co. have now ready an illustrated pamphlet giving full particulars and instructions for using the Bristol electrical time check. This price list can be obtained on application to the Western Electrical Works, Bristol. The check was fully described in our issue on January 12th last.

INDIAN TEXTILE DIRECTORY.—We have received from the publishers of the *Indian Textile Journal* a copy of their Directory of Indian Manufactories, recently published. The book will be found of service to those interested in the textile industries, and lists are given of managers, owners, &c., of the principal cotton spinning and weaving mills in India. The Directory is issued by the publishers at 27, Meadow-street, Fort, Bombay, price 7s. post free.

THE JOURNAL.—Part III. of the *Journal* of the Institution of Electrical Engineers is now ready, and contains Papers by Mr. W. M. Mordey, Prof. W. E. Ayrton and T. Mather, and Prof. W. E. Ayrton and C. S. Whitehead, with full reports of the discussions thereupon. Copies can be obtained of Messrs. E. and F. N. Spon, price 3s.

FOREIGN EXHIBITIONS.—The *Moniteur Officiel du Commerce*, of Luxembourg, announces that a labour exhibition is to be held in that city from April to September, the principal object being to make known the different types of improved small motors, machine tools, and tools and accessory apparatus used in the different trades in the smaller industries, as well as the products made with these instruments.

——— An international exhibition of machine tools driven by electricity is, according to the *Bulletin du Musée Commerciale*, being arranged for by the Hungarian Commercial Museum in conjunction with an executive committee nominated by the Hungarian Minister of Commerce. This exhibition was to be opened in May, and is to remain open until the end of September.

——— The mining exhibition which is to be opened at Santiago in September is to be divided into eight sections, including motor machines, electricity, mining machinery, mechanical preparation of ores, metallurgy, chemical industries, statistics and plans, and products of the working of mines and metallurgy.

GAS AND ELECTRICITY.—At a meeting last week of the Liverpool Gas Fittings Company, the Chairman mentioned that some years ago, when electricity was coming to the front, they altered their Articles of Association to enable them to supply fittings for the electric light. Had they not done so they would have lost a good deal of business which had lately come to them. They were constantly getting orders for electric light fittings and that was one reason why they had been able to maintain their dividend (10 per cent.).

ASHTON-UNDER-LYNE.—At the last meeting of the Town Council a Sub-Committee was appointed to consider the question of erecting an electric lighting central station in connection with a refuse destructor. The Corporation obtained a Provisional Order in 1892.

AYR.—The Town Council on Monday agreed by a majority of 10 to 7 to adopt a plan prepared by Mr. Robert Hammond for the introduction of the electric light, the estimated cost being about £15,000.

BARKING.—New public offices are being erected for the Local Board, and the question whether gas or electricity should be adopted for the lighting was discussed at the last meeting, and, notwithstanding the advantages offered by the electric light, the question of cost was made the first consideration, and it was decided to use gas.

BRECHIN.—At a meeting of the Town Council on Thursday last week, Mr. Jamieson said that Messrs. Ferguson and Eggie, and himself, had inspected the Coatbridge electric light station, with which they had been highly pleased. He moved that the Town

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Council apply for a Provisional Order, but although some discussion ensued no decision was come to. During the discussion it was pointed out that unless something was done by the Local Authority a private company would apply for a Provisional Order, and any opposition the Council had then to offer would have comparately little weight owing to their not proceeding in the matter themselves.

BOLTON.—At a meeting of the Gas and Electricity Committee of the Town Council it was decided to have a scheme prepared by the electrical engineer setting out the terms and conditions upon which arrangements may be made for the hire-purchase of electrical fittings by consumers from the Corporation's mains. Excellent progress is being made with the works, and Messrs. Siemens Brothers and Co. have begun the laying of the electric lighting mains.

BRIGHOUSE.—The consent of the Town Council has been asked for the obtaining by a proposed local company of a Provisional Order to take over the plant of Mr. A. B. Brooke, and to supply electricity in the borough, but at their meeting last week the Council decided to withhold their consent.

CAMBERWELL.—The Vestry have resolved to adhere to their determination to compel the London County Council to put all wires for fire stations underground. The County Council, from motives of economy, desire to place the wires overhead.

CARDIFF.—Mr. W. H. Massey, the electrical engineer to the Cardiff Corporation, has presented a report on the progress made with the electric lighting works. He states that the laying of mains and street work generally was practically complete, and that the machinery would soon be all in position. It has been decided by the Corporation to prepare a pamphlet setting out the scale of charges for electric current and bringing before possible consumers the advantages to be derived from adopting the electric light.

CARLOW.—It is stated that Major Alexander, of Milford House, Carlow, has purchased from the receiver of Messrs. J. E. H. Gordon and Co. (Limited), the plant, &c., of the Carlow Electric Lighting Company.

CHURCH LIGHTING.—An additional 200 lights is to be added to the installation at the Marylebone Presbyterian Church, Upper George-street, London, W., the order being placed with Messrs. Rashleigh Phipps and Co.

COVENTRY.—Mr. H. F. Tulloch held a Local Government Board inquiry last week into the application of the Coventry Corporation for permission to borrow £20,000 for the purpose of the electric lighting of the city. The Town Clerk and Mr. Robert Hammond, the consulting engineer, supported the application, which was not opposed. The Electric Light Committee have reported to the Town Council that they have approved the plans and specification of the proposed electric lighting station, and have ordered that advertisements inviting tenders be issued. 8d. per unit is the price fixed for lighting currents. 8d. per unit is the price fixed upon for lighting current.

DUNOON.—The Burgh Commissioners are contemplating the introduction of the electric light at the Castle Gardens this summer, at an estimated cost of between £400 and £500. The matter is to be finally decided at an early meeting of the Commissioners.

DERBY.—The Electrical Exhibition was opened on Monday last by the Mayor, and is held under the direction of the Electric Lighting Committee of the Town Council. The original idea emanated from Mr. W. H. Marsden, J.P., the Chairman of the Committee, but was not at first received with much enthusiasm; however, in the fulness of time, and by diligent application on Mr. Marsden's part, those who originally opposed the holding of the exhibition were brought to view the idea with favour. A catalogue has been issued, consisting of nearly 70 oblong quarto pages, giving a short history of the Electric Lighting Order for Derby, and the progressive steps taken to bring the scheme to a successful issue. A description is given of the central station, and the plant therein installed. The advantages of the electric light are set out in a popular way, and the list of exhibitors is a sufficient guarantee that the exhibition is not wanting in support from the contractors for the supply of electrical fittings and apparatus. At the opening ceremony the Mayor was surrounded by the leading citizens of Derby, and Mr. J. E. Stewart, the engineer and manager of the electric light works, Mr. W. H. Marsden, and several others, had an opportunity of clearly demonstrating to visitors the advantages electricity offers over all other illuminants for public and private purposes. Messrs. W. T. Glover and Co., C. A. Parsons and Co., Crompton and Co., W. T. Henley's Telegraph Works Company, the General Electric Company, Siemens Brothers and Co., all occupy prominent stands, and the Edison-Swan Company, exhibit a large variety of lamps of all candle-powers, fittings, &c. Altogether the exhibition promises to be a great success.

EDINBURGH.—The Lord Provost's Committee of the Town Council have recommended that the electric light be extended to Fountainbridge.

GEORGETOWN (BRITISH GUIANA).—At the annual meeting of the Georgetown (British Guiana) Gas Company (Limited), held on Tuesday, the Chairman said that the Georgetown Town Council first of all lighted a portion of the public lamps by electricity instead of gas, which accounted for the reduced dividend on last year's working. Since then the electric light has been entirely substituted for gas in the remainder of the public lamps. The Gas Company's outlook was, therefore, described as "gloomy."

ETON.—The Local Board have appointed a committee of five members to meet a sub-committee of the Windsor Town Council to consult on the electric lighting question, the last named body having received a numerously-signed memorial urging that prompt progress should be made in the supply of the electric light.

FOLKSTONE.—The question of the electric lighting of Folkestone has been before the Corporation in one form or another ever since April, 1893, and on April 6, 1894, a resolution was passed by the Corporation approving of a scheme which would cost £35,000. There has been considerable opposition on the part of the ratepayers to the expenditure of so large a sum, and at a special meeting of the Corporation, held on Thursday last week, it was decided by 9 votes to 6 to rescind the resolution previously arrived at. The original resolution under which the above decision was come to was proposed by Councillor Hall, and seconded by Alderman Banks, a director of the gas company. Subsequently the Mayor made a lengthy address on the subject, in the course of which he said that 90 per cent. of the ratepayers, although in favour of the electric light, were against the heavy expenditure involved. A Mr. Baker, in the course of the discussion, mentioned a scheme under which he was prepared to light a similar area to that proposed by the expenditure of £35,000 for the sum of £12,000, but a resolution that Mr. Baker be asked to submit his scheme to the Corporation was lost.

GUILDFORD.—The Corporation have not yet come to an agreement with the promoters of the electric lighting scheme respecting the period at which the Corporation should have the option of purchasing. The Corporation suggest 30 years, but the promoters, while originally stipulating for a longer term, have accepted a suggestion from the Board of Trade that the period should be 35 years, and the Board of Trade propose to grant an order on these terms. At the last meeting of the Town Council a resolution was passed that the Corporation were not prepared to consent to the grant of the order upon these terms.

HERTFORD.—The Town Council have had under discussion further information with regard to the proposed scheme for electric lighting. Information is being collected as to the charges to be made to consumers, and the Electric Lighting Committee are ascertaining the amount of support likely to be accorded to the scheme. The annual cost of gas for the lighting of the town and public buildings amounts to about £500, and it is contemplated that the electric light can be adopted within this figure.

JOHANNESBURG.—Our contemporary, *South Africa*, in its last issue contained an account of an interview with Mr. W. F. Lance, who is in this country on business in connection with the Johannesburg Lighting Company, of which he is Managing Director. Mr. Lance said in the course of the conversation that the demand for the electric light was rapidly growing, and he was endeavouring to arrange for the extension of plant.

LONDON COUNTY COUNCIL.—At the last meeting a report was submitted from the Highways Committee as to the feasibility of providing for the lighting of Westminster and Waterloo Bridges by electricity, apart from the question of similarly lighting the Victoria Embankment. The Committee stated that they had come to the conclusion that, in view of the very large extra expense the establishment of a separate installation for the two bridges would involve, it was not advisable that the course indicated should be adopted. The drawings for the generating station were approaching completion, and it was anticipated that the installation would be completed in time for the Embankment and the bridges to be lighted by electricity next winter. The Committee had still under consideration the question of the positions in which the lamp-standards for the Embankment will be placed; but in the meantime the other work could be proceeded with. The report was adopted by the Council.

LARNE.—The Town Commissioners on Friday, after some considerable discussion, ultimately passed the draft agreement between themselves and Messrs. J. E. H. Gordon and Co. for the lighting of the town by electricity.

MORECAMBE.—At the last meeting of the Sanitary Committee of the Local Board reports were received from the Surveyor and from the Medical Officer on the subject of an alleged nuisance at the generating station of the Morecambe Electric Light and Power Company (Limited). The Surveyor states in his report that it is his opinion that the nuisance is the manufacture of gas by the Dowson apparatus. The Medical Officer's report is to the same effect, and after careful consideration it has been decided to take proceedings.

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against the Company unless the nuisance is at once abated. It is only fair to the Company to say that they have not yet had an opportunity of placing their views before the Committee; this opportunity is to be offered to the Secretary and Engineer at the next meeting.

NEWCASTLE.—The extensive premises of Messrs. James Coxon and Co. are now lighted throughout by electricity, the firm having undertaken the work with their own staff. Considerable extensions have recently been made.

NORTHUMBERLAND COUNTY ASYLUM.—The gas plant at the Northumberland County Asylum requiring renewal, the Visiting Committee have had estimates submitted them, showing the cost of renewing the gas works, and of supplying an electric lighting plant respectively. The total cost of new gas works, including boilers required for steam power for the new laundry, was estimated at £5,060, and the estimated cost of an electric lighting plant, including the same provision for the new laundry, was £7,275. The Committee, after some discussion, decided in favour of adopting the electric light, and have recommended it for the approval of the County Council.

PORTSMOUTH.—The Town Council have adopted the recommendation of the Electric Lighting Committee that the new electric lighting station be not insured, on account of the excessive premiums required by the insurance offices. Hydrants are to be provided at a cost of about £150, although it was said to be almost impossible for a fire to occur at the station.

ST. PAUL'S, COVENT GARDEN (LONDON).—The Charing Cross and Strand Electricity Supply Corporation (Limited) have applied to the Strand District Board of Works for their consent to the Corporation's application to the Board of Trade for a Provisional Order empowering them to supply electricity within this parish.

WEST HAM.—The Highways and Parks Committee of the Town Council have considered a proposal made by Councillor Hunns to advertise for a practical electrical engineer to advise the Council on the carrying out of the West Ham Electric Lighting Order of 1892, but, having given the matter careful consideration, the committee ultimately decided to recommend that the Town Clerk be directed to take all necessary steps to preserve the powers conferred on the Council by the Order, but that, owing to the outlay involved in the erection of the new sewage outfall works, no further steps be taken in connection with the electric lighting scheme for the present. It has been decided to invite tenders for lighting the Public Hall and Library, and the lamps in front of these buildings by electricity, the plant to be installed on the Public Hall premises.

WHITEHAVEN.—At the meeting last week of the Trustee Board the Chairman gave some figures showing the pecuniary results of lighting the town by electricity. He said that the total cost for the year had been £1,080. The revenue collected was £207, leaving the cost of public lighting for the year at £872, about £12 less than the cost for the preceding year, when the town was lighted by gas. He estimated that the cost of the public lighting during the coming year would be rather more, but it would then be considerably less than the average cost of gas for the last ten years, in addition to which the town was now considerably better lighted than it was formerly. It was remarked that for lighting the town twenty years ago the Gas Company were paid £1,990.

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

May 3, 1894.

8,815. L. MOND and R. L. MOND. London. Improvements in electrolytic cells.

8,823. J. A. L. DEARLOVE. London. Improvements relating to the transmission of signals through telegraph lines and cables.

8,825. THE ELECTRICAL INSTALLATION COMPANY (LIMITED) and E. L. O'BRIEN. London. Improved means for conducting electricity through table-cloths, carpets, and the like to electric lamps and other electrical devices.

8,835. W. J. STILL. London. Improvements in the electrical propulsion of cars.*

8,838. J. PILLISCHER. London. Improvements in fuses or cut-outs for electric lines.

May 4, 1894.

8,845. J. L. PHIPPS. Oxford. Harness collar for carrying the electric light on harness.

8,895. F. KING. London. Improvements in or connected with secondary or electric storage batteries.

8,896. A. JOSEPH. London. Electrical apparatus for preventing collisions and other accidents on railways.

8,917. H. ALEXANDER. London. Improvements in or in connection with apparatus for the electro-deposition of metals.*

May 5, 1894.

8,924. C. LANGSTONE, B. YOUNG, and J. A. EWINS. Birmingham. Self-contained electrical generating apparatus and driving mechanism.

8,972. F. GRIFFIN. London. Improvements in or relating to secondary batteries.

8,976. W. S. SEATON. London. Improvements in submarine telegraph cables.

May 7, 1894.

8,982. T. B. GRANT. London. Improvements in dynamo-electric machines.

May 8, 1894.

9,117. P. JENSEN. London. Improvements in and relating to electro-magnetic tools. (G. Fonda, ———.)*

9,123. H. S. MAXIM. London. Improvements in and relating to electric railways.

9,129. H. BLUMENBERG, jun. London. Improvements in electrolysis.

May 9, 1894.

9,178. A. G. WATERHOUSE. London. An electrolytic meter for measuring electric currents.

9,184. G. WILKINSON. London. Improvements in conductors for the distribution of electrical energy, and the insulation thereof.

9,215. C. E. DAVIS. London. Improvements in the system of circuit control for electric machines.*

May 10, 1894.

9,285. C. KELLNER. London. Improvements in or relating to electrodes, and method of manufacturing the same.

9,292. E. A. ALLEN. London. Improvements in or connected with electrolytic cells.

9,295. H. H. LAKE. London. Improvements in electric lamps for bicycles and similar vehicles. (G. Mayr, United States.)*

9,328. B. HOOKER. London. An improvement in or relating to apparatus for electrolysis.

9,342. R. HEATHFIELD and W. S. RAWSON. London. Improvements in the methods of electrically-coating wire tubes and similar articles.

9,348. A. WILSON. London. Improvements relating to electric lighting.

9,350. A. FORD-LLOYD. London. Improvements in apparatus for electric lighting by means of primary or secondary batteries.

9,351. C. H. ELLIOTT. Beckenham. Improvements in apparatus for testing telephone lines.

SPECIFICATIONS PUBLISHED.

All Specifications price 8d. each.

1893.

10,130. PIEPER. Driving vehicles on electric rail or tramways.

10,648. MITCHELL. Electric light and heat stove.

12,142. TYER. Electrical railway switch.

14,472. BARKSHIRE and WRIGHT. Switch for shop-door bell-circuits, &c.

22,912. WHEELER. Secondary batteries.

1894.

3,658. HALL. Dynamo-electric machines.

3,962. DORMAN and SMITH. Electrical switches.

4,987. DE SEGUNDO. Electric Arc lamps.

5,025. SMITH. Electric rail or tramway systems.

5,271. BROWN. Electric railways.

5,273. BARKER (Lawrence Electric Company). Electric railways.

COMPANIES' MEETINGS AND REPORTS.

Western and Brazilian Telegraph Company (Limited).

The twenty-seventh ordinary general meeting of this Company was held yesterday (Thursday) at Winchester House, Old Broad-street, under the presidency of Mr. W. S. Andrews.

The SECRETARY (Mr. R. M. Cunningham) read the notice convening the meeting, and subsequently the minutes of the previous ordinary general meeting.

The CHAIRMAN: Gentlemen, I presume that, as usual, you will take the report as read. We first of all have to deal with the receipts, and for the half-year ended December, 1893, they amounted to £80,338. 18s. 3d., as compared with £86,954. 11s. 3d. for the corresponding period, the difference being a diminution of £6,600. Remembering the state of things that existed during the half-year under review in Brazil, and what was to be expected, and what has actually happened, the receipts are very satisfactory. The international telegraph traffic with Brazil was completely suspended from September 6th to 20th; the internal traffic from September 6th to 18th; Santa Catharina was stopped for many months, and messages at various times were interdicted between Pernambuco

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and Rio, and with the State of Parana; with Bahia between February 23rd and 25th, and from March 4th to 15th between all parts; for a week with Rio Grande; and then for international traffic with stations south of Rio and between Brazil and the Plate from April 9th to 13th. That is a pretty long catalogue of interferences with our business, and I think it justifies our course in not declaring a dividend last time, and shows you the risks that were being run during this period by your enterprise. I have stated that there has been a diminution of £6,600, but the remarkable point about that is this—that, in spite of all these circumstances there has not been a loss of traffic. On the contrary, we have actually transmitted during this period more traffic than in the corresponding period of the previous year, and we should, as you will have seen, have even transmitted still more but for these inhibitions. Now, how is it, with this increase of traffic, that we have earned less money? It arises from a circumstance which you are all pretty well acquainted with—namely, the unfavourable exchange prevailing in Brazil. In fact, the exchange during the period ended December, 1893, reached the lowest point ever recorded. The average, for instance, in the corresponding period of the previous year was pretty low—12d., but during this particular half year which we are now reviewing the average amounted to only 10¾d. I am sorry to say that the record of lowness is being surpassed at the present time, because the state of exchange now shows a still further reduction. Talking of the state of the exchange and of these fractions of pennies does not convey a very clear idea to the shareholders, but translated into plain language it means this—that, as compared with the par of exchange, we lost £20,715. 12s. 10d., and that the Platino Company lost during the year £16,563. 0s. 9d. Now you know that the net receipts of the Platino Company come to us in the shape of dividend. Taking these two sums together they amount to £37,278. 13s. 7d., or another 2½ per cent.; in fact, you would have got 5 per cent. instead of 2½ per cent., but for this exceptional state of the exchange. I have a word or two to say about that presently as respects traffic, but meanwhile I will go to the expenses. The expenses under abstract A were £19,003. 7s. 8d., showing, compared with the expenses of the corresponding period of the previous year, a small reduction of £45. 13s. There are eight items of increase and five items of decrease. It is of no use labouring the matter, because the difference is so very small. There is, however, a staff increase in Brazil of £955. 3s. 8d.; and there are two items, travelling and furniture, which show a reduction of £1,000. On the whole, therefore, there is a slight reduction. It is quite true that there is an increase of £955 in the staff, which means a permanent expense as to a certain portion of it, but I shall surprise you, I think, when I tell you that, in spite of all the competition we are subject to now, and in spite of the circumstances I have mentioned, there is an increase in the number of international words transmitted. There is no loss of traffic even upon that, but there is an increase, although the increase is insignificant as compared with the augmentation in the messages exchanged in Brazil from station to station—what we call the Brazilian internal traffic. Although there has been a pretty constant augmentation in this traffic for a large number of years, the amount of it during the half-year under review was exceedingly large—in fact, it would not be out of place to use the word "immense," because if we add the number of the internal words transmitted to the number of the international words transmitted we have actually done no less than 52 per cent. more work. Unfortunately, the amount received for these messages per word is extremely small. I suppose that we can scarcely expect that such a very large traffic will continue, notwithstanding the fact that there has been constant progression in it, but there is one very satisfactory point in connection with this large volume of business, namely, that it has been shown that our staff and other arrangements, made at great expense for working the loops, have been well calculated, and that the capacity of the line is such that we have been enabled to deal with this enormous amount of business. I may tell you that during this December half-year we transmitted on our lines upwards of two million words, exclusive of service messages. If, consequent on the restoration of order in Brazil, the expected development of commerce, and consequently of communication in relation to commerce by the telegraph should take place, the circumstances I have just named show convincingly that the Company will be capable of dealing with any increase with its present staff, and dealing with it in a very satisfactory way, because I may mention that the average speed with which our business has been interchanged with Brazil has been eminently satisfactory all the way through. Under abstract B, shipping, the total is £9,381. 19s. 5d., and as compared with the corresponding period of 1892, that shows the small increase of £266. 10s. 8d. That is owing to the fact that the "Viking" was out of commission in the corresponding period of the previous year for some 17 weeks, and that there was a remnant of expense on account of the "Norseman," which came into that year. The most accurate way, I think, of looking at our shipping expenses will be, not to take a particular half-year as compared with a particular half-year, because the half-years vary considerably, but to take average of five years, and that is what I have done for the purposes of comparison. I find that taking the five years the average annual cost of our ships has been £24,482, or £12,241 per six months, with which our £9,381. 19s. 5d. now compares not unfavourably; and it must be remembered that a further economy will be secured in reference to the outlay that appears here in the accounts of the "Viking." Under abstract C, the expenses in London, there is a reduction of £210. 15s. 2d. That does not quite exhaust the financial position in the corresponding period of the previous year and this year, because in the corresponding period there was an expense of £1,283 for duplex, and repairs on the "Viking," which had been nine years on the coast, and required an outlay of £3,859. Our cash outlay this half-year has been relieved of those items. The result of all this is that after setting aside £5,000 to the reserve fund, and £7,073 to the debenture redemption fund, and allowing for the credit of £7,679. 4s. 7d. brought over from last half-year, and £9,233. 15s. received from the Platino Company, there is a balance available of £37,559. 9s., out of which the Directors recommend the shareholders to declare a dividend of 2½ per cent. for the half-year or at the rate of 5 per cent. per annum, carrying forward £1,045. 6s. 6d. to the current account. The Directors thought that, looking at the more normal state of things in Brazil, they might make this recommendation. The improvement is not quite so finally established as we should like to see, for there is still talk of battles in Rio Grande, but looking at the existing substantial improvement, and the probability that the Government will succeed in restoring tranquillity to the country, and that there will be a consequent return of confidence and an increased development of commercial transactions, we thought we might recommend you to declare this dividend. I have now dealt with the accounts side of the question, and I have now to go to paragraph 6 in our report. If you will allow me, I will read the observations I have to make upon this matter, because I have to refer to quotations from documents, and one's memory cannot be trusted in matters of that sort. The shareholders will no doubt have seen the paragraphs in the Directors' report referring to the agreement arrived at for the payment of £6,000 per annum by the Brazilian Company to this Company in consideration of the loop lines and the contention raised by the Brazilian Company to have sole control of the rates (I will call the Brazilian Submarine Company the Brazilian Company and our Company the Western Company for the sake of clearness). The first announcement respecting this agreement was made by the late Sir James Anderson at the meeting of the shareholders of the Brazilian Company held on May 4, 1892. Sir James fully explained the advantages gained by his Company in consideration of this payment, and from the official report of that meeting circulated by the Brazilian Company I will quote word for word the statement of Sir James Anderson, as follows:—"There is one other matter I should like to refer to. You are aware that the cables of the Western and Brazilian Company are partly duplicated, and that it required the laying of a second cable between Santos and Chuy to provide a complete duplicate system between Great Britain and Buenos Ayres. The want of this complete duplication prevented the service with the River Plate being entirely satisfactory to your Directors as a strong competing line, and as it is at Buenos Ayres that the Central and South American Company can best compete for traffic, we have arranged with the Western and Brazilian Company that they shall lay the necessary cable. The cable is now being laid, and will, I believe, be landed to-day, and I am sure, this cable will lead to results greatly to our mutual advantage and success in dealing with our competitors. The cost incurred by the Western Company has been very large, and, as the Brazilian Company's fair contribution, your Directors have agreed to pay that company a fixed sum of £6,000 per annum instead of making any alteration in the percentage of the joint purse. In addition to the advantage of the extra cable, the Western Company gave us the right to use their repairing ship for repairs of our cable off the coast of Brazil at a moderate charge per day. In certain cases this arrangement will save the expense of fitting out a steamer in Europe with a long journey to Brazil and back." Now, it will be observed that not one word appears here of the contention subsequently raised by the Brazilian Company—an omission of a positively extraordinary character had such an important matter been one of the conditions as now claimed. At the Western Company's meeting, held on May 12, 1892, I, of course, made no reference to any such condition, because we did not believe any such condition existed. At this stage we were pressed by Sir James Anderson to get on with laying the loop lines, and as this was held to be of great consequence, seeing that the new opposition line was becoming a certainty, we consented to urge the work forward, relying upon the letters exchanged between the companies, and without waiting for the preparation and execution of a formal contract. The line was, in fact, completed on June 8, 1892. We were continually pressing the Brazilian Company for the draft of the agreement putting these arrangements into formal shape, which the solicitors of the Brazilian Company had to prepare, but it was not until May 12, 1892, that this was received, when the work was practically completed. The draft for the first time formally put forward this claim, and we at once objected to the clause and returned the draft for correction, and the point has been under discussion ever since. Now, the Brazilian Company appears to base its claim upon a letter addressed to us on November 23, 1891, as follows: "My Company's offer was made on the understanding that your Company would concur in any reduction which we might find to be necessary to meet competition." Now, it seems perfectly obvious that had the Brazilian Company at this time the idea to get full control of the tariff as a condition of the agreement, the Company would have said in a straightforward way: "My Company's offer was made on the understanding that your Company would concur in any reduction which my Company might find to be necessary to meet competition." But you see the Brazilian Company departs from what would have been the obvious language that should necessarily have been used to support their present claim, and instead, quits the singular altogether, and uses the plural "we"—"which we might find to be necessary"—that is, the two Companies, as we read it. Then they go on: "And that the agreement of the £6,000 per annum, &c., would be for the period of the joint purse." And again: "These points are, of course, understood between us." Now, the only understanding on our part is contained in our letter to the Brazilian Company of November 25, 1891. There was absolutely as respects this question no other, and in this letter the Western Company says: "In reference to your letter of the 23rd inst., I am directed to refer you to our letter of October 9th, wherein the question of reduction of tariffs is treated. When from competition or otherwise it is considered advisable to reduce the rates, we shall be quite willing to act in concert with you in the matter." But, now, what does the letter of October 9, 1891, say? That letter was as follows:—"My Directors would be prepared to concur in reductions of rate found to be necessary, and, as far as they can, to meet competition, and in such other

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measures as might be mutually deemed advisable for the same purpose." I think that is pretty plain enough. No answer was received to the above letter of November 25, 1891, referring to that of October 9, 1891. Then, on account of the large outlay of capital and additional expenses we should be put to, we had asked the Brazilian Company on November 24th, to increase the £6,000 to £7,500 per annum, and on December 2, 1891, the Brazilian Company writes:—"I am instructed by my Directors to acknowledge your letter of the 24th ult., and to state that they are unable to go beyond the terms and amount offered you by their letters of November 18 and 23, 1891, viz., £6,000 per annum." The Brazilian Company subsequently raises the contention—at least, we suppose it does—that notwithstanding our letters of October 9th and November 25th, when that Company used the word "we," the word must be read, not in its natural plural signification as applying to both companies, as we read it, but as applying to the Brazilian Company only. But this extraordinary claim does not rest even here, for in consequence of conversations held between me and our Managing Director and Sir James Anderson, an arrangement was negotiated subsequently, under which the Brazilian Company, in consideration of obtaining the control of the tariff to meet competition, was to guarantee the Western Company's expenses, debenture interest, and debenture redemption, and the Brazilian Company's solicitors sent us on November 17, 1892, a draft of an agreement purporting to embody this arrangement. This draft, however, did not carry out properly the *pourparlers* we had with Sir J. Anderson, and, consequently, the Western Company did not see its way to proceed further. But the draft proposal of the Brazilian Company, if that Company held that it already possessed sole control of the tariff, was surely unnecessary, because under it the Brazilian Company proposed to undertake very large liabilities in order to obtain what that same Company said it had already got nearly twelve months before. The present position of this matter, however, is that late in the day on April 10, 1894, the Brazilian Company gave us formal notice of a resolution passed by their Board on April 4th that the Brazilian Company would reduce the tariff whether we agreed or not. To protect the interests of our shareholders, we were compelled to give notice of application for an injunction to prevent this, and when the day of hearing arrived, the Brazilian Company agreed without prejudice that it would not make the reduction, but failing agreement with this Company would proceed to arbitration, as provided by the joint purse agreement, the claim being referred to the Court for adjudication. The case we are advised will probably be settled before the next meeting of the shareholders, and acting under the advice of eminent counsel, we have dealt with the £6,000 per annum as detailed in the report. Meantime, the Companies have concurred in arriving at an agreement for a reduction to meet as far as may be held necessary the reductions made by the competing line, and how much further these reductions may be considered necessary will depend upon the traffic results, which are being carefully watched both by the Brazilian Company and ourselves. That ends that question. Owing to the state of the market for shipping, we have not as yet succeeded in disposing of either of the ships laid up, but we are constantly on the look out either for sale or charter in order to make the best we can of the position. Meanwhile we shall keep them in a fit state, either ready to go to sea at any moment at as small an expense as possible. The expenses will not, it is believed, exceed £800 a year. When I last reported upon the debenture reorganisation question, I said that we had surmounted all the legal impediments; but that the condition of Brazilian affairs precluded any attempt to carry out any scheme at that time. The present improved prospect of tranquillity in Brazil leads us to hope that presently we shall find ourselves at all events within more measurable distance than we have been for some time of carrying out that measure. I do not like to speak too definitely, however. We shall push the matter on as soon as circumstances are sufficiently favourable. I do not think there is anything else I need trouble you with. I have endeavoured to place the matter before you as plainly as I can, and to explain how we stand, but before putting the resolution to the meeting I ought, perhaps, to say a word with respect to the enforced absence of our Managing Director. I am sorry to say that he has had a nasty attack of the prevailing demon, and that it has been complicated by a certain amount of blood poisoning. He is at present in a very weak state, and is quite unable, of course, to be here to-day. The doctors have recommended him to go away for some time and not to think of business in any shape or way whatever. I now beg to move—

"That the report and accounts to December 31, 1893, be and are hereby approved and adopted, and that a distribution of 7s. 6d. per share (free of income-tax), being a dividend of 2½ per cent. for the year 1893, be and is hereby declared payable on the 18th inst."

Mr. C. W. EARLE seconded the motion.

Mr. ENNIS said he gathered from what the Chairman had said that the agreement referred to in the sixth paragraph of the Directors' report had not been concluded, but that both Companies were loyally adhering to the agreement as far as they could.

The CHAIRMAN: I think I had better dispose of that at once. The agreement, of course, exists in the form of correspondence as submitted to counsel. The draft, as it came on to us, contained the objectionable clause, which, of course, we could not in your interests accept. What interpretation the Brazilian Company may put upon their obligations it is impossible for me to say. We believe that we, at all events, have been loyally carrying out the agreement. We have spent about £100,000 and have duplexed our lines, and gone to very great expense for staff and appliances of all kinds. The solicitor reminds me that we were advised by Sir Horace (now Lord Justice) Davey and by others that we have a contract which is legally binding and, therefore, enforceable. In reply to another shareholder the CHAIRMAN added: the question whether the Brazilian Company under the correspondence between the Companies has the power to regulate the tariff without consulting the Western Company is the point before the Court.

Mr. FRY said that he had proposed to raise one or two questions at the meeting, but after the clear and precise explanations they had had from the Chairman with respect to the agreement with the Brazilian Submarine Company he would not do so.

The retiring Directors (Lord Richard H. Browne and Mr. C. W. Earle) were re-elected.

The retiring auditors were afterwards re-elected, and a vote of thanks to the Chairman brought the meeting to a close.

African Transcontinental Telegraph Company (Limited).

The second ordinary general meeting of this Company was held at the office, 19, St. Swithin's-lane, E.C., yesterday, the Duke of Abercorn, K.G., presiding.

The SECRETARY (Mr. Herbert Canning) read the notice convening the meeting, the report of the Directors and statement of accounts being taken as read.

The CHAIRMAN then said: Gentlemen, in submitting the usual resolution asking you to approve the report and accounts already before you, it is unnecessary for me to detain you more than a very few minutes. The report explains fully the position of the undertaking, which you will observe is divided into two sections, the southern section dealing with the portion of the telegraph from Salisbury upward towards the Zambesi, and the other, the northern section, dealing with that portion of the line running from Zomba downward to the Zambesi, including the construction of the line across that river to connect with the first-mentioned section. As regards the northern section, I desire to correct an error in our report. We refer to a portion of the telegraph route having been through a dense forest; this should have been stated as in the section south and not north of the Zambesi. I am glad to be able to add that the construction of the southern section is also substantially better than appears from the report. We learn from our mail received last Saturday that the surveyors and contractors for the Salisbury-Tete section have completed their survey, and that the telegraph way is cut for 220 miles, which is practically the whole distance between Salisbury and Tete. The work of cutting this road was very difficult, in consequence of the great scarcity of water, and the country was found to be very rocky at about 70 miles from Tete. The contractors state that they would be ready with their party to start construction at once if the material were at hand. The delay in its arrival at the western terminus of the Beira Railway (near Chimoio) is, we hope, now overcome, and the material in course of transit to Salisbury. The contractor has himself gone down to Chimoio to hasten transport matters there, and his colleague is in the meantime with a large staff of natives, digging holes for the telegraph posts, and preparing the way generally. Owing to the difficult nature of the country, we are informed that the material will, for the greater part of the distance have to be transported by native carriers. We rely upon the support of Her Majesty's Government to overcome the difficulty raised by the Portuguese as to the construction of the line within the sphere of influence of that country, and we learn that negotiations are now on foot between the two Governments to this end. I beg to move

"That the report and accounts be approved and adopted."

Mr. J. WERNHER seconded the motion, which was carried unanimously.

Mr. Robert Maguire, M.P., and Mr. J. Wernher, the retiring Directors, were re-elected, as were also the auditors, Messrs. Cooper Brothers and Co., and a vote of thanks having been passed to the Chairman and the Board, the proceedings ended.

NEW COMPANIES. STATUTORY RETURNS, &c.

ELECTRIC MOTIVE POWER COMPANY (LIMITED).—This Company was registered on May 10th, with a capital of £20,000, in £1 shares, to acquire the business, patents, rights, and assets comprised in an agreement made between Ernest J. Clubbe and Alfred W. Southey and the Company, as omnibus and carriage proprietors and carriers of passengers and goods, and electricians, electrical engineers and mechanicians, manufacturers and owners of electrical vehicles and carriages, and workers and dealers in electricity, electric machines, appliances, apparatus, motive power, heat, and light. The subscribers are:—

	Shares.
Gordon Cox, 3, Salters Hall-court, E.C.	1
Lyons R. Walcott, 1, Gray's Inn-place, W.C.	1
Desmond G. FitzGerald, 94, Loughborough-road, S.W.	1
Carl T. J. Oppermann, 2, Wynyatt-street, Clerkenwell, E.C.	1
George B. Hilliard, Florence-road, Ealing, W.	1
Ernest T. Clubbe, Yiewsley, Uxbridge	
Alfred W. Southey, Rosenthal, Dacres-road, Forest Hill, S.E.	1

The first Directors are to be appointed by the signatories to the Memorandum of Association.

IMMISCH ELECTRIC LAUNCH COMPANY (LIMITED).—This Company was registered on May 9th with a capital of £12,000 in £1 shares, to acquire in whole or in part from the General Electric Power and Traction Company (Limited), their electric launches, charging station, lease of Platt's Eyot, and generally the goodwill, business and undertaking of the Thames Launch Department of the said Company, as a going concern; to let out on hire or otherwise, steam, or electric launches, or other craft, to generate, accumulate, distribute and supply electric, magnetic, or other force, and to carry on business as electrical and mechanical engineers, electricians, suppliers of electricity, and manufacturers of and dealers

boats, launches, machinery, materials, stores, appliances, and apparatus of every description connected with the use of electricity, or similar business. The subscribers are :—

	Shares.
Moritz Immisch, 48, Tollington-park, N.	1
Luis Alwyn, 49, Queen Victoria-street, E.C.	1
Horace Gardner, Queen-street-chambers, Queen-street, E.C.	1
William Bullock, 4, Warwick-villas, Bound's-green, N.	1
Stephen Sellon, Cromwell House, Gresham-road, Staines	1
Herbert Twelvetrees, The Hollies, Clapham Common, S.W.	1
H. S. Hodgson, Queen-street-chambers, Queen-street, E.C.	1

The first Directors are to be appointed by the signatories to the Memorandum of Association.

METALLIC DRAWING ROLL COMPANY (LIMITED).—This Company was registered on May 3rd, with a capital of £30,000 in £10 shares, to acquire certain patents, particulars of which do not transpire, and to carry on the business of ironmasters, steel makers, mechanical engineers, electrical engineers, tool makers, &c., at Manchester and elsewhere.

WILKES CONTRACT COMPANY (LIMITED).—This Company was registered on May 11th, with a capital of £5,000, in £1 shares, to contract for and maintain railways, tramways, harbours, telegraphs, and works for the use or application of electricity for light or power.

WRIGLEY'S PATENTS (LIMITED).—This Company has been registered with a capital of £60,000, in £1 shares, to acquire certain patents granted to Thomas Wrigley, and to carry on business as ironfounders, mechanical and electrical engineers, tool makers, brassfounders, metal workers, &c.

L. ALWYN (LIMITED).—The first annual return of this Company made up to February 19th was recently filed. The nominal capital is £2,000, in £1 shares, of which 1,514 have been taken up. Of these 500 were issued, with 15s. per share considered as paid, and on the remaining 1,014 shares a call of 17s. 6d. per share has been made, resulting in the payment of £891. 5s.

EDISON-BELL PHONOGRAPH CORPORATION (LIMITED).—The first annual return of this Company, made up to April 3rd, has been filed. The whole capital of £60,000, in shares of £5 each, has been taken up and allotted, and of these 4,000 were issued as fully paid.

EDISON-GOWER-BELL TELEPHONE COMPANY OF EUROPE (LIMITED).—The annual return of this Company, made up to April 12th, states that out of a nominal capital of £500,000 in shares of £1 each, 385,009 shares have been taken up, and of these 370,000 have been issued as fully paid. On the remaining 15,009 shares the full amount has been called. The Consolidated Telephone Construction and Maintenance Company (Limited) hold 209,994 shares, George E. Gouraud 94,996 shares, and Messrs. Paskas, Bailey and Gouraud 72,000 shares.

ELECTRIC AND AUTOMATIC ENGINEERING COMPANY (LIMITED).—The first annual return of this Company, made up to March 2nd, has been filed. Out of a nominal capital of £10,000, in shares of £1 each, 47 shares have been taken up, and upon each of these the full amount has been called. The Assets and Debenture Securities Corporation (Limited) hold the 40 shares.

ELECTRIC EXPLOITATION COMPANY (LIMITED).—This Company has just entered into an agreement with Max Sussmann, of Neuruppin, in the Kingdom of Prussia, which provides for the sale to the Company of Letters Patent and Provisional Specifications granted to him for "a portable secondary battery lamp for use in mines and other places, for "improvements in the manufacture of secondary battery plates," and for "improvements in or connected with so-called 'dry' electrolyte for secondary batteries," and all his interest in the same. The purchase consideration has been fixed at £20,000, payable by the allotment as fully paid of 20,000 shares of £1 each, Nos. 8 to 20,007 inclusive. Inasmuch as certain gentlemen have assisted the vendor by the advance of money, and by introducing the inventions, he has stated that the following shares will be transferred to them :—John Aldwinckle (4,562), Sigmund A. Rosenthal (4,375), Robert Lawson (250), William Lawson (250), Villeroy C. Doubleday (750), John A. Buchanan (688), Archibald Gray (250), Hugh O. Macan (125), William Wood (750), Percy C. Atkins (375), George Watson (63), and Alaric H. Tredwen (62).

FAREHAM ELECTRIC LIGHT COMPANY (LIMITED).—The annual return of this Company, made up to April 4th, was recently filed. Out of a nominal capital of £5,000, in £1 shares, 4,154 shares have been taken up, the full amount called, and all calls paid.

FOREIGN PILSEN ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The annual return of this Company made up to March 15th was recently filed, when 29,800 shares out of a nominal capital of £30,000, in £1 shares, were taken up, and all issued as fully paid to the shareholders in the Union Electric Light and Power Company (Limited).

HOUSE-TO-HOUSE ELECTRIC LIGHT SUPPLY COMPANY (LIMITED).—The annual return of this Company, made up to April 5th, has been filed. The nominal capital is £350,000, divided into 57,900 Ordinary, 100 Founders', and 12,000 Preference shares of £5 each. 8,322 Ordinary, 100 Founders', and 5,000 Preference shares have been taken up, and of these 100 Founders' and 1,000 Ordinary were issued as fully paid. Upon the remaining 7,322 Ordinary and 5,000 Preference shares the full amount has been called, resulting in the total payment of £61,610.

INDIA-RUBBER, GUTTA-PERCHA AND TELEGRAPH WORKS COMPANY (LIMITED).—The annual return of this Company, made up to March 1st, has been filed. Out of a nominal capital of £812,000, in £10 shares, 50,000 have been taken up, the full amount called, and all calls paid.

KESWICK ELECTRIC LIGHT COMPANY (LIMITED).—The annual return of this Company, made up to March 9th, was recently filed. Out of a nominal capital of £5,000, in £1 shares, 3,420 have been taken up, the full amount called, and all calls paid.

LANCASHIRE AND CHESHIRE HOUSE-TO-HOUSE ELECTRICITY COMPANY (LIMITED).—The annual return of this Company, made up to January 11th, was filed on May 9th. Out of a nominal capital of £100,000, divided into 19,900 Ordinary and 100 Founders' shares of £5 each, 100 Founders' and 7 Ordinary shares have been taken up. The Founders' shares have been issued as fully paid to the House-to-House Electric Light Supply Company (Limited), of Richmond-road, Earls Court, London, S.W., and no calls have as yet been made upon the seven signatories' shares. Similar returns have been filed by the Liverpool, the Manchester, and the Northern House-to-House Electricity Companies (Limited).

LIVERPOOL ELECTRIC SUPPLY COMPANY (LIMITED).—The annual return of this Company, made up to March 9th, was recently filed. The nominal capital is £300,000, in £5 shares, of which 45,000 have been subscribed for and allotted. On each of these shares the full amount has been called, resulting in the payment of £220,985. 10s., and leaving £4,014. 10s. in arrears.

MEXICAN GAS AND ELECTRIC LIGHT COMPANY (LIMITED).—The annual return of this concern, to November 28th last, has just been filed. The whole nominal capital of £100,000, in shares of £20 each, was considered as fully paid. Messrs. Gibbs and Gibbs, of 15, Bishopsgate-street Within, London, E.C., hold 4,993 of the shares.

NORTHAMPTON ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The annual return of this Company, made up to March 8th, has been filed. Out of a nominal capital of £50,000, divided into 10 "A" and 49,990 "B" shares of £1 each, 10 "A," 10,000 "B" Ordinary, and 3,200 "B" Preference shares have been taken up. No calls have been made on the "A" shares, while the full amount has been called on the other class, resulting in the payment of £13,200.

NORTHERN ELECTRIC WIRE AND CABLE MANUFACTURING COMPANY (LIMITED).—The annual return of this Company, made up to April 25th, has been filed. The capital of £20,000 is divided into 660 fully-paid and 3,340 Ordinary shares of £5 each. All the former and 2,267 of the latter class have been taken up, and a call of £2. 10s. per share has been made on the Ordinary shares, resulting in the payment of £5,665, and leaving £2. 10s. in arrear.

CITY NOTES.

CHAGFORD AND DEVON ELECTRIC LIGHT COMPANY (LIMITED).—A meeting of this Company was held on Friday, at which the Directors' report and the accounts and the Manager's report were adopted by the shareholders. The manager (Mr. G. H. Reed) reported that fresh applications for additional lights were constantly being received, and that the lights continued to give entire satisfaction. The Company was making satisfactory progress, and was expected shortly to be in a position to pay a satisfactory dividend. Mr. Reeves, a Director, stated that he had examined the works thoroughly, and as a practical electrician, had pleasure in reporting that the works had been carried out and the cables laid in a manner highly creditable to Mr. Reed, and that the whole was now in a satisfactory condition.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended May 13th were £905, as against £787 in the corresponding period of 1893, being an increase of £118. The total receipts for the half-year amount to £17,305, as against £16,941 for the corresponding period of 1893, an increase of £364.

HOTEL LIGHTING.—An adjourned general meeting of the Brighton Grand Hotel Company (Limited) was held yesterday at the Cannon-street Hotel, under the presidency of Mr. B. H. Van Tromp, to receive the joint report of the Committee of Conference and the Board of Directors appointed last February to report on various economies and in regard to the electric light. The report, after dealing with the circumstances under which the electric light installation was put down, said that, although an error of judgment had been committed, the Directors did at the time what seemed wise under the circumstances. There was no doubt that the cost of the electric light during the past two years had been excessively high. The Board had, however, under professional advice, during the past year been making efforts to bring about a reduction, which the Directors thought might be reasonably estimated at from £500 to £600 per annum. The Brighton Corporation had, however, submitted an estimate for lighting the hotel, which promised even better results, and it had been arranged that a supply of electricity from the Corporation shall be first made for one year, in preference to continuing the use of their own installation, even under the improved conditions referred to.—Mr. J. Broad went into figures as to the cost of the coal used for the electric light in the years 1891, 1892 and 1893, and he maintained that the proportion used by the Hotel Company was larger than that used by the Brighton Corporation. He stated that, at the request of the Committee, they obtained the services of Mr. Wright, who was the manager of the electric light works for the Brighton Corporation, who found that there were 675 lights of 8-c.p., 32 of 10-c.p., 109 of 16-c.p., and seven of 25-c.p. They reduced all these to 8 c.p., making a total of 952. Mr. Grunholt said that his experience of the electric light at Richmond was that for his hotel it cost him some 50 per cent. more than he paid for gas; but the difference in the light—its brilliancy—was 200 per cent. more in worth, and therefore he was quite willing to pay the difference as between electric light and gas. The Directors' report was adopted.

PANULCILLO COPPER COMPANY (LIMITED).—At an extraordinary general meeting of this Company, held on Wednesday, the resolutions passed at the meeting held on the 24th ult., authorising the transfer of the undertaking to a new Company, were confirmed.

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COUNTY OF LONDON AND BRUSH PROVINCIAL ELECTRIC LIGHTING COMPANY (LIMITED).—Mr. D. R. Plunket, Q.C., M.P., and Mr. Anthony Noel Denny, have been appointed Directors of this Company, Mr. Plunket becoming Chairman of the Board.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended May 11th (after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited), were £2,891.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share	Last Dividend	Name	Previous Week's Price, May 9	Price Wednesday, May 16	Rate per Cent. Yielded (£ s. d.)	Dividend Due	Business Done During Week Ending May 16 — Highest	Lowest
			TELEGRAPHS.						
£1,184,640	Stock	9/0	Anglo-American	43 45	43 45	5 5 6	Jan., Apr., July, Oct.	44	–
£2,982,680	Stock	18 0	Do. Preferred	80½ 81½	80½ 81½	5 16 7	"	81½	80⅞
£2,982,680	Stock	5/0	Do. Deferred	7⅜ 8	7⅜ 8	..		–	..
£184,500	100	4%	African Direct Telegraph 4% Deb. (Reg. & Bearer)	101 104	101 101	3 16 11	January and July ..	..	..
130,000	£10	3/0	Brazilian Submarine	12 12½	12 12½	5 4 0	Mar., June, Oct., Dec.	12 1/16	12
£18,700	£100	5%	Do. 5 per Cent. Bonds	100 103	100 103	4 17 1	January and July ..	..	–
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	108 112	108 112	4 4 10	June and December	.	–
10,000,000	$100	$1¾	Commercial Cable Capital Stock	140 146	140 145	4 16 7	Jan., Apr., July, Oct.	..	–
16,000	10	8/0	Cuba Submarine	12 13	12 13	6 3 1	February and August	.	–
6,000	10	10%	Do. Preference 10 per Cent.	18 19	18 19	5 5 3	" "	..	–
12,931	5	1/7½	Direct Spanish (£4 paid)	2⅞ 3¼	2¾ 3¼	4 16 8	April and October	..	–
6,000	5	10%	Do. Preference 10 per Cent.	8⅞ 9½	8⅞ 9½	5 8 1	" "	..	..
60,710	20	2 0	Direct United States Cable, 1877	9¼ 10	9¼ 10	6 0 0	Jan., Apr., July, Oct.	9⅞	9⅞
400,000	10	2/6	Eastern	14¾ 15½	14¾ 15	4 6 8		15	14½
70,000	10	6%	Do. 6 per Cent. Preference	16 16½	15½ 16½	3 13 10	" "	16⅛	16
£1,294,100	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock .. xd	114 117	112 115	3 9 7	May and November	116	113½
£105,900	100	5%	Do. 5 per Cent. Debentures, 1899	107 110	107 110	4 10 11	February & August	109	–
260,000	10	6/6	Eastern Extension	15⅝ 15⅞	15⅝ 15⅞	4 9 7	Jan., Apr., July, Oct.	15⅝	15 1/16
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	114 117	114 117	3 8 5	February & August	..	..
£62,700	100	5%	Do. 5 p. c. (Austin. Gov. Sub.) Debs 1900	103 106	104 107	4 13 6	January and July ..	..	..
£108,700	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	103 106	103 106	4 14 4	" "	101⅞	–
£300,000	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	104 107	104 107	3 14 9	February & August	..	..
£300,000	£25	4%	Do. 4% Mauritius Sub. Debs.	105% 108%	105% 108%	3 14 1	May and November	104¼	..
180,227	10	2/6	Globe Telegraph and Trust	8¾ 9	8¾ 9	5 0 0	Jan., Apr., July, Oct.	9	8⅞
180,042	10	6%	Do. 6 per Cent. Preference	15⅜ 15⅝	15¼ 15⅝	3 18 1	" "	15⅝	15⅛
150,000	10	7/2	Great Northern	21½ 21⅝	21 21½	3 19 1	Jan., April, and July	..	..
£200,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	104 107	104 107	4 13 6	March & September	..	–
17,000	25	37/6	Indo-European .... xd & bonus	45 47	43 45	5 11 1	May and November	–	..
37,548	10	5/0	London Platino-Brazilian .... xd	4 6	4 6	..	" "	..	–
£100,000	100	6%	Do. 6 per Cent Debentures	106 109	106 109	5 10 1	March & September	..	–
£100,000	£100	4%	Pacific European Tel. 4% Guar. Debs. "Red 1942	102 105	102 105	3 16 2		..	–
11,839	8	4/0	Reuter's	5½ 6½	5½ 6½	..	April and October	..	..
2,331	£100 Cert.	85/0	Submarine Cables Trust 6 per Cent.	111 115	112 116	5 3 5	" "	..	–
15,600	10	5/0	West African Telegraph	3 5	3 5	..	January and July	..	..
£249,900	100	5%	Do. 5 per Cent. Debentures	100 103	100 103	4 17 1	March & September	..	..
30,000	10	2/0	West Coast of America	2½ 3	2½ 3	..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1898	105 109	105 109	7 6 10	June and December	106	..
88,321	10	9d.	West India and Panama .... xd	1½ 1⅝	1 1½	..		1½	..
34,563	10	6%	Do. 6 per Cent. 1st Preference .... xd	10½ 11	10½ 10¾	5 11 7	May and November	..	..
4,600	10	6%	Do. 6 per Cent. 2nd Pref. .... xd	9 10	9 10	6 0 0	" "	..	–
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	109 112	109 112	4 9 3	June and December	..	..
64,242	15	4/6	Western and Brazilian	7½ 8	7½ 8	..	May and November	7⅞	7⅞
33,129	7½	4/6	Do 5 per Cent. Cumulative Preferred	6⅞ 7	6⅞ 7	..		6⅞	6⅞
33,129	7½	4/6	Do. 5 per Cent. Deferred	2 2½	2 2½	..		2½	..
£178,200	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	106 109	106 109	5 10 1	February & August	..	–
£222,700	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	106 109	106 109	5 10 1	" "	–	–
$1,214,600	$1,000	7%	Western Union 7% 1st Mtge (Building) Bonds	110 115	111 115	6 1 9	May and November	..	–
£160,000	£100	6%	Do 6 per Cent. Sterling Bonds	100 104	100 104	5 15 5	March & September	–	–
			TELEPHONES.						
44,000	5	10/0	Chili Telephone (fully paid)	1½ 2½	1½ 2½	..	May and November	..	–
224,460	10/0	3½d.	Consolidated Telephone Const. & Maintenance	[illegible] [illegible]	[illegible] [illegible]	..	Yearly	..	–
171,504	£1	6d.	Oriental Telephone and Electric (fully paid)	[illegible] [illegible]	[illegible] [illegible]	..	June and December	..	–
484,597	5	2/6	National	4½ 5	4½ 5⅛	4 17 7	" "	5	4⅞
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	15 16	15 16	3 15 0	" "	..	..
15,000	10	6%	Do 6% Cumulative 2nd Pref. (fully paid)	14½ 15½	14½ 15½	3 17 6	–	..	..
119,234	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	5½ 5⅞	5½ 5⅞	4 6 11	January and July	5⅜	..
925,017	£100	4½%	Do. Deb. Stk. 4½%	114 116	114 116	3 17 7	" "	114⅝	114½
58,000	5	1/0	United River Plate	1½ 2	1½ 2	–	" "	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	90 100	90 100	5 0 0		–	–
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	..	City of London Electric Lighting (fully paid)	12 13	12 13	–	–	–	–
20,000	10	6/0	Do. 6 per Cent. Cumulative Pref. (fully paid)	13½ 14	13½ 14	..	–	13⅞	13⅞
19,900	£5	–	Electricity Supply Co. for Spain	..	..	–	–	–	–
£150,000	£5	..	Electricity Supply Company Ordinary	..	..	–	–	–	–
£50,900	£100	5%	Do. 5 per Cent. Debentures, 1900	..	..	–	–	–	–
8,822	£5	–	House to House Electric	..	..	–	–	–	–
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	..	..	–	–	–	–
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..	..	..	January and July	–	–
30,000	£5	1/9	Liverpool Electric Supply (£4 10s. paid)	5¾ 6¼	5¾ 6¼	..	–	–	–
15,000	£5	2/6	Do. (fully paid)	6¾ 6¾	6¾ 6¾	..	–	–	–
111,000	5	..	London Electric Supply	[illegible] [illegible]	[illegible] [illegible]	.	..	–	–
49,930	£10	5/0	Metropolitan Electric Supply (fully paid)	7½ 8	7½ 8	3 2 6	June and December	7⅞	7 1/16
£100,000	Stock	5%	Do. 5% Debs. (Bonds of £10, £20, & £40)	108 111	108 111	4 10 1	–	110½	–
6,452	£10	..	Notting Hill Electric	4½ 5½	4½ 5½	.	–	–	–
19,980	£5	4/6	St. James' and Pall Mall	6¾ 7½	6¾ 7½	.	–	–	–
20,000	£5	7%	Do. 7 per Cent. Preference	8 8¾	8 8¾	4 2 4	–	8½	–
50,900	5	2/6	Westminster Electric Supply (fully paid)	5⅞ 6¼	5⅞ 6¼	3 4 0		6 1/16	–
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
30,000	3	1/6	Brush Electrical Engineering	2⅝ 3	2⅝ 3	6 0 0	–	..	..
60,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	2⅜ 2⅝	2⅜ 2⅝	5 1 1		2⅝	–
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	108 111	103 111	4 1 1	March & September	..	–
20,000	5	2/6	Crompton and Co., 7 per Cent. Cumulative Pref.	3½ 3⅝	3 3½	..	January and July	..	..
12,129	5	..	Edison and Swan United	–	–	–	–	–	–
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	..	..	–	–	–	–
120,000	2	..	Electric Construction	[illegible] [illegible]	[illegible] [illegible]	..	–	..	..
12,845	2	..	Do. 7% Cumulative Pref.	1½ 1½	1½ 1½	..	..	..	–
91,195	2	10/0	Elmore's Patent Copper Depositing	[illegible] 1	[illegible] 1½	–	–	1 1/16	[illegible]
20,000	5	..	Fowler-Waring Cables (fully paid)	[illegible] 1½	[illegible] 1½	–	–	..	..
50,000	10	15/0	India Rubber, Gutta Percha &c., Works	23 24	23 24	5 4 2	February & August	23⅝	22½
£300,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102 104	102 104	4 6 7	March & September	–	–
11,224	£10	6/4	International Okonite Ordinary	..	–	–	–	–	–
16,000	£10	–	Do. 8 per Cent. Preference	–	–	–	December and June	–	..
20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	– [illegible]	– [illegible]	–	–	–	–
78,940	5	3/6	Swan United (£3. 10s. paid)	2 2¾	1⅞ 2¾	3 6 2	May and November	–	–
37,350	12	36/0	Telegraph Construction and Maintenance	39 41	39 41	5 17 1	March and July...	40½	39½
£150,000	100	5%	Do. 5 per Cent. Bonds	104 107	104 107	4 13 6	January and July	..	–
37,514	£5	–	Woodhouse and Rawson Ordinary (£3. 15s. paid)	–	–	–	–	–	–
41,008	£5	–	Do. Preference (fully paid)	–	–	–	–	–	–
			RAILWAYS AND TRAMWAYS.						
£600,000	Stock	5%	City and South London Railway	30	29 31	3 1 8	May and November	30	–
37,000	£10	1%	Liverpool Overhead Railway			–	–	–	–

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THE ELECTRICIAN:

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NOTES.

An article by Dr. John Hopkinson, which appears in another column, gives a simple and interesting discussion of the formula for the force exerted by an electromagnet upon its armature. Quite apart from the importance of the subject itself, this article has special interest for us from two points of view. In the first place, it is an example of the use of graphic constructions, which we recently taxed Dr. Hopkinson with undervaluing in his Forrest Lecture on the applications of mathematics to engineering. In the second place, it introduces the term "characteristic" as a synonym for curve of magnetic induction, as distinguished from its original use to denote the curve which in a dynamo or motor gives the relation between amperes and volts.

We give in the current number a first instalment of a Paper by Prof. Galileo Ferraris, which will be of great value to all those who are interested in the problem of the alternate-current motor. It relates to a method of treating by graphic calculation or by simple trigonometric symbols the quantities with which the electrician has to deal in considering rotatory magnetic fields and the so-called rotatory current. It has been evident for some time that a new and simple calculus was desirable for handling such problems, and this has now been provided by Prof. Ferraris, who has thus doubled his claims on the scientific world in this department of modern electrical work. We venture to think that our readers will prefer the simplicity of the new method to the more cumbrous calculations employed by Sahulka, Arnold, and others. It is one of the many curious coincidences in science that an almost identical method was independently worked out in France and published only a few days later than the memoir of Prof. Ferraris. The translation (from the original Italian) is from the pen of a lady whose face has been occasionally seen at the meetings of the Institution of Electrical Engineers.

The proper use of glow lamps for domestic purposes is gradually becoming understood, but there are, unfortunately, many examples of lighting which fully deserve to be called "bad for the eyes" or "unbecoming." The very liberty with which the lamps may be used affords opportunity for inartistic brass work and unintelligent arrangement. But in the hands of a decorative artist the possibilities of domestic electric lighting are as delightful as they are inexhaustible. Domestic lighting need only please, as a rule, two persons, and of these two one is of minor importance, for he has only to pay for it; but the lighting of public buildings is a more responsible matter. To please a sub-committee is possible, to satisfy the authorities is difficult, but to please the general public is practically out of the question. No wonder then that there seems to be some difference of opinion about the success of the experimental lighting of St. Paul's Cathedral. The ugliness of the wood and paper contrivances which have been stuck here and there on the piers cannot be denied, even when allowance has been made for the temporary character of the work. Gen. Webber has defended this experimental work, for which he assumes the responsibility, and gives three objects of the tests, namely, to compare arc and glow lamps, to give sufficient light, and to avoid glare. We hope that some competent person is fully alive to a much more important object than any of these, and that is to ensure a strict observance of the canons of architectural decoration. Whether St. Paul's be lighted by electricity or no is of small importance, provided that in the lighting the edifice be not defaced, and we say this with less hesitation since we are confident that it can well be done. Arc lamps bearing the makers' names on the globes have been used in a church in this country, but that would displease an ordinary vestryman; the evils to be avoided in this case are those which would offend cultivated architects and connoisseurs.

From some remarks of Prof. Kennedy at the last annual dinner of the students of the Institution of Civil Engineers, we are given to understand that the poor attendance at Students' Meetings is "engaging the serious attention of the Council," and that there is some idea of excluding students from the joys of associateship until they shall have put in an appearance at 250 meetings at least. The most obvious way to secure a good attendance would seem to be to exhaust every effort to secure good Papers, and judging by the quality of the Papers that are occasionally printed in the *Proceedings* of the Institution of Civil Engineers, this device would appear to have been tried. Perhaps a little more publicity is what is wanted, and in the case of the Students of the Institution of Electrical Engineers we have endeavoured as far as we can to give it. An even better minimum than the one suggested would be a receipt for at least 250 pence spent on technical journals.

When electrical engineers have discussed sufficiently exhaustively the relative values of Welsh coal and bituminous

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slack, and the comparative merits of Lancashire and water-tube boilers, there is another question, which quite as much affects the economy in electric supply stations, which they will have to face. We refer to the problem of how far it is economical to try to economise. The number of appliances for "saving half the coal," which are offered on every hand to electrical engineers, are almost countless; there are furnace economisers, exhaust steam economisers, "hydrogen units" economisers, oil economisers, &c., &c. But the question which will some day have to be answered is, How far does it pay to practice all these economies? This is a problem from which the mathematician must be bowed out, his formulæ and his assumptions are unavailing. Practical experience alone can justify or condemn the expenditure of any given amount of capital on any given proposed economy.

We are a long way from having arrived at a satisfactory solution of this problem, but experience already acquired justifies the engineer in believing that an approximate estimate may in some cases be made. All would be comparatively plain sailing if our electric supply stations worked at 100 per cent. load factor. But it is the remembrance that for a great proportion of the time his adopted economisers will be lying quite or partially idle, while all the time there is the item "interest on capital expended" eating its way into the annual balance-sheet, which makes the electrical engineer hesitate to decide just how large an economy he ought to arrange for. He knows well enough that that is the best plant which is designed according to a sort of Thomson's law, but the Sphinx's riddle is, what size of plant *will* be according to that law?

Our esteemed contemporary, the *Engineer*, has lately directed its attention to the important question of the best arrangement of generating stations for Metropolitan electric supply. It arrives at the conclusion that a large number of detached generating stations, such as now exists, is the least likely method to yield a profitable return for the capital invested, and it bases this conclusion upon a very plausible line of argument. "No one in his senses," it says, "fancies that a gas works could be constructed near Berkeley-square to supply 60,000 lights which would prove remunerative. Why should an electric light station?" Why, indeed, except that the cases, whilst having something in common, are by no means on all fours. The coal cartage nuisance in the case of electric lighting stations, is, as Mr. Kapp points out, an almost negligible quantity, but in the case of a gas works it would be a formidable problem. The only way in which an electric lighting station usually offends its neighbours is by setting their dwellings on the wobble; its area of nuisance is concentrated. A gasworks, on the contrary, has an almost indefinite area of nuisance. A Paper was recently read before a scientific society on the audibility of Big Ben at Norwood and its connection with the weather. We could wish that its author would investigate in like manner the influence of meteorological conditions on the limits of "smellibility" of a gas works.

Our contemporary thinks that existing stations should be turned into sub-stations, and that they all should be fed from one and the same generating station, situated at some place outside the metropolitan area, a "peripheral station" as Mr. Kapp calls it. The existing companies might even purchase their supply of electrical energy from the owners of this fountain head, and retail it to their own little coterie of consumers. The main point, though not the only one, upon which our contemporary bases this system of electric power distribution, is the fact that by supplying power to the entire metropolitan area from a single station, a much better load factor could be obtained, than where the area is subdivided into detached and independent districts. One portion of the area would find work for the station in the daytime, another portion in the early evening, and a third portion in the midnight hours.

To properly light the metropolis, 8,000,000 lamps of 8-c.p., or their equivalent, would be necessary; and our contemporary estimates that a provision of 200,000 H.P., would be required, in order to meet this demand. This figure is based on the assumption that the maximum load on the station is equal to half the lamps wired. In this assumption we cannot concur; for we consider that, in any such comprehensive station as the one proposed, the maximum number of lamps in use at any one time would be very much below one half of the total lamps wired. Our contemporary forgets that the very principle upon which it proposes to improve the load factor of the station, must directly operate to reduce the ratio of the maximum lamps *used* to the lamps *wired*. If the commingling of diverse districts is to considerably improve the one quantity, it must of necessity reduce the other; because it can only operate if different districts, or classes of consumers, are in full action at different times. Now, it is very rarely indeed that existing detached stations experience a load equal to 50 per cent. of the total lamps connected. Therefore, it is highly probable that, by the coalescence of several stations, this figure would be considerably lowered.

The fundamental principle of patents for inventions, in this and in other countries where it has been imitated, is that of a bargain made between the State and the inventor. Protection for a limited period is granted on condition that the invention shall be freely thrown open or made patent to the public on the expiry of that period by a full description of the details; and, in order that the public may know what matters are under State protection, this full description is published as soon as possible after the protection has been granted. A list of the names and numbers of patents which have expired or have been dropped is issued by the Patent Office, but probably receives little attention; the public have to find out, as best they may, whether the bargain is at an end. We have from time to time called attention to patents for well-known inventions, as the term of fourteen years has expired, and amongst these it may be noted that the Maxim dynamo and Pilsen arc lamp thus ran out last month. The United States Patent Office appends to its *Official Gazette* a list of patents whose term of seventeen has expired. The list is illustrated, and the inventions are easily recognised. The majority of expiring patents in the last *Gazette* are dated

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May, 1877, and contain but a single electrical item, PRESCOTT'S quadruplex telegraph. A British list would be more interesting, on account of the more modern character of the inventions, owing to lapse by non-payment of annuities.

Royal Society.—The Ladies' Conversazione is announced for Wednesday, June 13th.

Wolverhampton.—On Monday afternoon the Mayor of Wolverhampton (Alderman C. T. Mander) laid the foundation-stone of the Municipal Electric-lighting Works.

Personal.—Herr F. Uppenborn, editor of the *Elektrotechnische Zeitschrift*, has been offered and has accepted the appointment of municipal electro-technical engineer to the city of Munich.

The Sir John Pender Gold Medal.—At the recent distribution of prizes in the Glasgow and West of Scotland Technical College, Mr. J. Fred. Nielson was awarded this medal for excellence in electrical engineering.

The Leipzig Electrical Exhibition.—The *Elektrotechnische Zeitschrift* announces that, in spite of the short duration of the forthcoming (June 8th-17th) Electrical Exhibition at Leipzig and the general indifference displayed, over one hundred firms will be represented.

Cable Interruptions:	Date of Interruption.
Cayenne-Paramaribo	Oct. 25th, 1893.
Bissao-Bolama	Nov. 24th „
Brest-St. Pierre (P.Q. Co.)	Mar. 29th, 1894.
Accra-Kotonou	April 1st „
Accra-Lagos	May 21st „

Electricity and Gas.—A Glasgow evening newspaper declares that the verdict of a certain individual who has used the electric light in that town is: "Cost four times gas, and saved a dozen boxes of matches in a year." We may be sure, at any rate, that he saved the matches; the other calculation may have dropped a coefficient somewhere.

Long-Distance Telephony in India.—Following upon the experiment of telephoning from Calcutta to Nagpur, an attempt was made the other day, says *The Englishman*, to communicate directly with Bombay, a distance of 1,500 miles. The results were not very satisfactory. The telephone line between Chicago and New York covers a distance of about 1,000 miles.

Electric Supply in America.—President E. A. Armstrong, in his address before the National Electric Light Association, said that according to the most trustworthy information available there were now in the United States upwards of 2,300 electric supply undertakings, representing an invested capital of £40,000,000; and it was estimated that at least an equal amount was invested in the manufacture of electrical machinery and supplies.

Portsmouth.—While making a trial run, a few days ago, the armature of the Parsons 150 kilowatt steam turbine-alternator was burned out, necessitating its removal to Newcastle for repairs. The burn out is all the more remarkable, as it is said that the armature was on open circuit at the time. It is expected that the accident will not interfere with the success of the inaugural ceremony at the station, which is fixed for Wednesday, June 6th.

Aberdeen.—The electric light station has been thrown open to the public on Saturday afternoons between the hours of four and six. Last Saturday about thirty persons—mostly mechanics—availed themselves of this opportunity of visiting and inspecting the plant. The assistant-engineer was in charge, and conducted the visitors over the different parts of the station. About a score of people visited the gasworks, and were shown over the whole process of manufacture from beginning to end.

Royal Society.—The following were some of the Papers down for reading yesterday before the Royal Society:—Messrs. J. W. Swan and J. Rhodin, "Measurements of the Absolute Specific Resistance of Pure Electrolytic Copper;" Mr. J. W. Swan, "On some Voltaic Combinations with a Fused Electrolyte and a Gaseous Depolariser;" Prof. T. Gray, "On the Measurement of the Magnetic Properties of Iron;" Prof. Threlfall and Messrs. J. H. D. Brearley and J. B. Allen, "Researches on the Electrical Properties of Pure Substances. No. 1.—"The Electrical Properties of Pure Sulphur."

Forewarning by Telegram.—Some months ago a serious landslip occurred at Gohna, in the Gurhwal district of Bengal, blocking the flow of a considerable river and converting a valley into a huge lake. Since then the water has been gradually rising, and it is feared that when it overtops the dam it will carry it away, notwithstanding the enormous thickness of the latter, and cause a most destructive flood. The *Times* Calcutta correspondent says a temporary telegraph line is now being constructed from Hurdwar to the spot in order to give timely warning to the people inhabiting the threatened tracts; but apparently no measures are being taken to try and avert what may be a terrible disaster. The water is still 200ft. below the top of the dam, but it may now be expected to rise rapidly, as the snow will soon melt with the advance of the season.

Ealing.—A long discussion took place at the meeting of the Ealing Local Board on Thursday last week, concerning the position in which the electric lamps shall be placed in the Uxbridge-road from the Broadway to the boundary of the district at Hanwell. There were three propositions before the Board—one being that the lamps should be erected in the centre of the road; a second that they should be placed by the side of it; and a third that they should be erected alternately at the side and in the centre of the road. Each of these propositions was put to the vote, and lost in turn, the supporters of the second and third-mentioned plans combining together to defeat the original proposition that the lamps should be erected in the centre of the road. Having thus deadlocked themselves, the municipals left the matter for final decision to the engineers.

The Heilmann Locomotive.—In a recent number of *L'Elettricista* of April 1st, M. Brunelli points out that, although the results given by the Heilmann so-called electric locomotive have not been better than those obtained from the usual type of locomotive, it must be remembered that while the Heilmann machine is on a quite new and original principle, which is susceptible of improvement, the usual type has probably reached it highest perfection. The Heilmann locomotive may succeed ultimately, as it is only in fact a steam locomotive in which the transmission take place electrically. It must be remembered that the power supplied by the usual locomotive is much more costly than that produced by an ordinary steam-engine, and also that the present system of transmission is very detrimental to the permanent way. The Heilmann plan may in these respects prove an economical one.

Gas and Electricity in Birmingham.—At a meeting of the Birmingham City Council on Tuesday, the chairman of the Gas Committee said that three important factors had influenced the accounts of the gas department—the coal strike, the decrease in the consumption of gas, and the increase in the price. During last year the consumption of gas decreased by no less than 6 per cent., and when compared with the sale of two years ago, last year's consumption showed a decrease of 26 million cubic feet. That reduction he attributed to four causes—the bright weather during the year, the bad trade, the introduction of electric light, and the greater use of economical burners. The conclusion he had arrived at was that they would no longer see the giant strides by which the consumption of gas had risen in 18 years from 2,300 to 4,000 million feet, but that there would still be a gradual, if slow, increase.

Civil Engineer Students.—At the nineteenth annual dinner of the students of the Institution of Civil Engineers, held at the Holborn Restaurant, on the 11th inst., Prof. Kennedy, speaking of the poor attendance of students on Friday evenings, said that the matter was engaging the serious attention of the Council, and suggested that a minimum attendance of say, 250 meetings, by the student presenting himself for admission to the associate membership, should be requisite. Mr. Godfrey. student, in responding for the local associations, was understood to complain that so long as students of the Institution had to pay a fee of ten guineas in addition to passing an examination to become an associate, he thought a further condition such as that mentioned by Prof. Kennedy could be dispensed with when

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it was considered that outsiders were admitted as associate members simply by election by the Council on payment of the fee. It might be further urged that most of the out-of-London students could not attend many meetings, and further that attendance at meetings gave no clue to a student's ability, much as it might give as to his serious desire to "pass."

Cardew's Vibrator.—The following letter from Major H. F. Chesney, R.E., which appeared in *Engineering* last week, will be read with interest:—

SIR,—To those of your readers who are interested in telegraphy, a short description of the successful manner in which long interrupted lines were worked through, with the aid of the Cardew's vibrating sounder, during the late severe weather in Persia may be of interest. On the first occasion all the wires were buried under mud and water in the *débris* of a village which had been destroyed by flood. For nearly 24 hours all the international traffic between Europe and the East, which is carried by the Indo-European Telegraph Company and Department, was transmitted between Ispahan and Shiraz, a distance of 332 miles, by means of Cardew's sounders, working through the above-mentioned dead earth. When it is remembered that nearly the whole of the traffic consists of difficult code and cypher messages, the importance of the result achieved can be understood. During this period the ordinary Morse instruments were, of course, useless. On the other occasions the traffic was passed between Shiraz and Bushire, a distance of 186 miles, in the same manner, and interruptions of six and eighteen hours respectively saved. I believe these instruments have not hitherto been successfully used on lines of this length, and certainly not to carry international traffic.

Lamp Shades.—The following letter, signed A. Dupré, appeared in *The Times* of Wednesday. As the material referred to is so much used to swathe up the modest 8-c.p. glow lamp, the letter will be read with interest by others than users of duplex lamps:—

SIR: If you could find room in your widely circulating paper for the following lines, they may be the means of preventing accidents similar to the one which happened at my house on May 10th. On the evening of that day one of my children complained that a smell of burnt paper was perceptible in the house. This smell had been noticed some hours previously, but was not then traced to its source. A careful search led to the discovery that a paper lamp-shade in one of the rooms had been entirely consumed by fire. For two days prior to the accident the lamp, a duplex, had not been lighted, and there had been no fire in the room. Since the morning of that day, when the room was dusted and the shade apparently in its usual condition, no one had entered the room. The shade was made about a year ago from so-called crinkled tissue paper, one white and one yellow sheet, gathered together on the upper part where it was fixed to the wire frame, where it formed a considerable bunch, and spreading thence over the frame below. On examination the yellow paper was found to be coloured by chromate of lead, and this, no doubt, was the cause of the accident. There can, I think, be no doubt that this was a genuine case of spontaneous ignition, though I have not as yet been able experimentally to reproduce the necessary conditions leading to such a result. Fortunately there were no readily inflammable articles near, or a serious fire might have resulted, the origin of which would probably never have been suspected. The dangerous paper is readily recognised by setting fire to a piece of it and blowing out the flame. In the case of ordinary paper it will be found that the glow along the burnt edge is very soon extinguished, whereas, in the case of these chromatic papers, it continues until the whole is consumed, as is the case with ordinary touch-paper. I find that besides the yellow paper, pale green paper also contains chromate of lead, and would, no doubt, be equally dangerous, and possibly there are papers of other colours containing the same material. It would be interesting to learn whether any similar case has been observed before.

American Institute of Electrical Engineers.—At the meeting of this Institute, which was held in Philadelphia on the 15th, 16th, 17th, and 18th inst., the following Papers were down for reading:—"On Light Distribution and the Use of Lamps," by Prof. Wm. A. Anthony; "Discriminating Lightning Arresters and Recent Progress in Means for Protection Against Lightning," by Alexander Jay Wurtz; "Central Station Economy," by C. Reginald Van Trump; "Unipolar Dynamos for Electric Light and Power," by Prof. Francis B. Crocker and C. Howard Parmly; "Relative Advantages of Toothed and Smooth Core Armatures," by Alton D. Adams; "Test for Closed Coil Arc Dynamo," by Prof. R. B. Owens; "Alternating Currents and Fuse Wires," by Prof. Dugald C. Jackson and R. J. Ochsner; "Some Storage Battery Phenomena," by W. W. Griscom; "The Waste of Zinc in Open Circuit Batteries when Standing Idle," by Henry A. Lardner; "Standardising Electrical Measuring Instruments (*a*) by the Potentiometer Method; (*b*) an Improved Direct Reading Potentiometer," by Elmer G. Willyoung; "Resonance Analysis of Alternating and Polyphase Currents," by Prof, M. I. Pupin; "Some Facts About Polyphase Motors," by Dr. Louis Bell; "The Law of Hysteresis (Part 3) and the Calculation of Ferric Inductances," by C. P. Steinmetz; "Experiments with Two-Phase Motors," by Dr. Louis Duncan.

The Field Electric Railway Patent.—Judge William K. Townsend, of the United States Circuit Court, at New Haven, Conn., on May 3rd, rendered an important decision on a final hearing of a bill in equity, alleging infringement on letters patent, granted to Stephen D. Field, July 16, 1889, for improvements on electric railways and assigned to the complainant, whose motion was finally denied. The evidence of infringement, as stated in the decision, applies to the combination of a stationary dynamo-electric generator driven by a suitable motor and circuit of motors, composed in part of an insulated or detached section of the line of rails of the railway track and the electric magnetic motor mounted on a wheeled vehicle and used for propelling the same, and included in a circuit of conductors; also a current-controlling device placed upon such vehicle. The defence was a denial of infringement, anticipation by prior patents, publication, and prior inventions. Judge Townsend states that the complainant admits that every element in the invention existed in art before the combination was made, and he finds that there was a question in the Patent Office in 1879, as to whether patents could be granted to Field, because of a prior patent, known as the Clark, which embodied the same principle.

Magnetisation of Iron at High Frequencies.—At a recent meeting of the Kaiserliche Akademie der Wissenschaften of Vienna, Prof. Klemencic read a Paper on the magnetisation of iron and nickel wires by rapid electrical oscillations. An abstract of this is given in *Nature*. From the amount of heat developed in a wire of a magnetic material traversed by electrical oscillations, the author calculates, by means of the formula given by Lord Rayleigh and Stefen, the value of μ (the permeability). The heat developed in the wire under observation was determined by means of a thermoelectric couple, and was compared with the heat developed in a non-magnetic wire under similar circumstances. The following are some of the values obtained for μ:—Soft iron, 118; steel wire, soft 106, hard 115; Bessemer steel, soft 77, hard 74; nickel 27. These values agree very well with those obtained by Lord Rayleigh and Bauer for very feeble magnetising forces. The results obtained by these observers show that for certain values of the magnetising force the permeability is constant, and that it afterwards rapidly increases. Now the results obtained by the author show that over the range he is employing μ has a constant value. This fact may be explained either by supposing that the magnetising forces employed are so small that we are dealing with that part of the curve where μ is constant, or that, although the magnetising forces are much greater than those to which the former supposition limits us, the magnetisation is unable to follow the rapid changes in the magnetising force, so that the magnetisation never reaches that part of the curve where μ is variable and has very much greater values. A rough estimation has shown that, at least on the surface of the wire and at the commencement of the oscillations, the magnetising force exceeds more than a hundredfold the maximum limit within which μ is constant. Thus, in these experiments there must exist a time lag in the magnetisation which must not be confused with the hysteresis. It would also appear that Bauer and Lord Rayleigh's results which refer to longitudinal magnetisation, also apply to circular magnetisation.

The Electrical Trade Section.—In the twelfth annual report presented by the Council on Monday last to the members of the London Chamber of Commerce the following paragraph is devoted to the Electrical Section:—During the year this Section and its committees have held twelve meetings. The Section has again had under its consideration the Regulations of the Board of Trade on Overhead Wires. The Board have hitherto refused to modify these regulations, on the ground that they were drafted in consultation with the Institution of Electrical Engineers, and until alterations were recommended by that body they saw no reason to depart from the attitude already taken up. It is satisfactory to record that the Institution of Electrical Engineers has now recognised that, looking to the commercial aspects of the in-

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dustry, it is absolutely necessary that these regulations should be to some extent modified, and negotiations were in progress at the end of the year which it was believed would remove the disabilities from which the industry now suffers in this respect, consistently, of course, with a due regard for the public safety. Another question considered by the Section during the year was the position of the electrical industry in reference to the Telephone Company's monopoly of the use of earth. Recognising that this position was a serious hindrance to the development of the traction industry, the Section resolved upon the appointment of an Electrical Traction Committee, which should have power to raise funds, engage counsel, and take such other steps as might be, in the opinion of the Committee, necessary for the advocacy or propagation of traction interests. This Committee was in due course constituted, and presented its case before the Joint Committee of the Houses of Lords and Commons on Electrical Power, with results entirely satisfactory to the traction industry. At the close of the year the Traction Committee were in communication with the Board of Trade as to the regulations under which the industry might be carried on consistently with the recommendations in the report of the Parliamentary Joint Committee already referred to. The Section also directed its attention to the National Telephone Company's Powers Bill, railway rates on electrical goods, and the desirability of the promotion of lectures on the commercial aspects of the industry during the winter months.

Technical Literature and Style.—Commenting not long since on the speeches made at the Royal Literary Fund dinner, the *Standard* directs attention to the decay of style, and enters a protest which comes, we think, none too soon. "The time was," says our contemporary, "when no one was in any doubt as to what was literature. Those who wrote for the public were few in number; and, even where they had little or nothing to say, they took care to say it in a certain manner, and conformed to well-ascertained canons of composition. But with the assertion of individual liberty that accompanied and followed the French Revolution, the standard of taste and correctness in writing was overthrown, and by degrees everybody began to think that it was open to him to write as he pleased, without the smallest reference or regard to the great and acknowledged masters of style who had preceded him." The utilitarian views, observes the *Engineer*, which in most of the affairs of this century are for ever battling with the æsthetic are as much to the front in our technical literature as in any other direction. To the eye of the world at large the engineer is a person whose connection with poetry and delicate feeling is similar to that of Tommy Atkins with the Grand Turk—that is to say, if it exists at all it is antagonistic. If it were possible to record in the census the number of men possessed of certain poetic faculties—by which we mean an appreciation of the true and beautiful, and not an ability to string jingling words together—we are inclined to believe that amongst those professing mechanical crafts the percentage would be far above the average. We regret to feel that in a technical journal these observations seem out of place, and we hasten to give our reason for having made them. Through the hands of a reviewer there passes annually a large number of books devoted to technical interests, and it is against the utilitarian style which disfigures the greater number of these volumes that we wish to protest. It must be understood, however, that we employ the adjective "utilitarian" in its worse sense, the sense which means that man forgets his higher nature and becomes a grubber after a material building up, and an intellectual down-pulling. The disease begins in a text-book, and reaches—at present—its climax in a catechism. In the text-book form it may be so mild as to be practically harmless; in the catechism it attains astonishing virulence; and in the "telegram" stage, to which it is tending, high fever will be reached. If brevity is the soul of wit, dwarfishness is the crown of ugliness. If utility is the criterion of art, utilitarianism is the measure of ungracefulness. Are we to have the style of printed literature reduced to that of the manuscript pocket-book? Does it not seem a disgrace that we accept work after work, and whilst admiring the author's depth of knowledge, never censure his ignoble style? Surely some attempt should be made to keep our English language at a high level, and we should be prepared to sacrifice some little brevity for the sake of a little more grace.

The Royal Society Selected Candidates.—Our readers may be interested in reading the qualifications of some of the selected candidates for Fellowship of the Royal Society, which, though they may be briefly stated, represent in many cases long years of painstaking research:—HUGH LONGBOURNE CALLENDAR, Fellow of Trinity College, Cambridge, Lecturer on Physics, has made important investigations on the measurement of temperature by electrical means. These are described in the Papers, "On the Practical Measurement of Temperature" (*Phil. Trans.* R.S., 1887, A, page 161); "On the Determination of the Boiling Point of Sulphur, and on a Method of Standardising Resistance Thermometers by reference to it" (*ibid.*, 1891, A), (this Paper is written in conjunction with Mr. Griffiths); "On the Construction of Platinum Thermometers" (*Phil. Mag.*, July, 1891); "Some Experiments with a Platinum Pyrometer on the Melting Points of Gold and Silver" (*ibid.*, February, 1892).——— JOHN VIRIAMU JONES, B.Sc. (Lond.), Principal and Professor of Physics in the University College of South Wales and Monmouthshire, Fellow of University College, London. Distinguished for his acquaintance with physics. Engaged in the teaching of physics as well as in the organisation of scientific studies, and is anxious to promote the progress of science. Author of a memoir "On the Determination of the Specific Resistance of Mercury in Absolute Measure" (*Phil. Trans.*, Vol. CLXXXI.,1890). Author also of the following Papers:—"On the Calculation of the Co-efficient of Mutual Induction of a Circle and a Coaxial Helix" (*Proc.* Phys. Soc., Vol. X.); "On the Use of Lissajous' Figures to determine a Rate of Rotation, and of a Morse Receiver to measure the Period Time of a Reed or Tuning-fork" (*ibid.*); "Suggestions towards a Determination of the Ohm." Read before the British Association at Leeds, 1890 (*The Electrician*, Vol. XXV.).———Rev. FREDERICK JOHN SMITH, Clergyman of the Church of England, Millard Lecturer in Experimental Mechanics, Trinity College, Oxford. Distinguished for his researches in practical mechanics and physics, and the invention of important dynamometric and integrating instruments; also of the chronograph—registering graphically periods of time from ·00005 sec. to 1·0 sec.—now used in the measurement of the flight of projectiles and in physiological research. Author of numerous Papers, among which may be mentioned:—"An Experimental Investigation of the circumstances under which a Change of the Velocity in the Propagation of the Ignition of an Explosive Gaseous Mixture takes place in Closed and Open Vessels. Part I.—"Chronographic Measurements" (*Proc.* Roy. Soc., Vol. XLV., 1889); "Description of Dynamometer and Integrator for Measuring the work done in Driving Dynamos and other Machines" (*The Electrician*, 1881); "Ergometer or Work-measuring Machine" (*Phil. Mag.*, Vol. XV., 1883, and *Nature*, Vol. XXX.); "A New Form of Electric Chronograph" (*Phil. Mag.*, Vol. XXIX., 1890); "On Some New Methods of Investigating the Points of Recalescence in Steel and Iron" (*ibid.*, Vol. XXXI., 1891); "On Some of the Effects of Magnetism on Rods of Iron, Nickel, and other Metals which have Received a Permanent Torsional Set" (*ibid.*, Vol. XXXII, 1891).———JOSEPH WILSON SWAN, M.A. (*honoris causa*) Durham, F.C.S., F.I.C. Has devoted himself for many years with great success to experimental scientific work, chiefly in relation to electric lighting, the electro-deposition of metals, and the improvement of Photographic processes. His labours have resulted in material extension of knowledge, and in important inventions, among which are the incandescent electric lamp, the carbon process, by which the first permanent photographic prints were produced and which has formed the basis of many processes of photo-mechanical engraving (in this relation the property of salts of sesquioxide of chromium to combine with gelantine and render it insoluble was discovered), the highly sensitive gelatino-bromide photographic plate, the result of an original observation of the effect of heat on the gelatino-bromide of silver emulsion, the cellular form of electrical secondary battery plate, the production of lamp filaments from solutions, integrating electric meters, safety lamp for miners, and an electric firedamp indicator.

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MOTIVE POWER AND GEARING.*

BY E. TREMLETT CARTER.

(*Continued from page 73.*)

Furnaces and Boilers.

Furnace Temperature.—In a completely enclosed furnace, *i.e.*, one surrounded entirely by non-conducting walls, the furnace temperature may be calculated from the weight of coal and air involved in the production of a given amount of heat. Practically, however, this is impossible, for much of the heat passes away by radiation. The calculation, therefore, only serves to gives the highest limit of temperature. Furnace temperature or flue temperature may, in practice, be determined (1) by testing with samples of different metals to discover which one is just melted, when the temperature will be the melting point of that metal; (2) by a pyrometer, one form of which is constructed so that the electrical resistance of platinum may be measured at the furnace temperature; (3) by a calorimeter test, a piece of metal being placed for some time in the furnace until it is at the same temperature, and then removed and plunged into cold water, the weights of metal and water and the temperature of the latter being known. This last is sometimes modified by taking a live coal from the fire and plunging it into cold water, the specific heat of carbon at ordinary temperatures being assumed to be that of the live coal. It seems probable that the surface temperature of a glowing fire does not fall below 1,300°F., but that the highest point to which it may rise depends upon the manner in which the heat is disposed of. Heat passes away from the fire in two ways: by radiation and by convection; and it is the proportion of these to one another which affects the temperature. If the fire is surrounded entirely by a metal surface, on the other side of which there is relatively cold water, practically all the radiation will be absorbed through this surface, while, on the other hand, if the fire is completely surrounded by fire brick, which will become heated to nearly the temperature of the fire, nearly all the heat will be reflected back to the fire, and the temperature of the latter will accordingly become higher than in the former case. In internally fired boilers, in which there is no brick lining to the combustion chamber, it is probable that with the most rapid combustion the fire temperature does not exceed 2,000°F., while in externally fired boilers, where the fire is largely surrounded by brick setting, the furnace temperature may attain or even exceed 3,000°F., the fuel in both cases being assumed to be coal or coke.

Radiation.—Flame.—In order that heat may be absorbed into the boiler water by radiation, it is necessary that there should be a clear straight line from the source of radiation to the heating surface through which the rays are to pass. The source of radiation may be either the fuel itself, or flame, or heated brickwork. The proportion of heat which passes into the water in this way varies rapidly with the furnace temperature, and slightly with the temperature of the heating surface. Thus, in some trials by M. Péclet, it was found that with a furnace temperature of 1,500°F. and a temperature of heating surface of 350°F., about 82,800 heat units were radiated per hour from each square foot of glowing fuel; whereas, when the furnace temperature rose to 2000°F., while that of the surface of metal remained unchanged, the radiation amounted to 693,580 heat units in the same time. In general, the number of B.T.U. radiated from 1 sq. ft. of glowing fuel per hour is given by the following formula, where θ is the temperature of the surface of the fuel, and t that of the heating surface surrounding the combustion chamber:—

$$\text{B.T.U.} = 144\, k^{\theta}\, (k^{t} - 1). \quad . \quad . \quad . \quad (82)$$

The value of k, where the fuel is clean coal or coke, is 1·00425. Usually, the proportion of furnace heat which passes away by radiation varies from ½ to ¾ of the total heat, where coal or coke is used; the remainder of the heat being carried away by convection by the hot gases. Since so large a proportion escapes by the former process, it is very desirable that the radiant energy from the fire should encounter useful heating surface in all directions, or at any rate in as many directions as possible. This can best be attained by placing the fire inside the boiler, so that water will entirely envelop it, except where the fire-door and ash-pit are necessarily placed. It may, however, to a certain extent, be attained by placing the fire externally to the boiler, but in a setting of fire brick which by its reverberatory action will reflect most of the heat on to the useful heating surface. Fire brick is not a perfect non-conductor of heat, however, so that by this method it is inevitable that some of the heat will be conducted wastefully away. Experience shows that a square foot of useful heating surface, when exposed to the direct radiation of the fire, will absorb very much more heat per hour than when merely in contact with the escaping hot gases, even though the temperature of these hot gases may be very nearly as high as that of the fire. The first to put this to practical test was Mr. Robert Stephenson, of railway fame, who found that he could get 16 times the rate of evaporation from a square foot of surface in a locomotive fire-box, exposed to the fire, than was to be obtained from an equal area of tube-surface, not exposed to direct radiation. Every trial at a later date has but confirmed Stephenson's results, though the actual ratio of the evaporative values may differ in different types of furnaces. The advisability of directly exposing as much useful surface as possible to radiation is at once established; for, for every square foot thus exposed several square feet in other parts of the boiler may be dispensed with. It is on this account that flame plays so useful a part in steam raising. Every glowing particle of carbon in the flame acts as a centre of radiation; so that the flame, in its passage along the flues, carries to parts remote from the fire a means of obtaining radiant heat, and thus enhances their evaporative value.

With certain classes of fuels which are liable to develop smoke, it is sometimes found to be impracticable to directly rob them of their heat of combustion by taking the radiation straight from the fire into the water. The process lowers the fire temperature, and thereby tends to hinder the combustion, with the result that smoke is liable to be produced in large amounts. Some engineers have even gone to the extent of advocating the use of brick-lined combustion chambers to obviate this, for every class of coal; but this is by no means necessary, and it would rob the boiler of its most effective heating surface. There are conditions, however, such as where highly bituminous nuts or slack is fired by hand, under which it may be advisable to completely envelop the fire in a reverberatory chamber. An example of such a combustion chamber is given in Fig. 15, which shows a recent modification of a Babcock and Wilcox boiler, adapted to the consumption of very smoky fuel. Immediately over the grate is the lowest layer of water tubes, and upon these tubes there is built up a layer of fire tile, with an opening at the bridge end for the passage of the gases upwards to the upper combustion chamber. Over the further end of this upper chamber there is a similar layer of fire tile, built upon a layer of water tubes; and it is not until the gases have wended their way through both these reverberatory chambers that they can pass through the layers of tubes. The enhanced combustion chamber temperature tends to ensure perfect combustion of the volatile fuel before it reaches the colder metal surface of the ordinary tubes. It is very doubtful if such good results could be obtained in a brick-lined combustion chamber as in an open chamber; for if the fuel is too smoky for hand-firing, one has always two expedients at hand, the one is to mix the coal with a drier quality, the other is to adopt mechanical stoking.

Convection.—The heat which is conveyed from the glowing fuel by the gases is distributed in the following way. A small portion of it will pass through the heating surface over the fire, but the greater portion will pass over the bridge. Of this greater portion, some will be absorbed through the heating surfaces along the length of the flues; either for passage into the water, or for conduction to the outside of the setting and final loss by radiation. The rest of the heat will pass up the chimney, and will maintain the draught. It should be observed that in some cases a portion of the useful heating surface belongs, not to the boiler itself, but to an economiser

* From a forthcoming work to be published by *The Electrician* Printing and Publishing Company. All rights are reserved.

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affixed to it; the action on the furnace gases being, however, the same in both cases. Recognising that some of the convection heat is necessarily directed up the chimney, we have now to consider how best to abstract the remainder from the rapidly moving hot gases. We find that this heat is abstracted under two conditions of the gas relatively to the surface to which it imparts the heat: (1) during gliding motion of the gas over the surface, (2) during impingement upon the surface at or nearly at a right angle. Assuming, for simplicity's sake, that the heating surface itself is at a constant temperature which is very much lower than that of the hot gas, we will compare these two conditions. During perfect gliding the gas travels in unvarying stratification parallel to to the surface; in practice, gliding only approximates to this. The resulting tendency is to abstract heat only from the stratum of hot gas in immediate contact with the cold surface, the other strata losing heat only by slow conduction through this cooled inner stratum. As a consequence, the greater portion of the convected heat is thermally insulated from the cold surface; and the chimney gases escape at too high a temperature, while too little water is evaporated. On the other hand, if the hot gas impinges normally on the cold surface, the particles of gas as they come into contact with that surface will be robbed of their heat, and they will also be

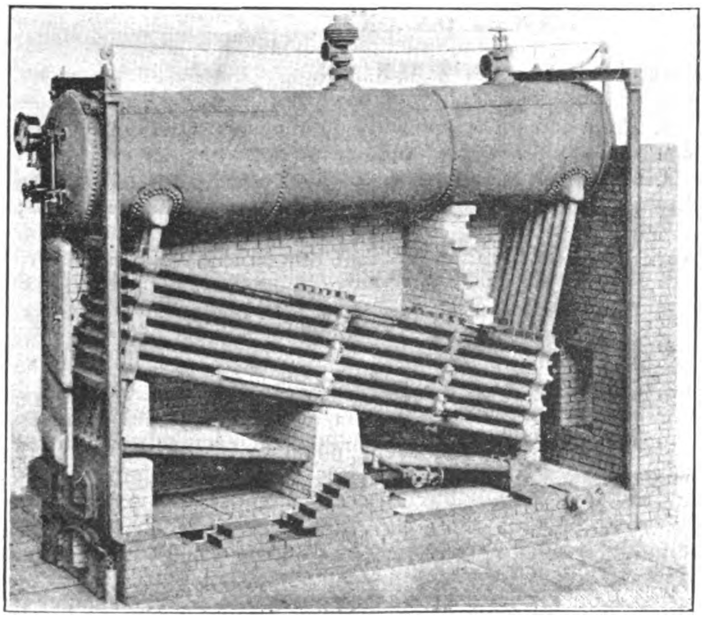

Fig. 15.—Babcock-Wilcox Boiler, fitted with "Scotch Furnace."

deflected at a sufficient angle to cause them to recede some distance from the surface, Thus, fresh heated portions of the gas continually strike the surface, and the rate of absorption of heat is rapid. The perfection of this action depends to a great extent upon the velocity of impingement. If the hot gases strike feebly the cold surface, a cushion of very much colder gas will instantly be formed between the hotter portions of the gas and the cold surface. It is on this account that the thermal absorption by surfaces directly exposed to the impingement of flame is so much lower than that indicated by theoretical calculation. The more rapid the impingement, the greater is the rate of heat absorption. It must be remarked here, however, that a very rapid flame impingement is liable to become injurious to the metal plates, through unequal and excessive expansion of the metal.

When we combine the effects of gliding gases with those of impinging gases, we have a very practical mode of abstracting convected furnace heat. By the interposition of bafflers, the gliding gases are frequently churned up, and fresh portions of hot gas are brought into contact with the cold surface, and in many boilers these bafflers constitute effective heating surfaces, impinging upon which, the gases are led to give up an extra amount of heat besides becoming intermixed. Another mode of reducing the loss of heat due to stratification of heated layers, is to arrange the heating surfaces, parallel to which the gases are to move, so that the mean distance of the gas particles from them is as small as possible. This is done in the locomotive type of boiler, for example, by subdividing the gases in a large number of parallel flue-tubes. To ensure efficient absorption of convection heat it is also necessary to provide that the hot gases shall remain for a considerable time in contact with the boiler surfaces; and to ensure this the gases must be made to travel through a sufficient length of flue at not too high a velocity. The actual length of the path taken by the gases, between the grate and the end damper will generally depend on the type of boiler. In locomotive return-tube and water-tube boilers the distance is small; while in boilers of the Cornish or Lancashire type it may be from 6 to 12 times greater. Moreover, in the locomotive type of boiler the velocity of the gases is often from 3 to 8 times more rapid than in the internal and external flues of boilers set in brickwork.

Heating Surfaces.—We may now direct our attention to what goes on in the boiler portion of the steam generator; and it will be convenient to consider first of all the manner in which the heat is disposed of by the useful heating surfaces. It was pointed out on page 409, Vol. XXXII., that it is impossible to calculate the heat-transference through a boiler heating surface solely upon the data supplied by the difference in temperature between the hot gas and the water and the thermal conductivity of the metal plate. One reason for this has just noticed; we may now mention some others. Firstly, the been temperature of the water stratum in contact with the surface is not constant, nor is it the same as that of the stratum immediately beyond it. Secondly, the plate usually consists of other materials than the mere metal, being incrusted on one side with soot and on the other side with calcareous and saline deposits. There is a well-worn fallacy, perpetuated in numerous text-books, to the effect that if the value of a horizontal heating surface transmitting heat to water above it be taken as unity, then a vertical surface will have a value of only one-half, while a horizontal surface with water below it will have zero value. This, in respect to boiler surfaces, is a complete fallacy; for it is possible to obtain as much heat through a vertical surface as through a horizontal one, provided that precautions are taken to prevent the accumulation of cold gas on its one side or of hot water on its other side. The value of any given heating surface is a function of the gas and water circulations on either side of it; and, apart from radiation, it will be high or low just in proportion as those circulations are properly or improperly designed. The object of water circulation is, to constantly bring fresh cool portions of water to the surfaces to replace the water just heated; just as the object of gas circulation in the furnace is to constantly bring fresh hot portions of gas to the surfaces to replace the gas just cooled. In the boiler, circulation is produced by so arranging the heating surfaces that the heated water can freely rise to the water surface, giving place to the colder portions of water, which will descend. It is caused by the difference in specific gravity produced by heating and expanding water; and the rapidity of the circulation will depend on the ratio of the moving force thus developed to the mass of water which must be set in motion. Rapid circulation is, therefore, obtained by designing the boiler so that its total useful heating surface shall be large as compared with the mass of water in the boiler shell. The usual allowance of heating surface, in boilers for ordinary work, varies from one square foot per 2,500 B.T.U. per hour, to one square foot per 5,000 B.T.U. per hour; although under high draught it is possible to transmit heat very much more rapidly. In boilers for electric power purposes, where it is necessary to rely upon the boiler plant for a considerable excess of its normal steaming rate during a short time every day, it is well to see that both the boiler and economiser surfaces are ample; and for this purpose it would be well to allow not more than 3,000 B.T.U. per square foot of boiler surface per hour, as the normal rate of transmission. It is customary to express the heating surface in a boiler in terms of its grate area. This, taken by itself, is a misleading datum, or no datum at all; but when the normal draught and rate of combustion on the grate have also been specified, it furnishes a

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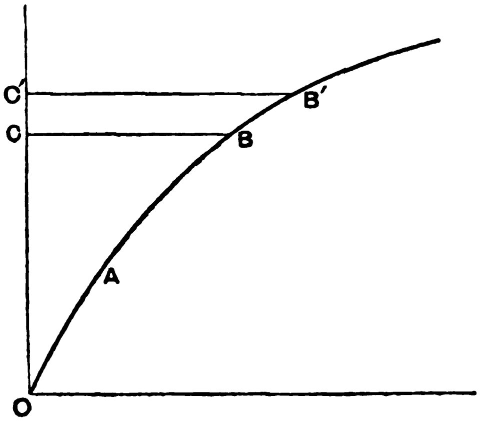
convenient guide to the steaming capacity of the boiler. In early days it was considered sufficient to allow a heating surface equal to 30 times the grate area ; but it must not be forgotten that at those times slower fires were burned under much lower draughts, as well as that a high economy was not expected. Boilers such as are used for electric power purposes are generally provided with heating surface amounting to from 40 to 55 times the grate area, under ordinary draughts ; no account being taken of the surface of the economiser, which, if included, would raise the total heating surface to from 90 to 120 times the grate area. Locomotive boilers under steam blast draught are provided with a heating surface some 100 to 150 times the grate area.

(To be continued.)

ON THE FORCE AN ELECTRO-MAGNET EXERTS ON ITS ARMATURE.

BY JOHN HOPKINSON, F.R.S.

1. Let O A B (Fig. 1) be the characteristic of an electromagnet in a given position of the armature, that is, the curve in which the ordinates are total inductions and the abscissæ are the corresponding magnetising forces.*



The work done in magnetising the field of the magnet is the area O A B C divided by 4π. Thus stated, this is almost obvious. For let T be the time taken for the induction to increase from O C to O C'.

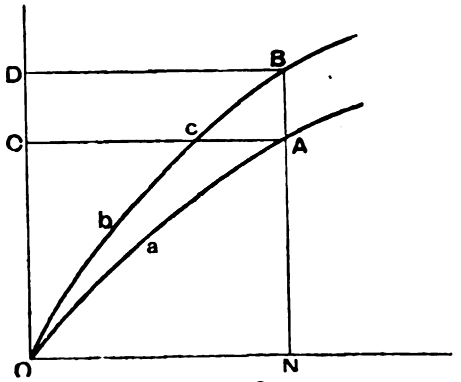


FIG. 2.

The electromotive force exerted by the electromagnet on the circuit is C C'/T × number of convolutions. The work done by this electromotive force in time T is C C'/T × number of convolutions × current × T = C C' × $\frac{\text{magnetising force}}{4\pi}$ = area C B B' C'/4π.

2. Consider one electromagnet with a movable armature. Let OaA (Fig. 2) and ObB be the characteristics of the electromagnet in two positions of the armature. Suppose a current of magnetising force, O N, to be circulating in the magnet, the current being maintained constant, let the armature be moved from position A to position B, in making this movement the magnet will do mechanical work in moving the armature, it will also receive work from the current, as it will exert an electromotive force opposed to the current. Now pass through the following steps: first, make the current work done by the current is O a A C/4π ; next, move the armature work done by the current C A B D/4π ; lastly, unmake the current work done on the current by the magnet is O b B D/4π, and the net work done by the current is O a A B b/4π, and this must be equal to the mechanical work done upon the armature.

Thus if we know, either by calculation or experiment, the characteristic of the electromagnet for various positions of the armature, we know the mechanical work done in moving from one position to another with a constant current in the magnet, and hence the force tending to cause that displacement.

When the distance between A and B is small, the area A B c is small of the second order, and the work done is the area O a A c b.

3. If the space between the armature and magnet is non-magnetisable, and if the magnetising force in the armature be neglected, A c is proportional to A N. Hence area O a A c B = $\frac{1}{2}$ A c . A N.

Now A c = A N × change in ratio magnetic force/total induction

$$= \text{A N} \times \delta \,.\, \text{O N/A N};$$

$$\text{work done} = \frac{1}{8\pi} \text{A N}^2 \delta \,.\, \text{O N/A N}.$$

4. From this we very readily obtain the well-known expression for the tension along the lines of force.

Let the lines of force all be parallel, and let there be a small displacement of the armature δl parallel to the lines of force;

$$\text{work done} = \frac{1}{8\pi} \text{A N}^2 \frac{\delta l}{\text{A}}, \text{ A being the area,}$$

$$= \frac{1}{8\pi} \text{A} \,.\, \delta l \,.\, \text{intensity of induction}^2;$$

$$\text{force} = \frac{1}{8\pi} \,.\, \text{A} \,.\, \text{intensity of induction}^2.$$

5. Consider the case where induction is proportional to the magnetising force, *i.e.*, where there is a coefficient of self-induction, in this case,

$$\text{induction} = \frac{1}{4\pi} \,.\, \frac{\text{L}}{n^2} \,.\, \text{magnetising force}$$

$$= \frac{\text{L}\,x}{n}$$

where x is current, L coefficient of self-induction, and n the turns in the magnet,

$$\text{mechanical work done} = -\frac{1}{8\pi} \,.\, \frac{\text{L}^2 x^2}{n^2} \,.\, \delta \frac{4\pi n x}{\frac{\text{L}\,x}{n}} = \tfrac{1}{2} x^2 \delta \text{L}.$$

The work done by the current is $x^2 \delta$ L, and of this half goes in work on the armature, half in increasing the moment of the magnet.

6. The curves of induction may be determined experimentally with a ballistic galvanometer, but on this the natural criticism would be that it would be as easy to measure the force directly. Or they may be determined *à priori* to varying degrees of accuracy by methods analogous to those I introduced for predetermining the characteristics of dynamo machines.

If the inductions and currents are in absolute units the work and force will be measured respectively in ergs and dynes.

* By magnetising force I here mean line integral of magnetising force

Search Lights and Coast Defence.—The Royal Engineers have completed a system of electric search lights for illuminating the Solent at night, thus affording protection against night attacks, and measures have already been taken to defend the entrance to Portsmouth Harbour by stretching a double line of wire hawsers from shore to shore.

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ON A SYNCHRONOUS ALTERNATE-CURRENT ELECTRIC MOTOR.*

BY GALILEO FERRARIS.

In a memoir recently accepted by this class for publication in the academical volumes,† I expounded a method for the treatment of rotating and alternating vectors, and showed, by some applications, its possible utility with regard to many phenomena, and also with regard to the clear and sufficiently elementary explanation of the fundamental properties of many electro-technical constructions.

In this memoir I confined myself to applying the new method to the study of the chief forms of alternate-current motors now in use. But the method also foreshadows the possibility of new combinations, and I believe that it will be not undesirable to point out one of these combinations which is capable of practical applications.

The method expounded in the memoir referred to is based upon the three following propositions :—

1. A sinusoidal alternating vector of fixed direction may always be considered as the resultant of two equal vectors, one of which rotates towards the right and the other towards the left, with the same period. The period of the two rotating vectors is equal to that of the alternating vector, and their common constant length is equal to half the amplitude of the alternating vector itself.

2. Given two groups of vectors, and supposing that at a given instant a is the length of one of the vectors of the first group, b the length of one of the second group, A the instantaneous value of the resultant vector of group a, B that of the resultant of group b, ϕ the angle contained between a vector a and a vector b, and Φ the angle between A and B, then

$$\Sigma\, a\, b \cos \phi = A\, B \cos \Phi$$
$$\Sigma\, a\, b \sin \phi = A\, B \sin \Phi.$$

3. Let a and b be two vectors rotating with the frequencies m and n; these frequencies are considered to have the same or opposite signs, according as the rotations take place in the same or in opposite directions. ϕ represents the angle (a function of the time) which the vectors make with each other. Then, if $m = n$, the products $a\, b \cos \phi$ and $a\, b \sin \phi$ have constant values. If m and n are not equal, these products are variable, and their mean value, calculated for a time equal to a multiple of $1/(m - n)$, or for a long time as compared with $1/(m - n)$, is equal to zero, or is very small.

By means of these propositions, I have, in the memoir referred to, presented the theory of an ordinary alternate-current synchronous motor in the following elementary form. The motor is simply an ordinary alternator; and if for simplicity we suppose it to be bipolar, it reduces itself to an armature consisting of a coil with parallel windings rotating in a magnetic field. The armature conducts an alternating current of frequency n, and the magnetic field, produced by magnets excited by a continuous current, is constant. The alternating current of the armature is equivalent to a magnet whose magnetic moment may be represented by an alternating vector whose direction is that of the axis of the coil, and whose length is equal to the product of the total surface of the coil multiplied by the current intensity in absolute electromagnetic measure. This alternating vector may be decomposed into two vectors, one of which, d, rotates towards the right, and the other, s, towards the left, their frequencies, referred to the armature considered as fixed, being $+ n$ and $- n$ respectively. If the armature rotates with the frequency $+ n$, the two rotating vectors rotate in space with the velocities $n + n$ and $n - n$; the first therefore rotates with a frequency double that of the armature, and the second remains immovable in a fixed direction, which makes a constant and definite angle ϕ with the direction of the magnetic field. The moment of the couple exercised by the fixed magnetic field upon the rotating magnet d has a mean value equal to zero, but that of the couple exerted upon s has a constant value. If $\mathfrak{B}$ represents the constant value of the induction in the magnetic field, the moment of the couple is

$$\mathfrak{B}\, s \sin \phi.$$

The couple tends to close up the angle ϕ. It aids or resists the motion according as the fixed direction of s, which is that of the axis of the armature at the instant of its greatest current intensity, is on the left or the right hand of the direction of $\mathfrak{B}$. In the first case, the apparatus represents an electric motor, in the second case, a dynamo.

Now let us consider the same apparatus on the supposition that the magnetic field in which the armature turns, instead of being constant, is a field alternating with frequency n equal to that of the current of the armature itself. Let us, in fact, suppose that the field magnets are no longer excited by a continuous current, but by the alternating current flowing through the armature, or by another alternate current of the same frequency. We can easily show that in this case also the apparatus can be made to act as a dynamo or as a synchronous motor, and that for this purpose it is sufficient to make the armature rotate with a velocity such that it makes $2n$ revolutions per second.

As a matter of fact, the alternating magnetic field is equivalent to two fields, one of which, D, rotates to the right, the other, S, to the left, with the frequencies $+n$ and $-n$. Let us then give the armature a rotation to the right, say, with a frequency $2n$. Of the two rotating magnets d and s, to which the armature may be supposed equivalent, d will then turn in space with a frequency $2n + n = 3n$; the other, s, will turn in the same direction with $2n - n = n$. The mean value of the moments of the couples exerted by d upon D and S, and that of S upon s will be zero. But this will not be the case for the couple exerted by D upon s, for both s and D will rotate to the right with the same frequency, and will, therefore, maintain a constant angular distance ϕ. Hence the mutual couple will have a constant moment. It will tend to close up the angle ϕ. The apparatus will work as a dynamo, or as a motor, according as s precedes or follows D.

Thus we have a synchronous motor with an alternating field. The theory, which I have expounded in an elementary form for the simple case of a bipolar apparatus, is extended without difficulty to the case of a multipolar apparatus.

This motor, like all synchronous motors, does not begin to work unless before switching on the current it is given the standard velocity, and this is actually equal to double the velocity at which it would work if its field were excited by a constant current. But it is not difficult to conceive devices for starting the motor analogous to those already in use for motors of other constructions. Thus, for instance, a motor with $4n$ poles might be provided with a commutator, by means of which it could, when starting, be made to work as a two-phase motor with $2n$ poles only, by passing through $2n$ coils a current of different phase with respect to that passing through the other $2n$ coils alternating with the first. By this means the armature may be given a velocity closely approaching that of synchronism in the $2n$ pole machine, which is exactly double that necessary for synchronism in the $4n$ pole machine. When that velocity is nearly reached all the $4n$ coils are, by means of the commutator, put in series, in parallel, or in groups in the same circuit, and the motor begins to work normally as a synchronous motor in the manner explained. For the production of the auxiliary current of different phase for the purpose of starting, the device employed by Brown for single-phase synchronous motors may be used, or other similar well-known contrivances.

* *Atti di Torino*, Vol. XXIX., April 1, 1894.
† *Memorie di Torino*. *See* also this week's *Electrician*.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

TO-DAY (FRIDAY), May 25th.

PHYSICAL SOCIETY.

5 p.m. "On the Passage of Hydrogen through Palladium," by W. Ramsay, F.R.S.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "The Development of the Astronomical Telescope," by Sir Howard Grubb, F.R.S.

TUESDAY, May 29th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "The Modern Microscope; an Instrument for Recreation and Research," by the Rev. W. H. Dallinger, F.R.S.

SOCIETY OF ARTS.

8 p.m. Foreign and Colonial Section. "Black and White in Afrikanderland," by W. A. Wills.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Annual General Meeting of Corporate Members only, to receive the Report of the Council, and to elect the Council and Auditors for the ensuing year.

THURSDAY, May 31st.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "Egyptian Decorative Art," by Prof. W. M. Flinders Petrie.

INSTITUTION OF ELECTRICAL ENGINEERS.

Annual Conversazione in the Galleries of the Royal Institute of Painters in Water Colours.

FRIDAY, June 1st.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "The Work of Hertz," by Prof. Oliver Lodge, F.R.S.

SATURDAY, June 2nd.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "The Stage and Society," by Robert W. Lowe.

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ELECTRICITY SUPPLY IN LONDON.

WE publish this week our annual analysis of the capital and revenue accounts of the statutory electricity supply concerns at present at work in the metropolis. Some care has been taken to ensure arithmetical accuracy, but originality, we frankly confess, need not be looked for. Figures, it is deprecatingly exclaimed whenever the subject of statistics is introduced, can be made to prove anything, and this sententious aphorism is usually quite sufficient to nip the tender budding efforts of many an embryo statistician, a result for which we have every reason to be thankful. The dictum, nevertheless, contains a flaw. Figures can be made to prove something. If a few obvious arithmetical operations show that the Belgravia and Mayfair Electricity Supply Corporation has a coal bill of only 0·5d. per unit sold, whilst the Upper Tooting Company's figure is 3·6d., there is really no denying that one concern spends more than seven times what the other does on coal per unit. So far the much-maligned statistician, always provided arithmetical fate has been kind to him, is in an impregnable position. Should he, however, desire to proceed one step further on his analytical career and draw the moral, let him refrain! Every district has its peculiarities and difficulties which no numeric can express; every company's system is, of course, the best; beware of hinting otherwise. To prove that one country has ten times the inhabitants per square mile that another has may or may not be a useful performance; at any rate, it is more or less of a

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fact. To "prove" therefrom that one country has ten times the brain power per unit area is perilous; there are heads and heads. It has, however, been our aim to *prove* nothing, to base our multitudinous percentages and decimals of a penny wholly and solely upon the figures given by the respective companies in their Board of Trade returns, and to deduce results likely to be useful to the engineer rather than to the financier. Whenever any important item has appeared likely to mislead, attention has been called in a footnote to its dubious character, but no attempt has been made to arrive at an approximation to the absolutely correct by the application of an arbitrary coefficient of "involuntary mendacity." In two instances, however, circumstances duly recorded in appropriate footnotes, have obliged us to indulge, much against our will, in a little editorial estimating; we trust the result will be found tolerably satisfactory.

Up to December 31st last, the ten companies and one Vestry engaged in the electricity supply business in London, had spent between them close upon 3½ millions sterling, an increase of some 34 per cent. upon the figure for 1892, the major portion being due to the City of London Company. By far the most important contributor to this total is the London Electric Supply Corporation with its capital outlay of £851,134. The average capital expended per lamp connected now stands at £5; the best individual figure being the £2. 10s. of the Chelsea Company—the Kensington, Westminster, and House-to-House Companies following close upon its heels. In regard to mains, the Notting Hill Company would appear to have made the handsomest provision for future contingencies, no less than 44 per cent. of its total capital being locked up in copper and conduit; the Westminster Company, however, is almost as sanguine, and makes a good second with 42½ per cent. of its money expended on mains.

Turning to the revenue accounts, it will be seen that the aggregate gross income for 1893 amounted to £285,061, and the total units metered to 9,889,794, the increase in either case being about 25 per cent. over the totals for 1892. Deducting the revenue derived from meter rents, transfer fees and such like adventitious aids, the total income arising from the sale of current will be found to be something over ¼ million sterling, showing that the average market price of the Board of Trade unit in London last year was 6·38d. The data at our disposal also enable us to deduce the figure of 7s. 6d. for the average return per lamp connected; owing, however, to the large additions which still continue to be made late in each year to the lamp connection, the 8-candle lamp is, as a matter of fact, a somewhat more fruitful source of revenue than this. The coal bill of the metropolitan electricity supply concerns amounted last year to £54,752, a figure which works out at 1·328d. per unit sold, or 10 per cent. less than in 1892. The Kensington Company wins the prize for the lowest coal

CAPITAL EXPENDITURE up to December 31, 1893, of Statutory Electricity Supply Companies at present at Work in London.

				Details of capital expenditure.											
COMPANIES.	Authorised Capital. (Share and Loan).	Paid-up Capital.	Capital Expended	Lands.	Capital Expended.	Buildings.	Capital Expended.	Plant (incl. Transf'rm'rs Instruments and Accumulators.	Capital Expended.	Mains.	Capital Expended.	Meters.	Capital Expended.	Miscellaneous.	Capital Expended.
	£	£	£	£	%	£	%	£	%	£	%	£	%	£	%
1. Charing-cross & Strand Electricity Supply Corporation	220,000	211,200	207,245	199,493[1]							96·2	2,158	1·04	5,593	2·7
2. Chelsea Electricity Supply Company	160,500	88,785	99,483	548[2]	0·55	11,715	11·8	40,798	41·0	28,384	30·0	3,677	3·8	14,360[3]	14·0
3. City of London Electric Lighting Company ...	1,200,000	799,610	708,921	75,342	10·6	71,231	10·0	210,852	31·1	207,899	29·6	7,333	1·3	136,963[4]	19·3
4. House-to-House Electric Light Supply Co.......	100,000	82,110	77,177	72	—	10,043	13·0	32,645	42·3	21,121	27·3	3,778	4·9	9,527[5]	12·3
5. Kensington & Knightsbridge Electric Lighting Company	428,260	174,260	175,926	9,213	5·2	17,068	9·7	54,090	30·7	65,167	37·0	5,963	3·4	24,423[6]	13·9
6. London Electric Supply Corporation	1,500,000	862,750	851,134[7]	127,177			14·9	243,071	28·5	166,825	19·5	8,680	1·0	305,380[8]	35·8
7. Metropolitan Electric Supply Company......	1,000,000	599,741	585,932	12,389	2·1	136,503	23·3	229,904	39·2	141,639	24·1	10,861	1·8	54,635	9·3
8. Notting Hill Electric Lighting Company ...	150,000	78,480	78,529	7,390	9·4	10,971	14·0	14,773	18·8	34,649	44·1	1,088	1·3	9,657	12·3
9. St. James and Pall Mall Electric Light Co. ...	300,000	200,000	211,029[9]	45,941	21·7	30,737[10]	14·5	57,000[11]	27·0	53,217[11]	25·2	8,524[12]	4·0	15,609	7·4
10. St. Pancras Vestry......	—	—	96,085	10,827	11·2	9,348	9·7	28,480	29·5	36,759	38·2	2,679	2·7	7,990[13]	8·3
11. Westminster Electric Supply Corporation...	400,000	400,000	381,276	16,917	4·4	75,478	19·8	97,303	25·5	160,311	42·4	17,084	4·5	14,183[14]	3·7

[1] Of this sum nearly £123,000 was paid for the land, buildings, plant, mains, &c., when the limited liability company was formed; the balance of £76,000 has been subsequently expended on these items.

[2] Includes property subject to £800 mortgage.

[3] This item includes the sum of £10,237 paid for the Cadogan Electric Light Company's business and plant.

[4] In order to make the various items of the accounts of this Company fairly comparable with the corresponding items in the accounts of other companies not engaged in public lighting or in telephone tube laying, all charges debited to these two enterprises have been placed as far as possible under the miscellaneous column; the expenditure on machinery, however, includes the outlay on arc lighters, and that on mains the outlay on the street lamp leads. The following are amongst the more important items of the miscellaneous expenditure:—Street lamps, £24,382; rents, rates, taxes, &c., charged to capital, £24,466; telephone tubes, £68,887; Southwark Order and mains, £8,592.

[5] This sum includes £7,500 paid in connection with patent rights and covenants with Managing Director.

[6] This sum is made up of £15,000 for purchase of the Kensington Court Company, £7,346 paid for the South Kensington Order, £2,077, cost of the Provisional Order.

[7] This is the total capital expenditure up to date, less £2,692 written off; so that the actual total amount which has been spent on capital account is £853,826.

[8] The chief components of this huge total are £249,107 paid for the Grosvenor Gallery business; £30,000 cost of redeeming debentures; £10,311 preliminary expenses.

[9] This is the total expenditure up to December 31, 1893, *less depreciation*, and as this amounts in all to £11,650 18s. 6d., the total capital outlay since the commencement of the Company has actually been £222,680.

[10] This is the total expenditure on buildings up to December 31, 1893, *less depreciation*, amounting in all to £1,239 17s. 5d.

[11] This is the total expenditure up to December 31, 1893, *less depreciation*, which for plant, machinery, &c. (presumably including mains, meters, and so on), amounts to £10,411.

[12] This sum includes cost of switches and labour.

[13] This includes £7,209 spent in connection with the public lighting.

[14] This sum includes £10,133 paid to the City of Westminster Electrical Syndicate.

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Analysis of the REVENUE ACCOUNTS for 1893 of the Statutory

Companies.	Board of Trade units supplied during 1893.	Price of Board of Trade unit during 1893.	Receipts during 1893.	Expenditure during 1893.	% Ratio Expenditure/Receipts.	Total Expenditure per Board of Trade unit sold.	Generating expenses.	Per cent. of the year's expenses.	Generating expenses per Board of Trade unit sold.	Distribution expenses.	Per cent. of the year's expenses.	Distribution expenses per Board of Trade unit sold.	Management expenses.
		d.	£	£	%	d.	£	%	d.	£	%	d.	£
1. Charing Cross and Strand Electricity Supply Corpo'rt'n	934,276	6	22,304	13,649[1]	61·2	3·50	9,284	68·0	2·38	606	4·4	0·15	1,436
2. Chelsea Electricity Supply Company	402,848	8	13,732	7,464	54·3	4·40	3,848	51·5	2·30	842	11·2	0·5	1,756
3. City of London Electric Lighting Company	799,453	8	26,462[4]	11,820	44·6	3·50	9,527	80·6	2·86	791	6·8	0·23	658
4. House-to-House Electric Light Supply Company	358,506	8	12,063	7,832	64·9	5·20	5,885	75·1	3·93	174	2·2	0·11	1,181
5. Kensington and Knightsbridge Electric Lighting Company..	724,308	8	21,744	13,195[5]	60·7	4·37	6,722	50·9	2·23	793	6·0	0·26	2,046
6. London Electric Supply Corporation	9:2,901[6]	6	25,317	25,144	99·3	6·54	13,096	52·1	3·41	3,510	13·9	0·91	5,085
7. Metropolitan Electric Supply Company	2,128,963[7]	7½	69,195	53,281	77·0	6·00	34,139	64·0	3·85	219	0·4	0·02	7,960
8. Notting Hill Electric Lighting Company	107,580	8	4,330	2,849	65·8	6·35	1,520	53·3	3·39	160	5·6	0·35	618
9. St. James and Pall Mall Electric Light Company	1,211,451	6	31,059	21,149[8]	68·0	4·19	10,827	51·1	2·14	1,509[9]	7·1	0·29	3,695
10. St. Pancras Vestry...	591,893[10]	6	15,022	8,810	58·6	3·55	6,103	69·3	2·46	893	10·1	0·36	837
11. Westminster Electric Supply Corporation	1,704,615	6	43,833	23,267[12]	64·5	3·98	14,623	51·7	2·06	1,595	5·6	0·22	5,551

[1] This includes £700 set aside for depreciation.
[2] The lighting of this Company's station alone costs £425 per annum.
[3] Wages of men alone included; salaries come under management expenses.
[4] The receipts, expenditure, &c., all relate solely to the Private Lighting business.
[5] This includes sums amounting in all to £2,690 set aside for depreciation, and written off suspense (law) account and preliminary expenses.
[6] As we have received no reply to our request to be supplied with information as to the number of units sold during 1893, we have been compelled to derive the figure from the selling price of the Board of Trade unit, viz., 6d., and the revenue obtained by sale of current per meter and under contract, viz., £23,072. 10s. 8d.
[7] As information as to the number of units sold during 1893 was refused by the Company, the figure given has been derived from the price charged

bill per unit, its figure being 0·74d., the Westminster Company coming next with 0·78d. Of the companies with coal bills trembling on the verge of twopence the less said the better; for no true comparison is possible unless considerations of total output, character of district, and facilities for coal transport are taken into account. An improved type of transformer has already in one case brought about a reduction in this source of expense, and an improved arrangement of the transformers may be reasonably expected to do likewise in other districts.

REVIEWS.

Electromagnetic Theory. Vol. I. By Oliver Heaviside. (London: *The Electrician* Printing and Publishing Company, Limited.)

"The well in which truth is said to reside is a bottomless pit." Thus Mr. Heaviside expresses his belief in the infinity of Nature. It is a characteristic way of putting it, though what is meant may not be quite obvious without somewhat careful consideration. In Heavisidesque, the "practical man" seems to think that science resides in The Bottomless Pit, but certainly Mr. Heaviside does his best to show all men that science is a child of light and not of darkness, even to the "practical man." Nevertheless, it is to be feared that the garb in which this child of light appears here may deter many a practical man from using the light. We must train up a generation instructed in the new ideas with a gradually grown familiarity with the most appropriate terms for electromagnetic descriptions before they will find Mr. Heaviside easy reading. Sentences such as the following require a deal of consideration before they convey much meaning to most minds:—"If we replace our illustrative conductor by an inductor, supporting magnetic induction, and suppose it surrounded by imaginary matter of zero inductivity, and have an impressed gaussage instead of voltage at the terminals, we shall have a flux of induction which will, if the force be weak enough, vary as the force." "The electric current is measured by the magnetic circuitation, or by the circuital gaussage." The practical man would think it better to measure it by an ammeter. The fact is that new sciences require new languages, and that just as the poor handloom weavers were thrown out of work by the introduction of power-looms, so those brought up upon charges of electricity and action at a distance find the more powerful analytical engines of the present rather unwieldy. Sir Francis Drake would probably be quite at sea in a modern warship. The value of an engine, analytical or otherwise, is to be judged not by the difficulty of learning how to work it, but by the work it does, and Mr. Heaviside's engines have done a great deal of work, and in this volume he has tried to put others in possession of the same engines by which he has done his work. It is hardly fair to call them analytical engines, because they are so largely geometrical, but in the larger sense of the word they analyse the phenomena into its component parts in such a way that we can discover how the phenomena work, and invent improvements in our working.

Mr. Heaviside has been greatly impressed with the value to himself of vectorial analysis, and a large part of his work is expressed in terms of it, and he has devoted a considerable part of this book to an introduction to vectorial analysis. It is a pity that, in order to avoid a minus and an S, he should have departed from Hamilton's notation, and have sacrificed an important series of interpretations of the equations that Hamilton's notation includes. The difference is, however, not very serious; in fact, the pity is that for the sake of so little, any change, especially one restricting the use of the calculus, should have been made. It is, any way, to be hoped that those who, in the future, set themselves to study these subjects from the mathematical point of view, will put themselves in possession of ideas and of a means of attack which have been judged to be so very valuable to themselves by leaders of modern science, such as Hamilton and Maxwell. It is not to be expected that all students of electrical science should be able to wield these engines. Division of labour is the essential means of progress. The engine-driver does not try to work the spinning jenny nor to design cards for weaving. It is

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Electricity Supply Companies at Work in London.

					Details of generating expenses.												
Per cent. of the year's expenses.	Management expenses per Board of Trade unit sold.	Rent, rates, taxes, &c.	Per cent. of the year's expenses.	Rent, rates, taxes, &c., per Board of Trade unit sold.	Coal.	Per cent. of generating expenses.	Cost of coal per Board of Trade unit sold.	Oil and waste, &c.	Per cent. of generating expenses.	Cost of Oil, &c., per Board of Trade unit sold.	Salaries and wages.	Per cent. of generating expenses.	Salaries and wages per Board of Trade unit sold.	Repairs and Maintenance.	Per cent. of generating expenses.	Cost of repairs and maintenance per Board of Trade unit sold.
%	d.	£	%	d.	£	%	d.	£	%	d.	£	%	d.	£	%	d.
10·5	0·37	2,323	17·0	0·6	4,290	46·2	1·1	758	8·1	0·19	1,895	20·4	0·48	2,341[12]	25·2	0·60
23·5	1·03	1,016	13·6	0·6	1,864	48·4	1·1	505	13·1	0·30	1,001[3]	26·0	0·60	478	12·4	0·28
5·5	0·2	844	7·1	0·25	5,414	56·8	1·6	819	8·6	0·25	2,304	24·1	0·69	989	10·3	0·30
15·0	0·79	591	7·5	0·39	2,838	48·2	1·9	676	11·5	0·45	1,836	31·2	1·22	534	9·0	0·35
15·5	0·68	3,633	27·5	1·2	2,245	33·4	0·74	489	7·2	0·16	1,695	25·2	0·56	2,294	34·1	0·76
20·2	1·32	3,452	13·7	0·8[illegible]	7,235	55·2	1·88	1,075	8·2	0·28	3,091	23·6	0·80	1,695	13·0	0·44
15·0	0·89	10,963	20·5	1·23	17,447	51·1	1·97	2,971	8·7	0·33	8,222	24·0	0·92	5,499	16·1	0·62
21·7	1·38	549	19·3	1·22	432	28·4	0·96	123	8·1	0·27	483	31·8	1·08	483	31·8	1·08
17·4	0·73	5,116	24·1	1·0	4,380	40·4	0·86	701	6·5	0·14	3,944	36·4	0·78	1,802	16·6	0·35
9·5	0·33	976[11]	11·0	0·39	3,052	50·0	1·23	428	7·0	0·17	1,630	26·7	0·66	993	16·2	0·40
19·6	0·78	6,492	22·9	0·91	5,555	38·0	0·78	1,401	9·5	0·20	5,927	40·5	0·83	1,744	11·9	0·24

during the year for the Board of Trade unit, viz., 7¼d., and from the sum given in the revenue account, under the heading of "sale of current, *less* reserve for doubtful debts, allowances, &c.," viz., £64,312. 8s. 5d.

[8] This sum includes £1,961 set aside for depreciation.

[9] This sum only includes repairs to, and renewals of mains; the salaries paid in connection with distribution work being mixed up with those paid in connection with generating expenses.

[10] This figure, like all the others relating to St. Pancras, include the public lighting; 197,676 units were sold to the public lamps at 6d., including trimming, repairs, &c.

[11] This sum includes an item of £731 for carbons, attendance, and repairs of public lamps.

[12] This total includes £2,900 set aside for depreciation.

sincerely to be hoped that every student of electrical science will not imagine that he could be an Oliver Heaviside; but, on the other hand, it is to be hoped that those who do feel that ambition, and feel that they have that ability, will put themselves in possession of the engines he has used. Without learning to use these engines, any student would have his views of electromagnetics enlarged by a study of the conceptions underlying these engines. Just as a student of physical science should have an elementary and accurate general conception of how steam engines work, so the engineering student should have an elementary and accurate general conception of how the efficiency of steam engines may be calculated so far as the theory is known. Without these elementary general conceptions, intelligent appreciation of the subjects and the prospects of improvement are small.

The number of problems attacked in this volume, and methods of attack, are too many to enumerate. With many interesting digressions into such questions as the depth of the electrified layer on a charged conductor, the cure of the disease of "4 π," discussions of the best working analogies to represent the structure of the ether, and other interesting things that crop up almost in every second paragraph the general current of the book leads from the elementary laws connecting electric and magnetic forces in conductors and non-conductors up to the propagation of waves along wires. It begins with Oersted's observation as to the law of magnetic force round changing electric displacement, and Faraday's observation as to the law of electric force round a changing magnetic displacement, with Ohm's law for conductors of electricity, and Heaviside's law for conductors of magnetism, from these four laws working on Maxwell's grand generalisation as to electric and magnetic displacements the whole fabric of electromagnetics is built up. In order to lead the student from these laws to their application to wave propagation, the effect of a moving electrical charge in producing electric and magnetic forces in its neighbourhood is introduced in the second chapter. This is just the sort of method of attacking the subject that disheartens the ordinary student, and distresses the practical man. "How on earth can he know what would happen when a charge of electricity moves with the velocity of light, and who cares what it would do?" And yet it is just these extraordinary methods of attack that betoken genius and enlarge our views of Nature. In an allied question that has only been once or twice made the subject of experiment, namely, the effect of the motion of the medium on the propagation of waves, Mr. Heaviside has, by his methods of attack, hunted out the cause of an anomalous conclusion obtained by Prof. J. J. Thomson, and has put the matter upon a satisfactory basis. From this he proceeds to discuss the way in which energy is transferred by the ether, and as to the stresses in the field, finishing up Chapter II. with an account of the dreadful epidemic of 4π, which is desimating electromagnetic calculations, and how the disease should be treated in a scientific manner, so as to produce a radical cure. However, while such monstrosities as fields measured by force per square inch are tolerated, and when it is seriously proposed to legalise a value of the ohm, which is not 10^9 C.G.S. units, there seems very little hope that a few 4π's coming in where they should not will cause sufficient general nausea for the scientific and practical world to vomit them forth.

In an appendix to Chapter II. Mr. Heaviside considers various theories that have been proposed as to the structure of the ether. The only one that he considers at all satisfactory is the same as that recently worked at so suggestively by Mr. Larmor in a communication to the Royal Society. This one, however, is rejected as not leading to the Maxwellian stresses and mechanical forces on charged and currented bodies. Mr. Heaviside does not explain his reasons for this statement which seems at variance with Mr. Larmor's Paper, and a further elucidation of the question beyond that given here and on page 258 would be most interesting. In this system magnetic force is a flow, while electric force is of the nature of a twist, the opposite analogy being the one most frequently put forward largely on an inconclusive deduction from the rotation of the plane of polarisation of light by matter when subject to magnetic force.

Chapter III. is an account of vector analysis, which, with the addition of the minus and the S that Mr. Heaviside

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discards, would make an admirable introduction to the study of quaternions, and as it stands is in most respects much more intelligible than other introductions to this calculus, which can do so much to enlarge the student's ideas as to analysis, geometry, and dynamics. In this chapter is introduced a very complete discussion of the various dynamical analogues that have been suggested for representing the structure of the ether and the motions and elasticities that may represent electromagnetic quantities. It seems probable that no simple analogy is possible, and that electric force and magnetic force are both kinetic, and both accompanied by irrotational and rotational motions. Mr. Heaviside has apparently discussed and disposed of all possible simple theories, and notwithstanding the recussitation of two of them by Prof. Boltzmann and Mr. Larmor, the prospects of a simple solution of the problem seem, on the whole, improbable.

Chapter IV. deals with the propagation of plane electromagnetic waves. This is studied principally with the object of leading up to the case of the propagation of signals in telegraph and telephone wires, a subject that the author has done so much to advance. He shows how the problem must be attacked when it is complicated by dealing with vibrations which are so rapid that the distributed self-induction of the line must be taken account of if we are to obtain an even approximately true solution. When Lord Kelvin originally attacked the problem of transmission of signals by submarine cables, the solution he obtained was one conditioned by the circumstances to which he was applying it. He attacked the problem before him, and did not attack a lot of other problems with which telegraphists at the time were not concerned. In the problem he attacked the most important factors were resistance and capacity, and he did not include in this simple case leakage or self-induction, because they were not of serious importance then. The whole problem of telephony has since acquired energy. In it we are dealing with alternations at the rate of thousands per second, where we were dealing with tens and hundreds per second before. Every electrical engineer knows how impedance is of importance with rapid alternations when it may be practically neglected with few alternations. Every electrical engineer is familiar with the way in which, by a proper balancing of capacity and self-induction, we can transmit electrical energy into a machine which would otherwise hardly respond at all to our alternating impulses. The complete problem of telephone wires is too complicated to attack upon simple principles such as these, but it is to be hoped that some of those who are concerned with the practical problem have sufficient mathematical ability to at least follow the investigations Mr. Heaviside has shown so much genius in inventing and has taken so much pains to work out in detail, so that any person at all conversant with the problem can understand what he states to be the conditions of success in telephony. Mr. Heaviside does not pretend that he has solved the problem in all its details as it may occur in actuality. He specially guards himself against such a supposition by qualifying his premises. He neglects radiation of energy into the surrounding medium and the curvature of the wave surfaces and of the wires; he calls particular attention to the increased resistance of wires to rapidly alternating currents, owing to their imperfect penetration; and although he states that this does not produce any very serious effect on telephony through copper wires, he has not gone into the question with the same degree of detail as he has as to the effects of leakage and self-induction. The effect of this in iron wires is so great that they have been discarded as telephone wires in America where long-distance telephony has been very largely tried. This is an example of one of the questions which was quite immaterial in the problem Lord Kelvin originally attacked, but which is of great importance in telephoning through iron wires, and must ultimately be appreciated by practical telegraphists, even though they for a time sneer at those whose bodily infirmities prevent them from helping the advance of mankind in any other way than by using their powerful intellects to solve the problems that at present require solution, in order that the practical man may improve his practice.

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ON THE EFFECT OF LEAKAGE ON WAVE PROPAGATION IN TELEGRAPH WIRES; OR, MR. OLIVER HEAVISIDE'S THEORY EXPLAINED BY ANALOGY.

BY GEO. FRAS. FITZGERALD, M.A., SC.D., F.R.S., F.T.C.D.

The first thing to understand is what sort of thing a series of electromagnetic waves is when going along a wire. They are sent as a series of alternating electric currents in the wire: just as a series of alternating compressions and rarefactions can be sent along a speaking tube. Of course, the analogy is not perfect. On the face of it we are dealing with something going on inside the tube, while we are obviously dealing with things going on outside the wire, there is magnetic force in circles round the current and electric force out from the wire wherever the electric pressure is higher than that of the earth, and in towards the wire where the pressure is lower than that of the earth. In the case of the wire, then, we are dealing with a case of lines of magnetic force in circles round the wire, and with radial lines of electric force diverging from the wire. Wherever the current is great the magnetic force will be great, and wherever the electric pressure is great then the electric forces will be great. The waves consist of alternations of current in opposite directions, which are propagated along the wires in much the same way as the vibrations of the molecules of air in a tube are transmitted along the tube. We may look upon the compressions and rarefactions of the air as analogous to the electric pressures positive and negative in the wire, and we may look upon the currents of air as it vibrates backwards and forwards, as analogous to the backwards and forwards electric currents. Of course, the analogy is somewhat rough, but on account of the want of familiarity of the ordinary student with electromagnetic waves, a rough analogy may help him to reason about these waves, or at least to follow the reasoning that is applicable to electromagnetic waves. Now in all cases of wave propagation there are certain very important conditions that must be fulfilled at each point in order that waves may be transmitted without reflection. In the case of sound waves, the ratio of the velocity of the particle to the velocity of the wave must be equal to the compression at each point. Everybody is familiar, in the case of light, with reflection of waves by a change in the nature of the medium and by obstacles placed in its way. A sound wave is similarly reflected by an obstacle. At the surface of the obstacle the motion of each particle is not all transmitted on to the next particles. We all know the way in which one ball hitting an equal one is brought to rest, and its motion transferred to the hit ball. If they are not equally massive, or if the hit ball is constrained by being gummed to the table, the motion is *not* all transferred, the hitting ball does not stand still after the impact, but is in a condition to send back motion to others behind it. Similarly when waves meet obstacles, their energy is not all transferred on to the parts of the medium in front, they retain some and send it back by the way it came. In the case of the balls hitting one another there must be an important relation between their mutual pressure and their velocities of motion in order that the energy of the hitting ball may be all transferred to the hit one; and in the case of waves being transmitted through air, there must be an important relation at each point of the wave between compression at that point and the velocity of the particles of air at the place, in order that all the energy at each point may be transferred forwards and none backwards. In the case of the electromagnetic waves we must have a corresponding relation between the electric pressures and the electric currents in order that a wave be transmitted all forwards and that there be no reflections. Now, in the case of the balls hitting one another, there are two ways in which the hitting ball may fail to give up all its energy to the hit one. This latter may be either too heavy or too light; it may be either too hard to move or too easily moved. In either case it will fail to absorb all the energy of the hitting ball. Similarly, in the case of an air-wave in a tube. A reflection may result either from an obstacle that prevents the

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air from moving, or from a hole in the tube that allows too great freedom of motion; in either case there will be reflection. These two causes do not make exactly the same kind of reflected wave, they produce what books on sound call reflection, without and with change of sign. In the case of an obstacle, a compression is reflected as a compression, while in the case of a hole, a compression produces a reflected rarefaction. In the case of electric waves, we can have reflected waves produced by obstacles which oppose the electric currents, or by leaks which relieve the electric pressures which exactly correspond to the two ways in which reflected waves are produced in tubes by interfering with one or other of the two things, velocity and compression, which must keep up a certain proportion to one another in order that waves be propagated all forwards without any going backwards. Now it is pretty evident that if there is an obstacle in a tube we might compensate for it by making a hole near it, and although the result would be that some of the energy of the wave would undoubtedly be wasted, still we would stop the effects of reflection. If there were a number of obstacles they will generally confuse a wave sent along a tube, because each will reflect forwards parts of the waves reflected to them by the others, and the result will be that a series of simple waves going along the tube will be quite unrecognisable when they reach the other end. Now, an ordinary speaking tube is affected by this, though not to any very serious degree. Every point of the tube offers some frictional resistance to the vibrations of the particles of air inside it, and as a consequence a single sudden impulse sent into the tube does not reach the other end as it went in, but is drawn out by what comes to the same thing as a whole series of multiple reflections that are taking place along the tube. Now, from our study of the nature of the reflection produced by the resistance of an obstacle, we saw that it might be neutralised by a corresponding leak or hole in the tube, so that we conclude that the distortion of the impulse we sent along the tube might be corrected by making the tube judiciously leaky, and that, as a result, a sudden impulse at one end would arrive at the other end as a sudden impluse, though, no doubt, it would be very much weaker than it went in. Now, what we want in the case of speech is that the waves that come out of the tube shall be the same shape as those that go in. Otherwise, our speech will be muddly and unintelligible, as it is in other cases of multiple reflections, and we might very often be quite willing to sacrifice loudness for the sake of distinctness.

Just the analogous things occur in telephoning through wires. The current of electricity is resisted by the want of perfect conductivity in the wire, and the effect of this is to draw out a sudden impulse by what is the same as multiple reflections from a great number of separate resistances, and as these resistances cause reflections by interfering in one way with the proper relation between the current and pressure, so we can compensate for them by relieving the pressure by a judicious amount of leakage. This is a nearly complete analogy between the waves in the tube and the electric waves in the space around the wires. There are, however, some further points that can be illustrated. In the first place we have dealt with the resistance at the surface of the tube, as if it were a resistance to the whole wave. This is only approximately true, and the approximation would be less and less accurate if we were dealing with very short waves in very large tubes. In the electromagnetic case we have made a similar simplification. Events are really occurring in the medium round the wire, and the effect of a resistance in the wire does not extend instantaneously all over the face of the wave, so that there are a set of phenomena due to this which have been neglected. We have, as it were, summed up all that is going on round the wire in a shorthand description when we spoke of it as electric currents and electric pressures in the wire. The electric current is a shorthand description of a complicated state of affairs partly inside and partly outside the wire, and the same is true of the term electric pressure in the wire. These shorthand descriptions are very helpful, especially in working out analogies, but we must take care to recollect that they are shorthand compendiums of a really complicated state of affairs, and that our analogies do not generally extend to the complications.

It may be worth while explaining how this investigation merges into the case that Lord Kelvin originally attacked, namely, that of comparatively slow alternations of current being driven into a cable. This case is like trying to blow air through a long tube. If we send a sudden puff of air it will be transmitted like a sound wave; but if we keep on a steady pressure, we will gradually get up a uniform blast, the pressure in the tube will be great at our end and small at the far end; and, if we suddenly stop, the blast at the far end will not suddenly stop, for the compressed air in the tube will escape at both ends for some time. This is just like what happens in a telegraph cable. We apply a high pressure suddenly, but it does not rise equally suddenly at the far end. We must wait until enough air has run in at the near end to produce the increased pressure of air inside that is required to drive as much along and out of the tube as we drive in, the pressure will rise until this equilibrium of flow is attained, and until then the flow at the far end will be less than that at the near end. In a case of this kind, it is evidently undesirable to have a large capacity in the tube, and, of course, a high resistance is very objectionable. In this case a considerable inertia in the fluid is of little importance, any effect it has is rather detrimental as preventing sudden changes in its velocity. It is quite different in the other case of our dealing with alternations that succeed one another so rapidly that the inertia of the fluid is of great importance. The inertia of the fluid is essential for wave propagation, and with a given velocity backwards and forwards the energy of the wave is proportional to the inertia of the medium. When there is resistance to be overcome, it is all important that we should have plenty of inertia. Everybody knows how hard it is to throw a cork to any distance, while a bullet of the same size, and projected with the same velocity, is hardly stopped by the resistance of the air. This is because the energy of the bullet is initially so much greater than that of the cork, that the same amount being taken from each very soon uses up that of the cork, while it leaves that of the bullet but little changed. Similarly, in the case of waves in tubes. If the resistance of the tube to the motion of hydrogen and of air were the same, which is not accurately true, a wave of given amplitude transmitted by hydrogen would be practically all wiped out long before a wave of the same amplitude in the tube full of air would be. The original energy of the air wave would be much greater than that of the wave in hydrogen, so that it would bear much more energy being taken out of it before it was practically deprived of all its energy. This is the basis of the proposal to increase the self-induction per mile of telephone wires. The self-induction of the wires corresponds to the inertia of the gas in the tube, and if it can be conveniently increased without unduly increasing resistance, and other causes of loss of energy, it may help very much in getting enough energy into the waves to enable them to travel far without serious loss. It may be interesting to point out that some of the "other causes of loss of energy" mentioned above may be illustrated by the air-tube analogy. One of them is induced currents in neighbouring bodies. This may be illustrated roughly by the movements produced in the containing tube. The loss by hysteresis in neighbouring soft iron may be illustrated by one of the ways in which one might try to increase the inertia of the medium in our tube. Suppose one were to try and do so by suspending a number of thin tinfoil plates in the tube which would be carried backwards and forwards by the currents of air particles, and add their inertia to that of the air. If they fitted well, their velocity would be equal to that of the air, and their inertia, of course, might be hundreds of times that of the air. If, however, they did not fit accurately, and if they rubbed against the sides of the tube with a proper law of friction, one could arrange that they tended to attain maximum velocity as the velocity of the air was increased. There would then be introduced effects which would fairly well represent both the want of constancy in the permeability of the iron and its hysteresis, one represented by the non-agreement between the velocity of the air and the plates, and the other by the frictional resistance to the motion of the plates.

In conclusion, it may be worth while calling attention to the general subject of dynamical analogies. They are really on

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the same footing as the representation of forces by geometry. In just the same way as we can find out the stresses in a structure by drawing lines, we can discover the way a complicated system will move by making a judiciously constructed analogous model. We are only making a practical application of the well-known principle of generalised co-ordinates.

ON THE MAGNETIC DEFLECTION OF CATHODE RAYS.*

BY P. LENARD.

§ 1. When cathode rays traverse a magnetic field, their otherwise rectilinear path becomes in general curved, they are deflected by the magnet. The deflection is not always of the same magnitude in a field of given strength. In the discharge tube, as usually made, the deflection increases with increasing pressure of gas. In this respect the behaviour of cathode rays agrees with that of a current of small negatively charged particles projected from the cathode. The paths of such particles would in fact be curved in a magnetic field, and the more curved the lower the speed; therefore, like the cathode rays, more curved in the denser and more resisting gas than in the more rarefied. This agreement between cathode rays and radiant matter, which is also to be found in other phenomena of the rays, and which, since Crookes' researches, has been regarded by many physicists as holding generally, can in reality be only superficial if the conclusion arrived at in my earlier Paper,† namely, that cathode rays are phenomena in the ether, be correct. That the resemblance is merely superficial in reality, seems to me to be proved by the following experiments, in which the agreement completely fails in this respect, that conditions which must have the greatest influence on the speed of radiant matter appear quite without effect on the amount of deflection

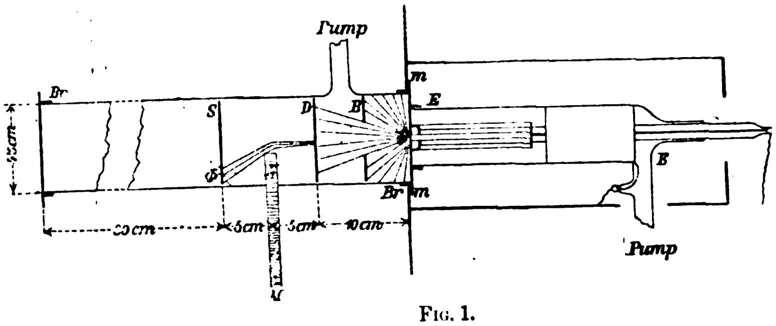

FIG. 1.

of cathode rays in a magnetic field. The experiments show that the amount of magnetic deflection is not in the least affected by the medium in which the rays are observed; that, on the contrary, the capacity for deflection of one and the same kind of cathode ray remains always materially the same in all gases at all pressures with every intensity of ray, and even when the rays have to traverse a metal partition placed in their path; and, on the other hand, that in gases at different pressures different kinds of cathode rays are produced, possessing different capacities for deflection.

§ 2. We produce the cathode rays for our experiments in the discharge-tube already described, E E, Fig. 1, from which they come through the air-tight aluminium window into the observing space. This space is surrounded by the glass-tube Br, which closes tightly on to the window partition *m m*, and it is in connection with a mercury air pump.‡ The observing space can, therefore, be filled with any desired gas at any required pressure. A second mercury pump produces the vacuum in the discharge-tube. In the observing space a movable diaphragm, D, having a hole 1·9mm. in diameter, cuts off a small pencil of rays, which shows itself as a spot of light on the similarly movable phosphorescent screen S. The position of this spot is read on a scale made on the screen itself. If now a small but powerful horseshoe magnet, N M, be brought to a certain position on the tube, and the position of the spot again read off, then the magnetic deflection of the rays is measured by the difference of the two readings. The magnet was always brought to the tube in such a manner that its poles on either side of the tube were as shown in Fig. 1, and the north pole of the magnet was always assumed to be uppermost, and the south pole below the tube. The rays are then directed towards the magnet to the position Φ; the oppositely-directed deflection produced by reversing the poles, was nearly of the same value. The magnet can be easily and surely replaced in this position, for the poles are nearer together than the diameter of the tube; the two poles touch the tube, therefore, and in definite points. A small displacement or rotation of the magnet in any direction from this point does not alter appreciably the amount of the deflection. Large displacements have, of course, appreciable effects. If we displace the magnet by sliding it along the tube from the position shown in Fig. 1 up to the window partition *m m*, the amount of the deflection increases at first slowly, until the magnet has passed the diaphragm D, then decreases again, becoming very small when the magnet arrives at the window partition. This behaviour is explicable on the supposition that the strong field of the magnet is confined to a small space, so that the rays, which come in all directions from the window, are only bent through a given angle just as they come past the magnet and move otherwise almost in straight lines.

The distances of magnet, diaphragm, and screen from one another and from the window assumed in the following as generally used are those shown in the figure; if a displacement is spoken of, both diaphragm, magnet, and screen are moved through equal distances, so that these three movable parts always retain their relative positions. Between window and diaphragm was placed in most cases the blind B, with an opening 17mm. wide. This blind has no influence on the phosphorescent spot or on the deflection, but it prevents the weak diffused illumination of the screen which would otherwise occur because the diaphragm does not fit tightly to the glass tube.

§ 3. Now, suppose all conditions of the phenomenon kept constant, and especially let the pressure of gas in the discharge tube be so regulated, that the spark length which measures the pressure remains always at 2·8cm. Now, while we watch the amount of deflection of the phosphorescent spot in observing space, let the air therein be lowered in pressure from 33mm. to 0·021mm. This considerable alteration of pressure, which is almost a hundred times as great as the difference of pressure within which it has been possible to observe hitherto, the deflection of cathode rays does not cause the smallest definitely observable alteration in the position of the deflected spot. The reduction of pressure was effected in 13 steps, and the amount of deflection observed every time. It varied irregularly, from discharge to discharge, between 9·5mm. and 10·5mm. backwards and forwards; similar variations from discharge to discharge were also observed if the pressure of gas in the observing space remained constant. Higher pressures than 33mm. could naturally not be used, as under those circumstances the phosphorescent spot in the turbid medium was so ill-defined and so large, that its position could not be definitely determined.

§ 4. But if, on the other hand, we keep the pressure of gas in the observing space constant, and alter the pressure in the discharge tube, this has at once a very distinct influence on the position of the deflected spot. The smallest alteration of pressure makes itself evident; even a rise or fall of a few centimetres in the level of the mercury in the pump vessel is sufficient to displace the deflected spot. The same small alteration of the pressure in the discharge tube makes itself observed in the sparking distance, which is a measure of this pressure. Corresponding to an alteration of this sparking distance from 2cm to 4cm. there is an alteration in the amount of the deflection of from 12·2mm. to 8·5mm. Increase of the pressure of gas in the discharge tube has, therefore, as a consequence, an increased deflection, and the alteration is in the same sense as that observed in the ordinary discharge tube. We have, then, learnt that the difference of deflection observed with varying gas pressures in the ordinary discharge tube is not caused by difference of the medium in which the deflection is observed, but in the difference of the rays themselves which are produced with varying pressures of gas.

§ 5. In order to further demonstrate the independence of the deflections from the medium in the observing space, we again keep the conditions of production of the rays constant, as before (§ 3), but replace the atmospheric air in the observing space on this occasion by hydrogen gas. At a pressure of 422mm. this gas becomes just clear enough for the experiment. The deflection is again equal to 10mm. (±0·5mm.), as in air. It remains also unaltered, if the pressure of hydrogen be lowered step by step down to 0·012mm. Twenty different intermediate pressures were investigated. Also in oxygen and in carbon dioxide the deflection was constant and equal to 10mm. with all the pressures used (3·3mm. to 0·034mm. for oxygen and 10mm. to 3mm. in carbon dioxide).

§ 6. The rays retain the same capacity for deflection all along their length. We test this by moving the diaphragm, magnet, and screen together further and further from the window, all the other conditions remaining the same, and measuring the amount of deflection at each step. This experiment was carried out in hydrogen gas at 37·5mm. pressure at distances of 5 and 10cm. between diaphragm and window; at 12mm. pressure at 5, 10, 15, 30cm. distance; lastly, at 1·5mm. pressure and distances of 5, 15, and 30cm. The deflection remained equal to 10mm. throughout,

* *Wied. Ann.*, Vol. LII, No. 5, p. 23.
† See *The Electrician*, Vol. XXXII., March 23rd, *et seq.*
‡ The arrangement is one of these described before, only the observing tube is shortened to 50cm.

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§ 7. The above experiments showed that the amount of the deflection was also independent of the intensity of the rays. For this intensity was very varied in the different media traversed by the rays and at different distances from the window, judging not only from the previously determined transparency of the media, but also directly by the brilliance of the phosphorescent spot.

In order to especially test this independence, an aluminium screen was inserted in the observing space close against the window. This screen could be either placed in the path of the rays or removed from the same at will. In the former case, the rays coming from the window had to traverse another aluminium sheet 00·05mm. thick (twice the thickness of the window, 15 times that of aluminium foil), and this weakened their intensity to a marked degree; in the second case they remained unweakened

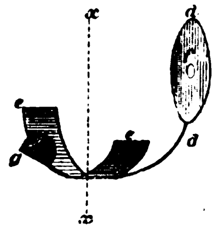

FIG 1A.

as formerly. The position of the deflected spot on the scale of the phosphorescent screen was now observed alternately with and without the intermediate aluminium screen without any displacement being observable. The experiment was conducted in air at 0·024mm. pressure, in hydrogen at 20mm. pressure, and in oxygen at 0·03mm. pressure. The arrangement of the aluminium screen used is shown (perspectively) in Fig. 1A, *e e* is a strip of sheet iron, *d* a wire soldered across it, both being bent according to the radius of curvature of the observing tube. The wire carries on one side the opaque sheet iron *d d*, with an opening *f* 1·7mm. in diameter, the same size as the window, and on the other side the balance weight *g*. The opening *f* is, on the back, covered with the sheet aluminium of the thickness described, and is at such a height that it lies exactly on the window when the screen is drawn against it

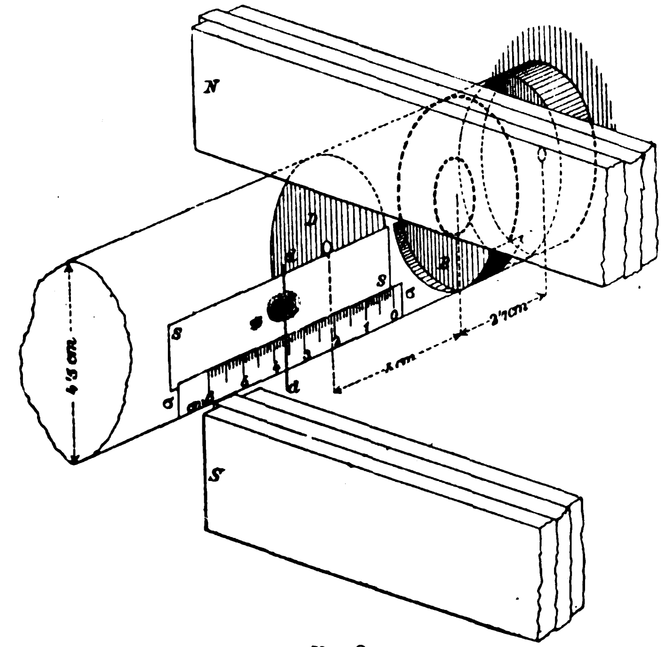

FIG. 2.

by the aid of a magnet. This is the position in which the screen finds itself in the path of the rays; if the path of the rays is again to be free, the screen is turned through 90deg. about the vertical axis *x x*. When this screen was in use the blind B (Fig. 1) was removed.

Thus the attempt to alter the deflection of the rays, that is, the amount of their curvature for a given magnetic field, by any alterations whatever in the observing space, was completely unsuccessful.

§ 8. The constancy of the deflections was still more rigorously tested than before in the following manner. The small magnet was replaced by a very powerful and large one, which was set up near the observing tube and took it between its poles (Fig. 2). The rays were now much more strongly curved than before; the spot would no longer fall on the screen used before, but on the glass wall. The screen, *s s*, used in this case, a strip of paper soaked in pentadecylparatolylketone, lies therefore on the inner wall of the tube, and there picks up the spot Φ. Parallel with the screen, but somewhat below it, is fixed the millimetre scale σ outside the tube, having its zero in the plane of the diaphragm. A vertical wire, *d d*, can be pushed along the scale forming a means of reading off the position of the phosphorescent spot on the scale. To avoid parallax, the eye is directed while getting the wire on the spot to a somewhat distant fixed point. This placing of the wire on the spot is done in the dark; only when it is completed is the scale illuminated in order to read the position of the wire on it. This method of working has the advantage over that used before, that it cannot be influenced in any way by prejudice.

In order to secure as far as possible constant conditions of production, the following plan was adopted:—Before each reading the pressure of gas was made somewhat too high in the discharge tube to allow the spark between the discharge knobs, placed 2 8cm. apart, to take place. If now the level of the mercury in the pump was lowered, the pressure in the discharge tube was gradually reduced, and the phosphorescent spot consequently moved (§ 4) to positions of less deflection (to greater numbers on the scale), generally moving about 8mm. During this movement the movable wire, *d d*, was gradually pushed after the spot, following it steadily, until such time as the sparks became audible, showing that the pressure in the tube had reached the predetermined desired value. The position of the wire thus obtained was read off as the required position of the phosphorescent spot on the scale. In this manner the following table was obtained in which every position is the mean of three separate readings.

Gas.	Pressure. mm.	Position of spot. mm.	Deviation from mean mm.
Air	31·0	33·9	+0·2
	15·4	33·5	-0·2
	6·4	33·3	-0·4
	3·5	33·7	0·0
	1·1	33·5	-0·2
	0·16	33·8	+0·1
	0·10	33·7	0·0
	0·022	33·6	-0·1
Hydrogen	332·0	33·1	-0·6
	220·0	33·4	-0·3
	149·0	34·1	+0·4
	108·0	33·9	+0·2
	50·5	33·6	-0·1
	23·8	34·1	+0·4
	4·3	33·8	+0·1
	0·48	33·6	-0·1
	0·020	33·8	+0·1

Mean of all positions, 33·67.

The constancy of the deflections for such varied pressures in two so different gases is thereby shown with the greatest certainty attainable by such measurements. The variations of the individual observations from the mean (last column) only in one case surpass ½mm., and this only with a high pressure, when the tenths of millimetres, only estimated in any case, become uncertain owing to the diffused nature of the spot. A relation between the alterations of gas or pressure, and those of the deflection, is not to be traced.

§ 9. Earlier researches showed that cathode rays which are produced at smaller degrees of vacuum, have more diffused paths than those which are produced at smaller pressures. Now, there appears (§ 4) yet another difference in these two kinds of rays; the former rays are more deflected by a magnet than the latter.

Just as the kind of rays here under investigation, namely, those produced at given pressure by a given apparatus, keep the amount of their capacity for deflection as an unalterable and characteristic distinctive quality, so would very probably also every other kind of ray produced by other apparatus at other pressures keep its particular capacity for deflection under all circumstances. If this be assumed, then a particular kind of cathode ray would be better characterised by its "deflectibility" than by a description of the circumstances of its production. We will also combine the two above results in this manner: the more "deflectible" cathode rays have more diffusion in gases than the less deflectible.

§ 10. It only remains to call attention to the peculiar deformations which were observed in the deflected phosphorescent spot.

The spots of undeflected rays were, as described before, always circular, and the distribution of light in them was dependent on the amount of turbidity of the gas in the observing space; in very turbid (dense) gases the edge of the spot is undefined; if the gas becomes clearer (rarer), there appears in the centre of the spot a more or less sharply-defined kernel, surrounded by a less bright penumbra; and whether gas is almost entirely removed from the observing space, the core alone remains, the penumbra has vanished.

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Even after deflection the spots retained in general this appearance, depending on the amount of turbidity of the medium, but the following details are to be noted:—Firstly, the deflected spots are always elliptical, with the major axis of the ellipse in the direction of the deflection. This is, perhaps, to be at once explained by the fact that the pencil of rays no longer encounters the screen at right angles to its plane. In very turbid gases no deformation but this elliptical one was to be seen. For the measurement of the amount of the deflection the centre of the ellipse was always used. But if the gas became more transparent, so that the spot had core and penumbra, the appearance of the spot was subjected to intermittent sudden changes from discharge to discharge. Fig. 3 (No. 1—5) show certain typical forms occurring in this case. The left-hand picture gives in every case the (unalterable) shape of the undeflected spot, the one on the right one of the (changing) shapes of the deflected spot; the deflection is thus imagined as directed from left to right. The part remaining constant during these changes was the position and shape of the deflected core; the centre of the core was, therefore, utilised for the measurement of the amount of deflection. The position and shape of the penumbra are alone subject to change. Often enough the penumbra remained after deflection concentric with the core (No. 1); not infrequently, however, it was displaced excentrically (Nos. 2, 3, 5), often so far that it appeared completely separated from the core (No. 4). The displacement of the penumbra was always in the direction of further deflection; in no

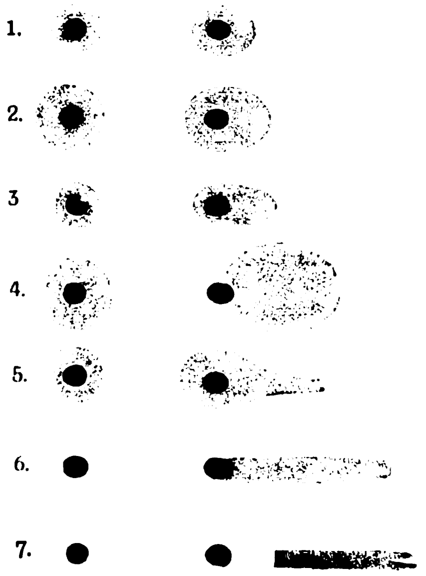

FIG. 3.

case was the penumbra less deflected than the core. Plainly, then, the penumbra often contains rays of greater deflectibility than the core, but never rays of less deflectibility. This is just what is to be expected if, besides the great mass of rays, composing the core, whose capacity for deflection does not alter from discharge to discharge, there are produced a certain number of other rays, varying from discharge to discharge, of variable, but never less deflectibility. These latter rays must then be found in the penumbra, for more deflectible rays have more diffused paths in gases than less deflectible ones.

If the gas pressure in the observing space be very small, such separation of the rays of different deflectibility by diffusion can no longer be produced. This separation is then produced by the magnet only. In this manner phenomena such as those shown in Fig. 3, Nos. 6 and 7, are produced, and which might be called the magnetic spectra of the cathode rays. As in the optical spectrum of rays of light of different refrangibility, the cathode rays of different deflectibility are here found separated in space from one another.

§ 11. The deflection of the cathode rays is, according to Hertz's experiments, not an action of the magnet on the rays themselves, but an action of the magnet on the medium traversed by the rays; the rays spread themselves differently in a magnetised and in an unmagnetised medium. For if forces worked between the magnet and the rays themselves, then the magnet itself, if made movable, would be deflected by the rays, which is not the case.* But the medium, whose magnetic alteration is shown by the curvature of the rays, is according to our experiments, the ether itself. For the curvature was found to be completely independent of the nature and density of any ponderable medium which chanced to be present, and was especially to be seen in the highest obtainable vacuum.

* Hertz, *Wied. Ann.*, 19, pp. 799 and 805; 1883.

Cathode rays give, therefore, by their curvature, distinct evidences that the condition of the ether between magnet poles is really altered, as is demanded by the theory of the action at a distance produced by them. The magnetic rotation of the plane of polarisation of light does not give any such evidence; for it only occurs through the mediation of matter, it differs from medium to medium, and does not occur in airless space.

A METHOD FOR THE TREATMENT OF ROTATING OR ALTERNATING VECTORS, WITH AN APPLICATION TO ALTERNATE CURRENT MOTORS.

BY PROF. GALILEO FERRARIS.

The study of certain modern electro-technical apparatus, and notably that of any kind of electric motors, leads to the consideration of alternating vectorial magnitudes. For the treatment of such magnitudes it may help to have recourse to some mode of graphic representation, which may give in itself, not only the amplitude and the phase, but also the direction.

I here present a simple and obvious method which may assist in the interpretation and in the elementary explanation of many phenomena. In order to show, therefore, the usage and utility of the new method, I apply it to magnetic fields, and explain by means of it an elementary theory of the principles of electric motors with alternating currents.

PART I.—ROTATING VECTORS AND ALTERNATING VECTORS.

1. *Definition.*—I shall designate by *rotating vector* a vectorial magnitude of which the scalar value is constant, whilst the direction rotates about an axis with uniform velocity. We shall here limit ourselves to consider rotating vectors in a given plane. In this case, to define a rotating vector, the following elements are necessary to us:—The *magnitude*, the *sense*, the *frequency*, or number of turns made in a unit of time, and the *phase*, or fraction of a turn reckoned from the origin of time. Given the frequency, we can represent the rotating vector by means of a segment of a straight line, od or os (Fig. 1), making simply this assumption,

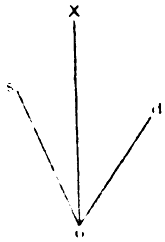

FIG. 1.

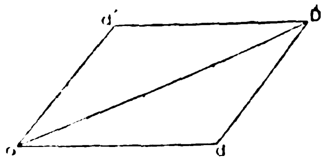

FIG. 2.

that the length of the segment represents the magnitude of the vector, that the direction of the same may be that which the vector has at the origin of time, and that the letters d or s indicate the sense *right* or *left* of the rotation. If oX is the straight line from which it is wished to measure the angles described by the vector, the angle Xod or Xos is that passed through by the vector from the origin of time, and is called the angular value of the phase. The ratio $\frac{Xod}{2\pi}$, or $\frac{Xos}{2\pi}$, is the phase. To name the vectors thus represented we shall make use simply of the letters d and s.

2. *Composition of Two Vectors of equal frequency rotating in the same Plane. First Case.*—Vectors rotating in the same sense.—Take two vectors rotating in the same sense and with the same frequency, and let them be, for example, d and d' (Fig. 2). At any moment their vectorial sum or their resultant is the vector represented by the diagonal o D of the parallelogram made upon them, or that which is equivalent to it, by the straight line o D, which closes the triangle od D or the triangle od' D. Now, if d and d' rotate in the same sense and with the same angular velocity, the angle dod' remains constant. The diagonal o D therefore also remains constant. It meanwhile rotates about o with the same angular velocity as the components. Thence the resultant of two vectors of equal frequency rotating in the same plane and in the same sense is also a vector rotating in the same sense and with the same frequency. If the angle dod' is equal to two right angles, if also the phases of d and of d' differ by 180deg., we say that d and d' have opposite phases. If the two component vectors have equal magnitudes and opposite phases, their resultant is zero.

It is unnecessary to say how from the case of two vectors only you pass to the case of any number of vectors rotating in the same plane and in the same sense; and as it was shown that the re-

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sultant vector is also a vector rotating in the same plane and in the same sense, and is represented by the straight line which closes the polygon made by the component vectors.

Second Case.—Rotating vectors in opposite senses.—If the two component vectors (Fig. 3) *o d*, *o s*, rotate in opposite senses, the angle *s o d* varies; then the diagonal *o* A inevitably varies in magnitude. It also may vary, and in general does vary in direction.

But we have to consider two cases: (*a*) The case in which the magnitudes *o d* and *o s* of the two component vectors are equal to each other; (*b*) that in which those magnitudes are unequal.

3 (*a*). *Case in which the Two Component Vectors have Equal Magnitudes.*—In this case the resultant has a fixed direction. In fact the diagonal *o* A is then at any moment the bisectrix of the angle *s o d*, and thus *o d* and *o s* rotate with the same angular velocity, one towards the right and the other towards the left. Thus it remains fixed in space. Instead, the *value* of the resultant varies, being bound to the variable angle A *o d* in the relation

$$o\,\text{A} = 2\,o\,d \cos \widehat{\text{A}\,o\,d}.$$

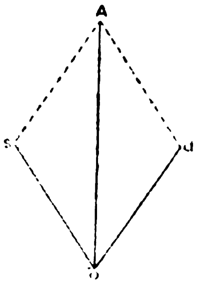

Fig. 3.

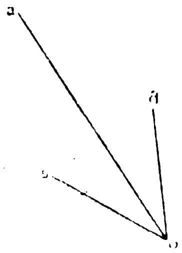

Fig. 4.

Supposing *o* A $= a$ and $2\,o\,d = \text{A}$, representing by *n* the frequency by *t* the time, and by *α* the value of the angle A *o d* when $t = o$, this relation can be written thus:

$$a = \text{A} \cos (2\,\pi\,n\,t + \alpha).$$

A magnitude varying according to this law is that which one commonly calls an *alternate*, or *alternating harmonic*, or *sinusoidal* magnitude. The constant A is the *amplitude*, *n* the *frequency*, the angle *α* the *angular value of the phase*, when you take as the origin of time the instant in which *a* is at the maximum. We, therefore, call *o* A an alternating vector, and conclude:—Two equal vectors rotating in the same plane with the same frequency, and in opposite senses give for resultant a vector of fixed direction, alternating with the same frequency. The direction of this alternating vector is that of the bisectrix of the angle which at any moment is contained between the two component vectors, is, therefore, also that of the bisectrix of the angle which the two component vectors contain in the instant in which $t = 0$, or that of the two segments of straight lines by which are represented, according to our assumption, the two component vectors.

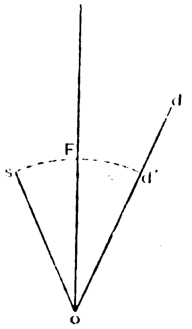

Fig. 5.

The amplitude of the resulting alternating vector is equal to twice the magnitude of one of the component vectors. *Vice versâ*, a sinusoidal alternating vector may always be decomposed into two rotating vectors of equal value and of opposite direction. Any sinusoidal alternating vector may be considered as resulting from two rotating vectors in the same manner. Now this mode of considering an alternating vector leads to very simple graphic representations, in order to indicate by an alternating vector the fixed direction, the amplitude, and the phase. The artifice consists in representing by a segment of a straight line the direction and the amplitude of the alternating vector, and ,with other segments of straight lines the rotating vectors of which this is compounded. Drawing all these three segments we have the figure indicated in Fig. 4. In this figure the segment *o a* indicates the direction and gives the amplitude of the alternating vector, whilst the segments *o d* and *o s* represent the rotating vectors, right and left into which *o a* may be decomposed. The angle *a o d*, or its equal *a o s*, represents the angular value of the phase. But as $o\,a = 2\,o\,s = 2\,o\,d$, and is only the bisectrix of the angle *s o d*, any one of these segments *o a*, *o s*, *o d* may be found when the other two are given. Whence we have a complete representation by merely drawing these two. By this method we can represent the alternating vector simply by *o a d*, or by *o a s*, or by *o s d*.

4 (*b*). *Case in which the Two Component Vectors have Different Magnitudes.*—If the component rotating vectors *o d* and *o s* (Fig. 5) are

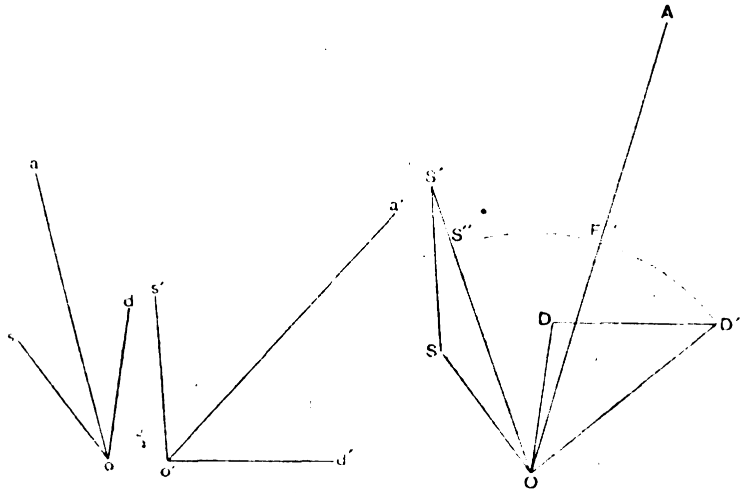

Fig. 6.

not equal, not only is the amplitude variable, but also the direction of the resultant vector. With the centre *o*, and with a radius equal to the smaller of the component vectors, equal to *o s* in the case of this figure, describe the arc of the circle *s* F *d'*. We may consider *o d* as the resultant of the two vectors *o d'* and *d'd* rotating in the same sense. Now, the two rotating vectors *o d'* and *o s* givefor resultantan alternating vector *o a* of fixed directionbisectrix of the angle *s o d*, and of amplitude $o\,a = 2\;o\,d' = 2\;o\,s$. Thence the

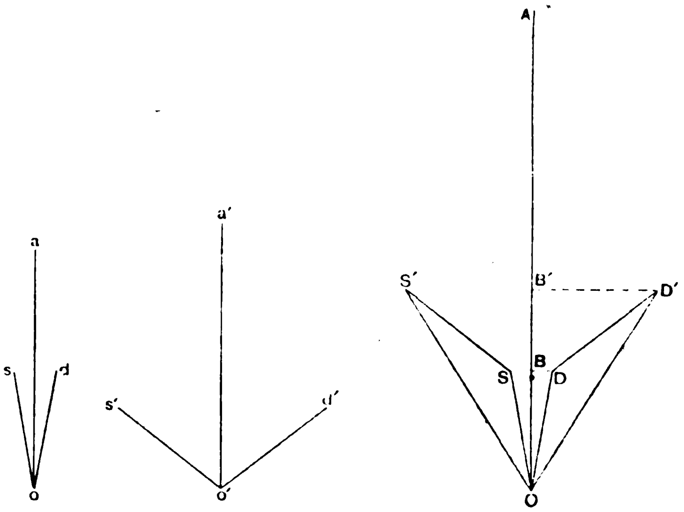

Fig. 7.

two rotating vectors *o d* and *o s* of opposite phases, and of different values, are equivalent to an alternating vector *o a* of fixed direction and to a rotating vector *d' d*.

5. *Composition of Two or More Alternating Vectors of Fixed Direction.*—Making use of the preceding considerations, we may reduce the composition of alternating vectors to that of rotating vectors. If, for example, we have two alternating vectors of fixed direction *o a s d* and *o' a' s' d'* (Fig. 6) we can compound *d* with *d'* and *s* with *s'*, and then compose together, in the manner before indicated, the two resultants. To compound *d* with *d'* we draw from a point O a segment O D, equal and parallel to *d*, and from D a segment D D' equal and parallel to *d'*; we thus find the resultant O D'. To compound in the same way *s* with *s'* we draw O S and S S' respectively equal and parallel to *s* and *s'*, and draw O S'. After that we can say whether the system of the two given alternating vectors *a* and *a'* is equivalent to the system of the two rotating vectors O D' and O S'. Now, having two rotating vectors O D' and O S', we can apply the preceding construction. If O D' is the lesser of the two, we take O S'' = O D', and on the bisectrix O F of the angle S' O D' we take O A = 2 O D' = 2 O S''. The two rotating

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vectors O D′ and O S′, and whence also the two given alternating vectors a and a' are equivalent to the alternating vector O A and to the rotating vector S″ S′.

The proposition can be extended without doubt to the case of any number of alternating vectors; whatever system of alternating vectors of equal frequency situated in the same plane, can be reduced to a simple system of an alternating fixed vector combined with a rotating vector. The manner of doing this is again that indicated in Fig. 6 with this sole difference, that in place of the triangles O D D′, O S S′ we have to make the polygons of all the components d and of all the components s of the given vectors. It is of importance to apply the proposition to particular cases.

6. *Particular Cases: (a) Alternating Vectors having the same Direction.*—Ia' is parallel to a (Fig. 7) the angles O S S′, O D D′ are equal to one another, whence the triangles O S S′, O D D′ are equal, and in consequence O S′ = O D′. Besides the bisectrix O A of the angle, S′ O D′, is also bisectrix of the angles S O D and S′ S, D D′, and is also parallel to $o\,a$ and $o'\,a'$. Thence the resultant O A, of the two alternating parallel vectors a and a', is also an alternating fixed vector, and is parallel to the components. In order to find this resultant it is not necessary to make use of all the construction indicated in Fig. 7. It is evidently sufficient to make a moiety of it; for example, the part O D D′.

According to the interpretation before given to the figure, the segments O D and D D′ represent the half of the component alternating vectors, and the segment O D′ represents the half of the magnitude of the resulting alternating vector. If we let fall the perpendiculars D B, D′ B on O A the *projections* O B, B B′ and O B′ represent similarly the half of the instantaneous value which the two component vectors and the resultant have at time $t=O$; and if it is supposed that the figure O D D′ revolves about O with frequency, n, the projections of O D, D D′, O D′ on the fixed line O A represent at any moment the half of the instantaneous value of the same vectors. But we can now represent with O D and with D D′ not the half but the entire amplitude of the component vectors, and with that we have at once in O D′ the representation of the magnitude of the resultant, and in the projections on O A the representations of the instantaneous values of the magnitudes of the three vectors under consideration. Thus we found the known and only construction, of which we make use, in the study of alternating magnitudes. This is a particular case of the more general construction indicated by us.

The facts considered extend, without doubt, to the case of any number of parallel alternating vectors.

(To be continued.)

ELECTRIC TRANSMISSION OF POWER FROM THE PERIYAR RIVER, SOUTHERN INDIA.*

A Committee, consisting of Colonel J. Pennycuick, R.E., Secretary to the Government of Madras P.W.D., Professor Unwin, Professor George Forbes, and Professor W. C. Roberts-Austen, having been appointed to consider the whole question of the use of the water power available on the Periyar Irrigation Works, have now issued the report of three of their number, and separate reports as notes by each member of the Committee. On the eve of his departure, last July, for America, Professor Unwin withdrew from the deliberations of the Committee, but his note is a very important one. Irrigation works are now in progress upon the Periyar River in the Madras Presidency, and when completed there will be a large amount of water-power available. The subject may be divided into two branches—firstly, the development of the power at the site by suitable hydraulic works; and secondly, its utilisation upon the spot or transmission to distant places. A note supplementary to Prof. Unwin's was added by Col. Pennycuick upon the hydraulic plant. It appears from the report that the development of power at the site would not cost more than £4 per horse-power for the hydraulic apparatus alone, and that the electrical apparatus for its transmission to Madras would not cost more than £35 per horse-power delivered at that city, while for the towns of Madura and Trichinopoly the cost would not exceed £23 and £17 respectively, the most important item being that of the conductors, which depends directly upon distance. After making due allowance for interest on first cost and depreciation of plant, it appears that power can be delivered in the three towns named at an annual cost per horse-power of £3, £2, and £1. 10s. respectively. Comparing these figures with the cost of steam power, there would seem to be every probability that a large portion of the available power can be profitably used in the towns in question as well as in the smaller towns on the road thereto. The most obvious and probably the most profitable use of power would be for electric lighting in the towns. It appears that none of these towns are supplied with gas, and that in Madras the cost of lighting by oil lamps forms a considerable portion of the municipal expenditure. The Committee concur in the view of the chief engineer to the Government of Madras, that the water should be brought to the hydraulic motors by means of pipes, a separate pipe being used for each motor, or, at most, two motors being fed from one pipe, and that, with a view of reducing lost, the fall should be divided into two or three stages. The great cost of a channel in the rock to carry all the water appears prohibitive.

The note by Col. Pennycuick, R.E., on the hydraulic apparatus required, states that the side slopes of the valley are such that there would be no difficulty in laying the pipes with a slope of 2¼ or 3 horizontal to 1 vertical, and the length of the pipes may be taken at three times the head. The total fall is a little over 1,000ft.; a single pipe for the full head would therefore need to be very thick at the base to withstand the pressure, and he therefore advises that the fall should be divided into two parts. Each stage would thus have 500ft. head, and each pipe would be 1,500ft. long. He recommends that the velocity of discharge shall not exceed 10ft. per second, and with a pipe 3ft. diameter, the effective head for each pipe would be 485ft., and it would develop 2,829 H.P. In Prof. Forbes' report on the electrical transmission of power the unit is taken at 5,000 H.P., and to generate this power on a fall of 500ft., about 120 cubic ft. of water per second would be required, and this would be carried by a pipe 4ft. in diameter with a velocity of between 9ft. and 10ft. per second. The pipe would have a mean thickness of ⅝in., and would weigh 392lb. to the foot. The total weight would be 262·5 tons, and the cost at £20 per ton £5,250, to which must be added £2,500 for cost of carriage to the site and £600 for laying, making the total cost £8,350. A turbine to generate 5,000 H.P. would cost about £6,000, and £750 might be added as a share of general expenses. The total cost of the plant would be £15,000, or £3 per horse-power. For a pipe 2ft. diameter, which would develop 1,230 H.P. the cost works out to £2,500, and inclusive of turbine about £3·67 per horse-power. Whatever units are employed the capital cost per horse-power would not exceed £4, and the annual charge 10s. per horse-power. The author had previously suggested Pelton wheels, but the Committee pointed out their impracticability for this special purpose.

A preliminary memorandum by Prof. Unwin is added in which he says that from the data supplied to him he finds there is a supply of 600 cubic feet of water per second all the year round, and a fall of 1,200ft.; this would yield 60,000 effective horse-power. He advises that that the fall should be divided into two parts, and as steel pipes of 4ft. and 5ft. diameter have been used in America, he considers that a steel pipe 4ft. diameter, double riveted for the lower part, and transverse joints riveted up from end to end, would be suitable. Such a pipe would carry 3,600 H.P. on 600ft. falls, and would weigh about 280 tons. The pipe might supply two turbines of 1,800 H.P. each. He puts down the capital cost for canals, pipes, turbines, and necessary buildings at from £5 to £10 per horse-power utilised. That power can be obtained cheaply is evident, if any application can be found for it. The hydraulic part of the problem is the least doubtful and the least difficult, and the cost of the power would be but a small fraction of the cost of electric machinery and transmission for applying it.

The next report is by Professor George Forbes, F.R.S., and deals with the electrical part of the problem. The author points out that he has no data as to cost of carriage, nor as to the cost of erecting a pole line to carry the conductors. He is, therefore, unable to give the cost of the work approximately. He proposes to develop the total horse-power of the fall by means of turbines, each of which would be capable of developing 5,000 H.P., and points out that if smaller units were used the cost would be greater. The dynamos would be fixed above the turbines upon vertical shafts. The points to which it is proposed to transmit the electricity are from 80 to 350 miles distant from the water power, and it is possible that a cheap power supply might attract factories to sites about 100 miles distant from the irrigation works. Besides the obvious field for supplying electricity for lighting purposes, the author suggests its use also for electric traction, and points out that the question is well worth consideration, whether the railways in the Presidency south of the town of Madras might not advantageously be worked by means of electric locomotives. He thinks that in India, where the atmospheric conditions are so favourable, it would be safe to contemplate the use of 30,000 to 40,000 volts. Passing to the current, he alludes to the fact that hitherto it has been impossible to construct a continuous-current dynamo of high electric pressure successfully, this arising from the fact of a commutator being necessary. An alternating-current dynamo can also be obtained about 40 per cent. cheaper than a direct-current machine for the same capacity when dealing with large amounts of power.

Dealing next with the question of phase, he points out that the single-phase is admirably adapted for all lighting purposes, and

* Abstract from the *Engineer*.

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that synchronising motors work with a very high efficiency, but they require to be started mechanically. Two-phase and three-phase motors start perfectly well on full load, and they have no commutators. The disadvantage of the multi-phase motors is that they require more than two wires, which is a defect. When alternating currents are used for transmission it is probable that the best way of using the power for traction purposes is to convert the alternating into a continuous current at the place where it is used by means of an alternating-current motor driving a continuous-current generator. The author states that certain advantages have been claimed for the three phases, that the cost of copper in the conductors is less than with two phases, and that the turning power given to a motor is more uniform with three phases than with two. But these claims are untenable. He puts aside the three-phase system as unsuitable, and gives reasons for preferring the two-phase system. With regard to frequency for motive-power purposes, he prefers about 10 periods per second, but if the current is to be used for electric lighting, such a low frequency is not available.

In the present case it is probable that a large amount of current would be used for the lighting of Madras, and therefore he would prefer, on the whole, to use a frequency of 50 periods per second, although the efficiency of the motors would not be so high as a frequency of 10 periods, and might only amount to 85 per cent. He dismisses the question of using step-up and step-down transformers as adding largely to the cost, and finally proposes to use a type of machine with the following characteristics :—5,000 H.P. vertical shaft generating 30,000 or 40,000 volts direct ; frequency, 50 per second, two phases ; the cost of such a dynamo may be taken at not over £6,000. The cost of transformers of 1,000 H.P. or over may be taken as certainly not over £1 per horse-power, and that they would probably not cost above half this amount. The principal cost would be for the line, which is next alluded to. The author proposes to use one overhead line for each 5,000-H.P. unit. The poles would be of A shape, and provided with special insulators, of which details would be furnished later on by the author. By this method it would be possible to use 40,000 volts, and transmit power 350 miles to Madras. With regard to density of current, this must be selected so that by either a slight increase or decrease in this density the additional gains and losses owing to difference in power wasted, and in interest on capital sunk, shall be equal. The author then gives a table showing for different densities of current the cost of copper in the line. With a density of 100 amperes per square inch the cost of copper per horse-power generated would be £70, and per horse-power delivered £76. At this rate 92 per cent. of the power produced would be delivered to Madras. With a density of 500 amperes per square inch the figures would be £14, £23, and 68 per cent. respectively ; and with a density of 1,000 amperes per square inch would be £7, £35, and 20 per cent. The cost of poles and insulators for each unit of 5000 H.P. may be taken at £90 per mile, being £1 per pole, and 2s. 6d. per insulator and attachments, and sixty poles to the mile. Assuming a density of 400 amperes per square inch, the total cost of the principal parts of the electrical plant come out as follows :—

Copper on the line	£25·0
Poles and insulators	6·3
Dynamos for 1·46 H.P.	1·75
Transformer for 1 H.P.	1·0
Per horse-power delivered total	£34·05

The annual charge may be taken at £1·91. The author has dealt with the case of Madras as being the crucial question, as if the power can be supplied to that city it can, of course, be supplied to points which are nearer the generating plant. He says that it seems quite clear that it will be possible to supply electricity at any low pressure suitable for electric lighting or motive-power, at not more than £4 per annum, including all costs, with a margin for contingencies.

ON THE TRANSFORMATION OF OPTICAL WAVE-SURFACES BY HOMOGENEOUS STRAIN.*

BY OLIVER HEAVISIDE, F.R.S.

In the optical wave-surface invented or discovered by Fresnel only one kind of eolotropy is concerned. But it may be either elastic eolotropy or inertial eolotropy, according to the particular theory employed. In the electromagnetic theory it may be either electric or magnetic eolotropy. In real fact it is the former, but it might be either. If there be duplex eolotropy, both electric and magnetic, the optical wave-surface is of a more general type, including Fresnel's, at its two extremes. It has some theoretical attractions on account of its symmetry with respect to the two eolotropies, whereas the Fresnel surface shows but an imperfect development of the theory concerned. Dr. Larmor has recently made the interesting remark that a duplex wave-surface of a special type, viz., with homologous eolotropies concerned, may be homogeneously strained to a simplex (or Fresnel) wave-surface. I have examined this question more generally, with these main results :—Any duplex wave-surface, when subjected to any homogeneous strain, usually remains a duplex wave-surface ; but sometimes it degenerates to a simplex wave-surface. There are four principal cases. When the strainer varies as the square root of the permittivity, and when it varies as the square root of the inductivity, we have the two simplest cases. But each of the reduced simplex surfaces may be strained to its reciprocal, also a simplex surface. This makes four. These transformations lead to a more interesting one, viz., that the duplex wave-surface itself may be strained to its reciprocal (of the same type) by a pure strain. This strain may also be replaced by three pure strains in succession, viz., first, turning the duplex to a simplex surface ; secondly, inverting the latter ; and thirdly, straining it to become the reciprocal of the original. There are two sets of such triple strains.

* Abstract of a Paper read before the Royal Society.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *May* 11, 1894.

Ocean Telephony.—Prof. M. I. Pupin, of Columbia College, has been granted patents for a method which, it is claimed, renders practicable ocean telephony and the use of Hughes' apparatus, for instance, for cable telegraphy. One patent relates to the principle, which consists in the employment in series of condensers interposed between the parts of a cable divided into lengths, the number of parts depending on the periodicity of the current to be transmitted. The patent gives the following statement of the new invention :—"Consider the current in the conductor of any section of the cable. That current consists of two distinct parts. One part is due to the charging of the terminal condensers of that section, and the other is due to the charging of the surface of the conductor itself. The first current I call the longitudinal displacement component, and the second current I call the lateral displacement component of the current in that section. The above-mentioned very important improvement consists, therefore, in diminishing the ratio between the lateral and the longitudinal displacement components of a rapidly varying current. The wasting of a current due to the lateral displacement components in the various parts of a cable acts evidently like an impedance, therefore it is to be understood that the word 'impedance' herein includes the impedance due, not only to ohmic resistance, self-induction, &c., but also the impedance resulting from the lateral displacement currents." In order to prevent discontinuity of the cable through a condenser breaking down, an induction coil is placed in shunt with each condenser, the coil being so constructed that the effect of the condenser capacity upon the current through the coil will be inappreciably small, with frequencies over 50 periods per second. The introduction of the impedance of this coal in the main circuit in case of a fault in the circuit will also permit the fault to be located. Another patent relates to the construction of a transformer, and to the combination of such a transformer with a line conductor having in circuit telephone or telegraph instruments, or both, the secondary of the transformer being divided into a number of equal parts and condensers interposed between each of these parts. A patent on the construction of the line conductor is referred to in one of the patents as now pending.

An Electric Conduit Railway for New York.—The Metropolitan Traction Company of New York City, has announced that it has accepted the offer of the Siemens-Halske Company to construct three miles of an electric conduit road in the upper part of the city similar to that now in use at Budapest. The road is to be constructed at the expense of the Siemens-Halske Company, and, if it proves satisfactory, the contract provides for four additional miles.

Electric Traction in Cuba.—Arrangements have, it is stated, been made by an English company for the establishment of a system of electric tramways in Havana. The projected line covers about 20 miles in all, and is to connect the principal wharves and thoroughfares with the existing tramways.

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CORRESPONDENCE.

WIRING PRICES.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I notice in your issue of the 18th inst. a letter from a professional gentleman in Manchester complaining of my having made remarks at Winchester, which he construes into an advocacy of jerry work in electrical wiring. It appears that the said member of the profession, as distinguished from the electrical plumbing fraternity, bases his views on his opinion that the work could not be well done at the price named; but in this he is mistaken. My suggested price of 8s. 9d. per light was confined (by an explanation, unfortunately not reported) to the ordinary cases of shop wiring, in which there would be, say, five lights on one line in the window and five lights on another line over the counter, with one switch for the window lights and two switches for the counter lights. Your correspondent has probably not realised how extremely simple such cases are, and how easily they lend themselves to economic treatment.

Time was when it was considered the function of a professional engineer to secure the maximum result for the minimum expenditure, but I regret to say that during the past few years the perusal of professional specifications has led me to the belief that in many cases the object aimed at was the exact reverse. I should have thought, however, that your correspondent would have been more careful not to have allowed the impression to get abroad that his practice was of a similar nature.

As to the case in point, I have made a careful estimate of the exact cost of materials and labour involved, and find that the whole can be supplied and properly fitted up at the price named, in accordance with the Phoenix Fire Office rules, at a fair profit to the local electrical plumber, but I will concede this much to your professional correspondent that I think on mature reflection an important job of this kind should not be undertaken without professional assistance, and on this account my suggested price might very well be raised to the extent of one shilling, thus providing a half-guinea fee to the professional man. I think perhaps your correspondent has not fully realised that in speaking at Winchester I had a clear view of the fact that there is no prospect of any work being undertaken there for at least 12 months to come, and that taking into consideration the spread of education, we may suppose that during that time electrical plumbers will succeeded in mastering the elements of arithmetic necessary for solving the problem—"if a herring and a-half cost three half pence, what will a dozen cost?"—without the aid of a professor.—Yours, &c., John S. Raworth.

Albert Buildings, 49, Queen Victoria-street, London, E.C., May 22, 1894.

BOOKS RECEIVED.

"Proceedings of the Royal Society of Victoria," Vol. VI., January, 1894.

"Journal of the Institution of Electrical Engineers." Vol. XXIII. April. 3s. 6d. (London: E. and F. N. Spon.)

"Electrical Apparatus." Edited by Francis Chilton-Young. Price 1s. (London: Ward, Lock and Bowden.)

"Magnetische Kreise." By Dr. H. du Bois. (Berlin: Julius Springer.)

"The Eight Hours' Day in British Engineering Industries." By J. Stephen Jeans. (London: Ballantyne, Hanson and Co.)

"Electric Light Installations." Vol. II. By Sir David Salomons, Bart. Price 7s. 6d. (London: Whittaker and Co.) 1894.

"The Law of Patents." By Henry Cunynghame. Price 25s. (London: W. Clowes and Sons, Limited.) 1894.

"The Steam-Engine." By J. A. Ewing, M.A., F.R.S. Price 15s. (London: C. J. Clay and Sons.)

"Continuous-Current Dynamos and Motors." By F. P. Cox, B.S. (London: Whittaker and Co.)

"Alternating Currents." By F. Bedell and A. C. Crehore. Second Edition. (London: Whittaker and Co.)

TRADE NOTES AND NOTICES.

[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.]

The 1894 Edition of "The Electrician" Electrical Trades' Directory and Handbook is now ready. This valuable book contains 1,000 closely-printed pages, and several new and useful features have been added. The price of the Directory and Handbook is 7s. 6d. Postage in the United Kingdom, 9d.; abroad, 1s. 4d.

"Electric Lamps and Electric Lighting," being four Lectures delivered before the Royal Institution in April-May, 1894, by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is in preparation, and will shortly be published.

"Electrical Engineering Formulæ," a pocket-book by W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. (abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application to the Publisher.

"Electromagnetic Theory," by Oliver Heaviside, is now ready, price 12s. 6d. (abroad 13s.). Prospectus on application.

"The Incandescent Lamp and its Manufacture."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application to the Publisher.

"Drum Armatures and Commutators."—This book, written by Mr. F. Marten Weymouth, is also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"Inventions, Researches and Writings of Nikola Tesla," by T. Commerford Martin, may be obtained from the Publisher of *The Electrician*, and a copy will be forwarded post free on receipt of 16s. 6d.

"How to Wire Buildings."—Copies of this work, by Augustus Noll, will also be sent by the Publisher post free on receipt of 6s.

Tenders Invited.—The Corporation of Bedford invite tenders for the construction, supply, and laying down of the necessary plant and mains for the supply of electric current within the borough. The contract is in two sections, of which particulars are given in our advertisement columns. Specifications can be had at the offices of Mr. F. H. Medhurst, B.Sc., 13, Victoria-street, Westminster, S.W.; and tenders must be sent in to Mr. T. S. Porter, clerk to the Urban Sanitary Authority, the Town Hall, Bedford, not later than Saturday, June 16th.

——— The Guardians of the Parish of Paddington (London) invite tenders for the electric light wiring and fittings for the infirmary situate in Harrow-road, W. Further information can be obtained of Mr. A. W. Sclater, 182, Oxford-street, W.; and tenders must be sent in to the offices, 289, Harrow-road, W., before five o'clock on Tuesday, June 12th. Mr. H. F. Aveling is clerk to the Guardians. Some further particulars will be found in our advertisement columns.

Tenders Accepted.—The tender of Messrs. Walker and Co., of Queen-street, Portsea, has been accepted by the Portsea Board of Guardians for providing and fixing electric light fittings, &c., in St. Michael's-road, at £67. Tenders were also received from two other local firms, at £79. 17s. 6d. and £119 respectively.

——— The following is the full list of the tenders received recently by the Corporation of Brighton:—

For Motor Alternators.

	£	s.	d.
John Fowler and Co.	£5,147	0	0
Manchester Edison-Swan Company	3,940	0	0
Siemens Bros. and Co.	2,560	0	0
Brush Electrical Engineering Company	2,450	0	0
Easton, Anderson and Goolden	2,125	0	0
Crompton and Co.	2,110	0	0
*Electrical Construction Company	1,731	17	0

Tenders for Alternating Current Cables.

	£	s.	d.
Siemens Bros. and Co.	£4,745	3	4
Fowler Waring Cables Company	3,960	18	4
*British Insulated Wire Company	3,579	6	0

* Accepted tenders.

——— The Huddersfield County Council have accepted the tender of Messrs. Calvert and Co., of Folly Hall, for the supply of an air vessel for the electric lighting works.

Liquidations.—At meetings of the shareholders of Swan's Electric Light Company (Limited), (?) held on April 21st and May 12th, at 141, Pilgrim-street, Newcastle-upon-Tyne, it was resolved that the Company be voluntarily wound up, and Mr. T. R. Hutchinson was appointed liquidator.

——— The shareholders of Wells, Gallimore and Taylor (Limited), at a meeting held on the 12th inst., resolved that the Company be voluntarily wound up, Mr. E. M. Sharp, chartered accountant, of Birmingham, being appointed liquidator.

Appointment.—Capt. W. P. Brett, R.E., has been appointed an instructor in electricity at the Royal Military Academy.

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VACANT APPOINTMENTS.—The Commissioners of Sewers of the City of London invite applications for the post of Inspector under the Electric Lighting Acts. Particulars of the duties required of applicants can be had on application to the City Sewers, Office, Guildhall. Further particulars are given in our advertisement columns, and applications must be sent in not later than noon on Tuesday, June 12th.

——— An advertiser requires the services of a practical working electrician to take charge of an installation of about 2,000 incandescent and 50 arc lamps. Applications should be sent in to No. 20B, *The Electrician* Office.

——— The Corporation of Cheltenham require in the Borough Engineer's Department an electrical engineer to superintend the laying of mains, and, subsequently, to take charge of the central station, at a salary of £200 per annum. Further particulars are given in our advertisement columns, and applications must be addressed to the Chairman of the Electric Lighting Committee, and sent in to Mr. E. T. Brydges, Town Clerk, not later than June 18th.

——— A leading firm of cable makers require a representative for Manchester and district. See advertisement elsewhere.

PERSONAL.—In our last issue it was announced that Mr. Arthur Ellis had been appointed clerk of the electricity works at Southport. Mr. Ellis has how been made resident electrical engineer, still retaining his position as clerk of the works during construction, Mr. Ellis was engineer to the Cambridge Electric Supply Company for nearly two years.

ALTERATION OF ADDRESS.—During the rebuilding of 11, Lombard-street, the temporary offices of the Guardian Fire and Life Assurance Company are situated at 6, Princes-street, Bank, E.C.

QUEEN'S BIRTHDAY.—The Foreign Office is to be lighted throughout by electricity on the occasion of the official celebration of the Queen's birthday to-morrow (Saturday).

NEWSPAPER INDEX.—Mr. Edward Curtice, who is well known in connection with the Press Cutting Agency, has just issued an index to *The Times*, the London morning and evening papers, and a number of weekly and provincial journals. The index claims to contain a record of the principal articles, correspondence reports, paragraphs, &c., appearing in the principal British journals; and the volume now issued covers the period from July 1st to September 30, 1893.

ADMIRALTY CONTRACT.—Messrs. Wiggins and Sons have again obtained the contract for the supply of mica to the Admiralty. This is, we understand, the largest order ever placed by the Department for this material.

AYR.—At a meeting of the Town Council a letter was read from the Caledonian Electric Supply Company, asking whether terms could be come to in the matter of lighting the district. The Company offered to take a transfer or lease of the Provisional Order on the understanding that ratepayers had the first chance of becoming shareholders of the Company to the extent of the capital necessary for completing the works. A long discussion ensued, during which several proposals were made, and ultimately a vote was taken on a motion that the Caledonian Company be allowed to approach the Council with a view to coming to terms, and this was agreed to by 9 votes, against 7 for a motion that a plebiscite be taken in order to ascertain the views of the ratepayers on the subject. During the discussion Mr. Auld, a member of the Lighting Committee, stated that he had already taken the opinion of the ratepayers for the ward he represented, and 75 per cent. of these were in favour of the introduction of the electric light.

ABERDEEN.—The question of lighting the new police buildings by electricity has been adjourned for a fortnight.

BALLARAT (AUSTRALIA).—It is announced that the Electric Light Co. have arranged for the erection of a preliminary plant for the lighting of a portion of the main thoroughfares of the municipality. It is anticipated that by the end of July a lighting plant costing about £40,000 will be imported from England. The machinery, &c., it is said, is to be erected under the supervision of Mr. K. H. Buchanan, C.E., Manager of the Crompton Electric Supply Company of Australia. The yards and grounds of the Ballarat Railway Station are also shortly to be lighted electrically; the number of fatal and serious accidents which have recently taken place in the shunting yards calling for an early adoption of the light, which will, it is expected, also be installed throughout the Government Offices at an early date.

BATTERSEA.—At the next meeting of the Vestry the following notice of motion is to be discussed:—"That considering the great expense of the horses of this Vestry, the Vestry is of opinion that electric motors be used in place of horses"!

BELFAST.—The Electric Lighting Committee of the Corporation have presented their report, in which the resident engineer sets out the progress made with the electric lighting works, and the Committee submitted Prof. Kennedy's plans and specifications for the central station in Chapel-lane, tenders for the building of which are now invited.

BLACKBURN.—It has been decided to light the new portion of the Free Library Museum by electricity, and the contract has been let to Mr. J. M'Lellan.

BOURNEMOUTH.—The Corporation have obtained from the Board of Trade an Electric Lighting Licence, and have instructed the surveyor to report upon the power at his disposal for electric lighting purposes. The Bournemouth Electric Supply Company have given notice of their intention to supply electric current continuously in certain streets of the borough.

CARLOW.—It is stated that the price paid by Major Alexander for the lighting plant, machinery, and goodwill of the Carlow Electric Lighting Company was £3,500, the original cost having been £20,000.

CHAPEL LIGHTING.—The Victoria-street Chapel, Blackpool, is to be lighted by electricity, and Messrs. Challoner have been entrusted with the installation.

DUBLIN.—Messrs. Edmundsons, of London and Dublin, have installed a large temporary plant for electric lighting for a Bazaar held this week in Dublin, to which the distinctive title "Araby" has been given. The Bazaar was held on the extensive premises of the Royal Dublin Society at Ball's Bridge, in aid of the funds of a local hospital. The lighting plant consisted of steam and gas engines equal to 150 H.P., supplying power for about 1,000 incandescents, 22 arcs, and two 20in. search-lights. The lighting gave every satisfaction, and added materially to the success of the Bazaar

GLASGOW.—The Works Committee of the Clyde Trust have had under their consideration for some time the question of lighting and crane accommodation for the new Sessnock Dock. Some time back a report was submitted to the Committee containing information collected from English and Continental sources giving comparative values of electrical and hydraulic appliances. The report further recommended that an electric light installation should be put down for lighting the Dock, and that the plant should be provided to work nine cranes on the south quay of the north basis, and tenders were invited for 35cwt. hydraulic cranes and the plant for working them, and alternatively tenders for nine 35 cwt. electric cranes and complete electric plant and apparatus. Twelve tenders were subsequently sent in for the hydraulic plant and 20 for the electric; but the tenderers furnished no data as to the cost of working and maintenance. An examination of the tenders showed that the initial cost of the electric plant would be much greater than that of the hydraulic, and the Works' Committee, therefore, recommended the adoption of hydraulic machinery, and have recommended the tender of Messrs. Fullerton, Hodgart, and Barclay (Limited), of Paisley, for acceptance. The Committee of Management, which includes all the members of the Clyde Trust, have approved the recommendation, and the consideration of the mode of equipping the remainder of the dock has been remitted to the Works' Committee.

HAMPSTEAD.—On Wednesday the ceremony of placing a memorial stone at the electric lighting buildings now approaching completion was carried out by Mr. Churchwarden Thwaites, Chairman of the Electric Lighting Committee of the Hampstead Vestry, who, at a dinner subsequently held, stated that the cost of the electrical plant for lighting the compulsory area is £19,794, and the cost of the building £7,500, out of a total estimated ultimate outlay of £80,000.

HONOURS.—Amongst the honours distributed by the Queen on the occasion of her official opening of the Manchester Ship Canal, this week, is a knighthood to Alderman W. H. Bailey, Mayor of Salford, and head of the firm of W. H. Bailey and Co. (Limited), Albion Works, Salford.

——— In the deluge of birthday and miscellaneous honours now occurring, Mr. Richard Tangye, head of the Cornwall Works, Birmingham, secures a knighthood.

KILLARNEY.—At a meeting of the Board of Governors of the Killarney District Lunatic Asylum, the question of introducing the electric light was again discussed, and the voting on a resolution proposing that a former decision agreeing to the introduction of electricity be rescinded resulted in a tie. As a doubt arose on the legality of the Chairman giving a casting vote, the decision of the matter has been left for a further meeting.

LLANDUDNO.—The Town Commissioners have passed a resolution opposing the proposal to adopt electric lighting for the town, being of opinion that the question of electric lighting should be adjourned till the reconstitution of the Board in November.

LOWESTOFT.—In reply to a question from Councillor Capps as to the advisability of applying for a Provisional Order, the Mayor stated that a paragraph in the Parliamentary Committee's report notified that the surveyor had been directed to have the replies made to his inquiries on the subject of the cost of gas and electricity tabulated and printed and circulated amongst the members.

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MILL LIGHTING.—The extensive range of buildings forming the timber mill of Messrs. Leyland, O'Brien and Co., at Auckland, has been lighted throughout by electricity. The works are frequently running night and day. Messrs. A. and G. Price have carried out the installation, which has given every satisfaction.

NEW BRIGHTON.—The proprietors of the Palace, New Brighton, have recently lighted the building inside and out by the electric light, the work having been entrusted to Messrs. A. Hall and Co., of Liverpool. The installation comprises a Crossley engine driving a 300-light dynamo.

NORWICH.—In a discussion which arose on the question of accepting the tender of the British Gas Light Company for lighting the public lamps for the ensuing year, Mr. Alderman Wyld remarked that there was at present a monopoly of street lighting so far as the Gas Company was concerned; but the success of the use of the electric light in St. Andrew's Hall during the 25 organ recitals recently given, had resulted in a saving of from 20 to 25 per cent., as compared with the gas lighting, and this result would, in the near future, lead to a more careful consideration of the question of lighting than had hitherto been attempted.

OXFORD.—Messrs. Drake and Gorham have obtained the contract for lighting the University Galleries extensions at Oxford. A number of arc and about 70 incandescents will be used.

PROVISIONAL ORDERS.—The Bill confirming the Provisional Order applied for by the Grimsby Corporation to supply electricity throughout the Grimsby district has passed the Examiners on Standing Orders of the House of Commons.

ST. PANCRAS (LONDON).—The Electricity and Public Lighting Committee report to the Vestry that, after consideration of the question of the charges made for lighting the public lamps by electricity, they are in a position to recommend that the price be reduced from the present charge of 6d. to 5d. per unit after the Michaelmas quarter. It was explained that this charge includes the supplying of carbons, labour, trimming the lamps, and repairs and maintenance, charges which altogether amount to 15 per cent. on the amount. At the meeting on Wednesday of the Vestry the recommendation of the Committee was adopted.

SALISBURY.—Mr. W. H. Gramshaw submitted a scheme at the last meeting of the Town Council for the formation of a local company to supply electric current within the city, and asked the Council for their consent to his application for a Provisional Order to be applied for before July 1st. Permission has been given the promoters of the Company to acquire the old town mill as a site for a central station. After discussion it was decided to adjourn the consideration of the scheme for a week in order to test public opinion on the matter and to obtain further details from Mr. Gramshaw.

SHREWSBURY.—At a special meeting of the local gas company, Mr. Spencer Phillips (who presided), in asking the proprietors for permission to borrow £10,000 additional capital, said they had heard a good deal about the electric light, but the Company did not look upon it as an enemy, or even as a friendly rival; they rather hailed with pleasure its advance. There was not a single town in England where the electric light had been introduced that had not had its gas consumption remarkably stimulated.

SOUTHAMPTON.—At the last meeting of the Harbour Board the Works Committee reported that they had received a letter from Mr. Kerbey Bowen confirming the arrangement agreed upon as to the supply of electric power to launches, and that they had given instructions for the electric lighting of the pier and the pavilion, to be carried out by the Board's own labour. The report was adopted by the Board.

SYNAGOGUE LIGHTING.—A new synagogue at the West End of London has just been lighted throughout by electricity, the expense being borne by Mrs. J. L. Hart. The current is taken from the mains of the Metropolitan Company. Mr. Schultz, engineer to the Notting Hill Company, superintended the installation, the contractors being Messrs. Money and Nash.

TAUNTON.—Mr. J. H. Smith, the Borough Electrical Engineer, has presented his report to the Town Council, which states that an increase in customers has taken place since the last report, equal to an increased demand for current for 248 8-c.p. lamps.

Telephonic Communication in Costa Rica.—The Government of the Republic of Costa Rica has recently granted a ten-years' concession for the establishment of a system of telephones in that country. Under the concession, all material and apparatus required for the system will be admitted free of import duty. The Government may acquire the system one year after it is established by paying the concessionaire the cost of installation and 50 per cent. more by way of indemnity; after the second year 25 per cent.; after the third year 15 per cent.; after the fourth year 10 per cent.; and during the fifth year the cost of installation only.

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

May 10, 1894.

9,357. W. ROWBOTHAM and E. ROWBOTHAM. Manchester. Improvements in and relating to electric arc lamps and their construction.

9,362. S. S. BROMHEAD. London. Electric alarm clocks with advertising spaces. (F. Beuner, United States.)*

9,364. D. YOUNG. London. An improved lubricant, chiefly designed for use on the collectors of dynamo-electric machines. (J. Marius, Italy.)

9,368. F. BRAIN. London. Improvements in electric fuses.

May 12, 1894.

9,399. A. DICKINSON. Darlaston. A combination of the electric overhead trolly system, and the electric accumulator system for railways and tramways.

9,410. C. H. CUTTING, G. H. CUTTING, and J. CUTTING. Derby. Improved means of gripping cords, wires, or the like, for electrical or other purposes.

9,437. H. LEA. London. Improvements in the method of, and apparatus for, regulating the amount of light from electric glow lamps.

9,456. C. N. RUSSELL. London. Improved junction or fuse box for electric wires.

May 15, 1894.

9,534. A. KOLBE. Liverpool. An improved device for use with current meters in observing the charging and discharging of electric accumulators.

9,540. A. H. POLLEN and A. DUNOLLY. London. Improvements in or relating to incandescent electric lamps.

May 16, 1894.

9,565. A. GRAY. Birmingham. Improvements in the metal screw, bolt, or other attachments for fixing insulators to carry electric wires.

9,605. W. M. MORDEY. London. Improvements in electric machines.

May 17, 1894.

9,627. C. N. DEXTER. London. Improvements in the mechanism of arc lamps.

9,647. J. NICOLSON. London. Improvements in and connected with telephones.

9,673. D. COOK. Richmond. Improvement in means for the distribution of alternating electric currents.

9,690. J. JAHNSSON. London. An improved electrical device for facilitating the lighting of gas.*

May 18, 1894.

9,743. E. BAILEY. London. Improvements in electric conductors principally designed for lighting and heating purposes.

9,761. T. CRANEY. London. Improvements in electrolytic apparatus.

May 19, 1894.

9,762. J. W. ROGERS. London. Improvements in arc lamps.

9,763. P. CADOT and A. CHARRON. A horary meter for electric light, air, gas, water (compressed or not) and motive force.*

SPECIFICATIONS PUBLISHED.

All Specifications price 8d. each.

1893.

8,881. HOWARD. Electric machine.

9,638. HALL. Telephone apparatus and circuits.

9,639. HALL. Telephone signalling apparatus and circuit.

9,640. HALL and PICKERNELL. Electrical signalling apparatus and circuits.

9,753. AYRTON and MATHER. Electrical measuring instruments, &c.

10,396. DUDGEON. (Société Anonyme John Cockerill.) Electric conductors.

11,842. PAYNE. Electrical conductors.

11,890. RABBIDGE. Telephones.

12,437. ROSLING and MATTHEWS. Electrically controlling lubricators.

13,996. BEHR. Vehicles and electric locomotives for elevated railways.

20,887. FORD and BARNES. Incandescent lamps.

21,379. ADAMSON. Electric light for photographic purposes.

1894.

4,091. JEHL and VON HARDTMUTH. Electric arc lamp carbons.

4,333. JOHNSON. Suspending electric light, &c., fittings.

4,909. COLLINS and JONES. Targets and electrical indicating apparatus

5,276. CUMMINGS and ENGELMAN. Electric railways.

5,807. EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY (LIMITED and PROCTOR. Electrical safety fuse.

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COMPANIES' MEETINGS AND REPORTS.

West Coast of America Telegraph Company (Limited).

The following is the report of the Directors of this Company for the year ended December 31st last to be presented at the Seventeenth Ordinary General Meeting, to be held at 50, Old Broad-street, E.C., on Tuesday, the 29th inst., at 12:30 o'clock :—

The gross income for the year 1893 was £15,096. 4s. 3d., as against £22,218. 16s. 9d. in 1892, and, in order to make up the loss on the year's working, and to meet the Debenture coupons, it was necessary to take £16,536. 12s. 3d. from the reserve. The traffic handled in 1893 was larger than in the previous year, but owing to the fall in the rates of exchange both in Peru and Chile, which continued throughout the year, the sterling value of the receipts was considerably depreciated. The total expenses were £19,632. 16s. 6d., against £21,919. 14s. 8d. in 1892, a saving of £2,286. 18s. 2d.

The cable between Valparaiso and Talcahuano, 267 nautical miles, was successfully laid by the Company's steamer "Retriever," and opened for traffic on October 1, 1893. A landline connects Talcahuano with the City of Concepcion. This addition to the system of the Company was effected at a total cost of £29,699. 4s. 3d. The traffic carried over this line, in the short time it has been open, is satisfactory. The landline between Buenos Ayres and Valparaiso, constructed by the Pacific and European Telegraph Company (Limited), was opened for traffic on March 19, 1894. The completion of this line restored the direct service between the Company's stations and Europe *viâ* Madeira.

The Directors regret to report the loss of an esteemed colleague through the death of Mr. Henry Roberts. Mr. J. Denison Pender and Mr. Frederick Walters retire from the Directorate, and offer themselves for re-election ; as does the auditor, Mr. John Francis Clarke.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1894, pages 274-300, *&c., &c.*]

ANGLO-AMERICAN TELEGRAPH COMPANY (LIMITED).—The annual return of this Company, made up to February 9th, was not filed till May 4th, when the whole nominal capital of £7,000,000 stock was fully paid up.

BENHAM AND FROUD (LIMITED).—The annual return of this Company, made up to May 9th, has been filed. Out of a nominal capital of £50,000, in shares of £10 each, 2,907 have been taken up, and the full amount per share called, resulting in the payment of £28,947. 10s., and leaving £122. 10s. in arrear.

BIRMINGHAM HOUSE-TO-HOUSE ELECTRICITY COMPANY (LIMITED). The annual return of this concern, made up to January 11th, was recently filed. Seven Ordinary and 100 Founders' shares have been taken up, the latter being issued as fully paid to the House-to-House Electric Light Supply Company (Limited), of Richmond-road, Earl's Court, London, S.W. No calls have as yet been paid on the Ordinary shares.

[Similar returns have been filed of the Midland, the South of England, and the Western House-to-House Electricity Companies.]

CORLETT ELECTRICAL ENGINEERING COMPANY (LIMITED).—The annual return of this Company, made up to May 14th, has been filed. The nominal capital is £10,000 in shares of £10 each, of which 620 have been taken up. Of these 100 have been issued as fully paid, while upon the remainder the full amount has been called and paid.

PHOSPHOR BRONZE COMPANY (LIMITED).—The annual return of this Company, made up to April 13th, was recently filed. The nominal capital is £150,000, divided into 15,000 Ordinary and 15,000 Preference shares of £5 each. 7,335 of the former and 8,375 of the latter have been taken up, and the full amount per share called, resulting in the total payment of £78,550. It is stated that no less than £11,560 has been paid on 1,156 forfeited shares.

A. RANSOME AND CO. (LIMITED).—The first annual return of this Company, made up to April 27th, shows that the whole nominal capital of £59,000, in £10 shares, has been taken up. Of these, 5,593 were issued as fully paid, and the full amount has been called and paid on the remaining 307 shares.

RANSOMES, SIMS AND JEFFERIES (LIMITED).—The annual return of this Company, made up to April 26th, shows that out of a nominal capital of half a-million in £100 shares, 3,075 have been taken up. Upon 2,185 of these the full amount has been called, while upon the remaining 890 shares a call of £50 per share has been made, resulting in a total payment of £263,000.

SOUTHAMPTON ELECTRIC LIGHT AND POWER COMPANY (LIMITED). The annual return of this Company, made up to April 18th, has been filed. The nominal capital is £30,000, divided into 4,000 Preference and 2,000 Ordinary shares of £5 each ; 50 Preference and 708 Ordinary have been subscribed for and allotted, and the full amount called on each share. The calls paid have realised £3,735, while £55 has yet to be sent in.

YORKSHIRE HOUSE-TO-HOUSE ELECTRICITY COMPANY (LIMITED).— The annual return of this Company made up to March 20th, has just been filed. Out of a nominal capital or £100,000, divided into 19,900 Ordinary and 100 Founders' shares of £5 each, 10,000 Ordinary and the Founders' shares have been taken up, and all the latter issued as fully paid. Upon 7,366 Ordinary shares the full amount has been called, and upon the remaining 2,634 shares a call of £2 per share, has been made, resulting in the payment of £41,900. 10s., and leaving £197. 10s. in arrear.

CITY NOTES.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended May 20th were £907, as against £794 in the corresponding period of 1893, being an increase of £113. The total receipts for the half-year amount to £18,212, as against £17,735 for the corresponding period of 1893, an increase of £477.

RUSTON, PROCTOR AND CO. (LIMITED).—The results of trading for the year ended March 31st last shows a total balance of £48,940, which, by allowance for depreciation of plant and machinery of the small sum of £3,232 and Directors' remuneration, leaves £44,531 for distribution. £18,750 has already been distributed in interest on debentures and interim dividend, and it is now proposed to pay a further dividend of 10s. per share, free of income-tax (making $7\frac{1}{2}$ per cent. for the year), and after allowing £10,000 in reduction of the goodwill account, carrying forward £3,281 to next account. The Directors' report states that the buildings, plant, and machinery have been well maintained out of revenue, and the usual provision made for ascertained or probable bad debts. A meeting of shareholders takes place at the Sheaf Iron Works, Lincoln, on Tuesday, the 29th inst., at 2:30.

METROPOLITAN ELECTRIC SUPPLY COMPANY (LIMITED).—Notice is given that the coupons due June 1st next on the Five per Cent. Registered Debentures of this Company (bonds Nos. 1 to 10,000) will be paid on and after that date at the banking house of Messrs. Prescott, Dimsdale, Cave, Tugwell, and Co., 50, Cornhill, E.C., or at the Royal Bank of Scotland, 123, Bishopsgate-street Within, E.C. Coupons have to be left three clear days for examination, and the register of debenture holders will be closed from the 25th to the 31st inst. inclusive.

THOMAS PARKER (LIMITED).—A prospectus has been issued this week inviting applications for 3,000 shares of £10 each in Thomas Parker (Limited), which is formed (according to the prospectus) to carry on the business of manufacturers of plant for electric lighting, electric transmission of power, electro-chemical, electro-metallurgical, and other purposes. The nominal capital of the Company is £75,000, in £10 shares. The vendor and promoter is Mr. Thomas Parker, F.R.S.E., M.I.C.E., M.I.M.E., M.I.E.E., "Mechanical and Electrical Engineer, Founder and Managing Director of Elwell-Parker, Limited, and for five years Works' Director and Chief Engineer of the Electric Construction Corporation (Limited)." For a list of important works and machinery designed and superintended by Mr. Parker and the Electric Construction Company's staff we must refer our readers to the prospectus, which further states that the Directors anticipate "an immediate turnover of £100,000 a year," although the prospectus is more than usually sparing of details. It is stated that the Eickemeyer winding patents are assigned to the Company by the vendor, who receives £25,000 in all, £17,500 in fully paid shares and £7,500 in cash. The vendor contracts to act as Managing Director to the Company for 10 years. The prospectus contains a waiver clause, which does not, however, affect the contract for sale.

In reference to the Eickemeyer patents referred to in the prospectus of Thomas Parker (Limited), Mr. James Gray, Secretary of the Electric Construction Company, writes : "One of the chief inducements which is held out to subscribers is the acquisition of the Eickemeyer patents for winding dynamos ; but the prospectus makes no mention of the fact that these patents are in Mr. Parker's hands subject to a general licence in favour of my Company for the whole of the United Kingdom. The statement in the prospectus that 'Mr. Parker and his staff designed and superintended' certain works is misleading, as only a portion of our staff employed upon the works in question has joined Mr. Parker since the Board of my Company dispensed with his services. We have reason to believe that we shall have to claim certain of the other patents which it is represented on the prospectus will be transferred to the proposed Company, as having been taken out by our employés. The whole matter has been placed in the hands of our solicitors, Messrs. Linklater and Co."

The following letter is also sent by Mr. W. A. Gibbs, of the Otis Elevator Company, in reference to the Eickemeyer patents :—"In the prospectus of Thomas Parker (Limited), among the 'advantages with which the Company start,' we find in the fifth paragraph a statement that 'the vendor has acquired, and will assign to the Company, the Eickemeyer patents for winding, &c.' It may be well to explain that the Eickemeyer patents cover machines designed for elevator or lift purposes, as well as machines for traction purposes, and I deem it well, therefore, to state explicitly that those Eickemeyer patents which refer to elevators or lifts are in the exclusive possession, by assignment, of this Company."

STOCK EXCHANGE NOTICES.—Application has been made to the Stock Exchange Committee for an official quotation for vendors' shares, Nos. 7 to 214 and 719 to 10,000 of the Charing Cross and Strand Electricity Supply Corporation (Limited).

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WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended May 18th (after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited), were £2,545.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the two weeks ending May 15th were £2,550, as compared with £4,005 for the corresponding period of last year. The receipts for January, estimated at £4,941, realised £5,053.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, May 16.		Price Wednesday, May 23.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending May 23. Highest	Lowest.
			TELEGRAPHS.					£ s. d.			
£1,012,880	Stock	9 0	Anglo-American	43	45	42	44	5 18 8	Jan., Apr., July, Oct.	43	.
£2,933,560	Stock	18 0	Do. Preferred	80½	81½	80½	81½	5 16 7	,, ,,	81½	80½
£2,933,560	Stock	5/0	Do. Deferred	7⅝	8	7½	7¾	..	.. ..	7⅝	..
£184,500	100	4%	African Direct Telegraph 4% Deb. (Reg. & Bearer)	101	104	101	104	3 16 11	January and July	.	..
130,000	£10	3/0	Brazilian Submarine	12	12½	12	12½	5 4 0	Mar., June, Oct., Dec.	12⅜	12¼
£18,700	£100	5%	Do. 5 per Cent. Bonds	100	103	100	103	4 17 1	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	108	112	108	112	4 4 10	June and December	..	..
10,000,000	$100	$1¾	Commercial Cable Capital Stock	140	145	140	145	4 16 7	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	12	13	12	13	6 3 1	February and August	12⅜	12⅜
6,000	10	10%	Do. Preference 10 per Cent.	18	19	18	19	5 5 3	,, ,,	..	—
12,931	5	1/7½	Direct Spanish (£4 paid)	2½	3½	2¾	3½	4 16 8	April and October	..	—
6,000	5	10%	Do. Preference 10 per Cent.	8½	9½	8¾	9½	5 8 1	,, ,,	..	..
60,710	20	2 0	Direct United States Cable, 1877	9¼	10	9¼	10	6 0 0	Jan., Apr., July, Oct.	9⅞	..
400,000	10	2/6	Eastern	14¾	15	14⅞	15	4 6 8	,, ,,	15	14¾
70,000	10	6%	Do. 6 per Cent. Preference	15¾	16¼	15¾	16¼	3 13 10	,, ,,	16¼	15¾
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock.. xd	112	115	112	115	3 9 7	May and November	114½	113½
£102,100	100	5%	Do. 5 per Cent. Debentures, 1899	107	110	107	110	4 10 11	February & August	..	..
250,000	10	6/6	Eastern Extension	15⅝	15⅞	15⅝	15⅞	4 9 7	Jan., Apr., July, Oct.	15⅞	15⅝
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	114	117	114	117	3 8 5	February & August	115½	114½
£62,700	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	104	107	104	107	4 13 6	January and July .	..	..
£95,100	100	5%	Eastern and S. African 5 per Cent. Mor. Deb., 1900	103	106	103	106	4 14 4	,, ,,	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures, 1909 (regd.) ..	104	107	104	107	3 14 9	February & August	..	..
£200,000	£25	4%	Do. 4% Mauritius Sub. Debs.	105%	108%	105%	108%	3 14 1	May and November	106	..
180,227	10	2/6	Globe Telegraph and Trust	8¾	9	8¾	9	5 0 0	Jan., Apr., July, Oct.	9	⅞
180,042	10	6%	Do. 6 per Cent. Preference	15¼	15⅝	15⅜	15⅝	3 18 1	,, ,,	15¾	15⅞
150,000	10	7/2	Great Northern	21	21½	21	21½	3 19 1	Jan., April, and July	21⅛	21
£190,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	104	107	104	107	4 13 6	March & September	..	..
17,000	25	37/6	Indo-European ... xd & bonus	43	45	43	45	5 11 1	May and November	—	..
37,548	10	5/0	London Platino-Brazilian ... xd	4	6	4	6	..	,, ,,	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106	109	106	109	5 10 1	March & September	..	..
£100,000	£100	4%	Pacific European Tel. 4% Guar. Debs. "Red" 1942..	102	105	102	105	3 16 2	..	..	..
11,839	8	4/0	Reuter's	5½	6½	5½	6½	..	April and October	..	..
3,381	£100 Cert.	35/0	Submarine Cables Trust 6 per Cent.	112	116	112	116	5 3 5	,, ,,	..	..
15,609	10	5/0	West African Telegraph	3	5	3	5	..	January and July .	..	..
£249,900	100	5%	Do. 5 per Cent. Debentures	100	103	100	103	4 17 1	March & September	..	..
30,000	10	2/0	West Coast of America	2½	3	2½	3	..	January and July	..	.
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	105	109	104	108	7 8 2	June and December	107	105
88,321	10	9d.	West India and Panama ... xd	1	1½	1⅛	1⅜	..	.	1½	..
34,563	10	6%	Do. 6 per Cent. 1st Preference ... xd	10½	10¾	10½	10¾	5 11 7	May and November	10¾	10½
4,669	10	6%	Do. 6 per Cent. 2nd Preference ... xd	9	10	9	10	6 0 0	,, ,,	..	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	109	112	109	112	4 9 3	June and December	..	..
64,242	15	4/6	Western and Brazilian	7½	8	7½	8	..	May and November	7⅞	7⅞
33,129	7½	4/6	Do. 5 per Cent. Cumulative Preferred	6½	7	6½	7	..	..	6⅝	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	2	2½	2	2½	..	..	..	..
£171,900	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	106	109	106	109	5 10 1	February & August	107	..
£214,800	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	106	109	106	109	5 10 1	,, ,,	108	107½
$1,211,000	$1,000	7%	Western Union 7% 1st Mort. (Building) Bonds	111	115	111	115	6 1 9	May and November	..	
£166,900	£100	6%	Do. 6 per Cent. Sterling Bonds	100	104	100	104	5 15 5	March & September	101½	101½
			TELEPHONES.								
44,000	5	10/0	Chili Telephone (fully paid)	1½	2½	1½	2½	..	..	..	..
224,850	10/0	3½d.	Consolidated Telephone Const. & Maintenance	[illegible]	[illegible]	[illegible]	[illegible]	..	May and November	..	..
171,504	£1	6d.	Oriental Telephone and Electric (fully paid)	[illegible]	[illegible]	[illegible]	[illegible]	..	Yearly — — —	..	..
484,597	5	2/6	National	4⅝	5⅛	4⅝	5⅛	4 17 7	June and December	5	4⅞
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	15	16	15	16	3 15 0	,, ,,	..	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	14½	15¼	14½	15¼	3 17 5	,, ,,	.	..
119,234	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	5½	5¾	5½	5¾	4 6 11	..	5⅝	..
1,000,000	Stock	4½%	Do. Debenture Stock, 4½%	114	116	114	116	3 17 7	January and July .	115½	114½
58,000	5	1/0	United River Plate	1½	2	1½	2	..	,, ,,	..	..
£146,733	Stock	5%	Do. 5 per Cent. Debenture Stock	90	100	90	100	5 0 0	,, ,,	..	—
			ELECTRICITY SUPPLY COMPANIES.								
40,000	£10		City of London Electric Lighting (fully paid)	12	13	12	13	—	..	12⅝	12½
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	13½	14	13½	14	..	..	13 11/16	13¾
19,900	£5		Electricity Supply Co. for Spain	..		.		..	..	..	..
£30,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	..		4½	5½	..	..	..	..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	..		..		..	..	..	..
8,322	£5	..	House-to-House Electric	..		..		.	..	..	..
15,000	£5		Kensington & Knightsbridge El. Light (fully paid)	..		..		..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..		..		—	January and July .	..	..
5,523	£5	1/9	Liverpool Electric Supply (£4. 10s. paid)	5¾	6¼	5¾	6¼	—	..	..	—
39,477	£5	2/6	Do (fully paid)	6⅝	6¼	6⅝	6¼	—	..	..	..
111,000	5	..	London Electric Supply	[illegible]	[illegible]	[illegible]	[illegible]	—	..	..	..
49,900	£10	5/0	Metropolitan Electric Supply (fully paid)	7½	8	7½	8	3 2 6	..	7⅞	7 13/16
£100,000	Stock	5%	Do. 5% Debs. (Bonds of £10, £20, and £40) ..	108	111	108	111	4 10 1	June and December	109½	..
6,452	£10	.	Notting Hill Electric	4½	5½	4½	5½	.	.	.	..
19,980	£5	4/6	St. James and Pall Mall	6½	7½	6½	7½	.	..	7	6¾
20,000	£5	7%	Do. 7 per Cent. Preference	8	8½	8	8½	4 2 4	..	8 7/16	..
59,900	5	2/6	Westminster Electric Supply (fully paid)	5¾	6½	6	6½	3 1 7	.	6 7/16	6½
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
90,000		1/6	Brush Electrical Engineering	2¾	3	2¾	3	6 0 0	..	3	2¾
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	2⅝	2⅞	2⅝	2⅞	5 1 1		2½	2⅝
£125,000	Stock	4½%	Do. 4½ per Cent Debentures	108	111	108	111	4 1 1	March & September	108	..
20,000	5	2/6	Crompton and Co., 7 per Cent. Cumulative Pref.	3	3½	3	3½	—	January and July .	3 1/16	3½
12,139	5	..	Edison and Swan United	—		—		..	..	—	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid) ..	..		..		..	..	—	..
120,000	2	..	Electric Construction	[illegible]	[illegible]	[illegible]	[illegible]	..	—	..	..
12,845	2	..	Do. 7 per Cent. Cumulative Pref.	1½	1¾	1½	1¾	..	..	..	—
91,195	2	10/0	Elmore's Patent Copper Depositing	1⅛	1⅜	1⅛	1⅜	..	..	1 3/16	1¼
20,000	5	..	Fowler-Waring Cables (fully paid)	[illegible]	1⅜	[illegible]	1⅜	—	..	..	..
50,000	10	15/0	India Rubber, Gutta Percha, &c., Works	23	24	23	24	6 4 2	February & August	23½	23½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102	104	103	105	4 5 9	March & September	103½	..
15,995	£10	6/4	International Okonite Ordinary	—		..		—	.	—	..
16,000	£10	..	Do. 8 per Cent. Preference	—		—		—	December and June	—	—
20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	—	[illegible]	—	[illegible]	—	..	—	..
78,949	5	3/6	Swan United (£3 10s. paid)	1¾	2¼	1¾	2¼	8 6 2	May and November	—	..
37,350	12	36/0	Telegraph Construction and Maintenance	39	41	39	41	5 17 1	March and July	40½	40
£150,000	100	5%	Do. 5 per Cent. Bonds	104	107	104	107	4 13 6	January and July	..	..
37,514	£5	—	Woodhouse and Rawson Ordinary (£3 15s. paid)..	—		—		..	..	—	..
41,098	£5	—	Do. Preference (fully paid)	—		—		..	..	—	—
			RAILWAYS AND TRAMWAYS.								
£630,000	Stock	1%	City and South London Railway	30	31	31	33	2 1 3	May and November	32½	30½
37,500	£10	1%	Liverpool Overhead Railway	8	8½	8 1/16	8 3/16	—	—	—	—

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THE ELECTRICIAN:

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NOTES.

What is everybody's business is, as usual, nobody's business, and although the glow lamps have been freed from monopoly for six months, and better quality was promised as well as better price, no tests of efficiency, life, or candle-power have been published, and only the vaguest rumours are current about the relative merits of the principal varieties now on the market. The Kensington and Knightsbridge Company have, in the interests of their customers, and of the popularity of electric lighting, conducted tests of initial candle-power, watts, and degree of vacuum, and on the strength of these tests recommend and sell such lamps as they think will give the greatest satisfaction. The information which they have obtained, but which is hardly suitable for publication (since it would be devoid of interest if the makers' names were omitted) is rather surprising. Eight-candle lamps nominal are found to be anything between ten or six candles, and nominal watts per candle are equally erratic, the vacuum is in some cases very poor.

Hitherto the only useful information on the subject of English lamps, that is to say, lamps which *were* available for use in this country, has been the very complete and valuable series of tests made under the direction of Prof. Ayrton. The chief point, and a very important one, settled by these tests was the relation between volts and candle-power. Life tests have also been made, we understand, under Prof. Ayrton, but nothing has yet been published; perhaps they will appear in conjunction with the tests of lamps which were begun, or were said to have been begun, at the Chicago Exhibition, and which, for all we know, are going on still. We are glad to announce, therefore, that an exhaustive examination of a large number of lamps is now being made by Mr. Preece at the General Post Office. Twelve or more lamps of each make are being run continuously, and others for a few hours a day, and daily tests are being made of candle-power and watts; the lives are of course accurately noted. The results, which we have been permitted to inspect, are in some cases very satisfactory. A full report of the tests will be communicated to the British Association, and will include the history of more than three thousand hours, if, as is not improbable, some lamps survive through this period.

The announcement in our last issue that the Corporation of Brighton have received tenders for motor-alternators has given rise to the idea that the electrical engineer to this body, who has for some years been a staunch convert to continuous currents, was going to supply outlying districts with continuous currents generated through the intervention of high-pressure, alternate-current transmission. But a motor-alternator is not an alternate-current motor; and Mr. Arthur Wright probably holds the very sensible view that there is nothing that an alternate-current motor can do, that cannot be done equally well by continuous current. No continuous-current man, with the exception, we believe, of one who was concerned with the original, and now abandoned, design of the Brighton station, has ventured to say that alternate currents are of no use at all, and Mr. Wright, finding that certain residences which are too distant and scattered for connection with a three-wire network, must be supplied by alternate-currents and house transformers, if supplied at all, has readily adopted this system; but as it is not worth while at present to put down an alternating plant in this station, alternators will be driven at a sub-station by means of continuous-current motors fed from the three-wire service.

We print this week an abstract of the discussions which took place in New York and in Chicago on the Paper by Mr. Farnham dealing with the electrolytic corrosion of gas and water pipes, and published in our issue of May 4th. The Chicago meeting was, on the whole, the more fruitful in practical contributions to the solution of the problem under discussion. The three-wire system, as used at Portland (Oregon) and Bangor (Maine) would appear to be a singularly neat and effective method of reducing earth leakage and electrolytic corrosion to a minimum, without at the same time reducing shareholders' dividends to zero. Nothing, perhaps, was more remarkable in this debate than the decided leaning to the double-trolley system. It seems but yesterday that the mechanical, electrical, and financial impossibility of this mode of working was demonstrated by the entire electrical press of the United States, with all the logical completeness of a problem of Euclid. Now, it is genially hinted that nothing but the influence of a single electrical manufacturing concern prevented the number of trolley wires in America from being double their present figure. Misery, we know, acquaints a man with strange bedfellows, but we must confess never to have anticipated that electrolytic corrosion would acquaint our transatlantic friends with the virtues of the double-trolley system.

A communication from the University of Wisconsin gave a plausible theory, based on actually observed effects and experi-

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ments, accounting for the large amount of corrosion which apparently takes place with such absurdly low differences of potential as 0·001 volt. Another less scientific, but possibly equally true and certainly more comforting hypothesis was that the gas people themselves must take a large proportion of the blame, filling as they do the earth surrounding their leaky pipes with "ammonia and other destructive products of the gas retort." Seriously speaking, however, electric traction engineers, whilst squarely facing this matter, will do well, even in the States where motor cars appear to be a prime necessity which is not the case with us, not to allow too tamely the implication that before their day corrosion was a disease which never afflicted underground metallic structures.

It is one of the strongest confirmations of the truth of any physical generalisation, when a deduction from it in regard to any one particular phenomenon is justified by subsequent experimental investigation. A fresh instance of this fact occurs in the case of recent deductions which have been made from the periodic law of chemical elements. According to this law, there is a definite harmonic relation between the atomic weights and the physical and chemical properties of the elements and certain of their compounds. Bearing this fact in remembrance, Mr. A. J. Wurtz has endeavoured to deduce the associates of the elements which he has experimentally proved to be non-arcing. As may have been expected, his deductions proved to be perfectly sound; for the deduced associates have turned out, on trial, to possess this same property of non-arcing. Mr. Wurtz has recently published some further particulars of his researches in this direction, and of the application of these non-arcing metals to lightning arresters. Chemical science is rapidly taking its place among the deductive sciences, especially in its relation to atomic quantities; and it seems more than probable that Mendelejeff's—or was it Newland's?—great generalisation has many more hidden facts, the discovery of which would prove useful to engineers, scientists, and mankind in general.

Some experiments have lately been undertaken by the Munich Gas Company with a view to test the suitability of the Welsbach system of street lighting. There has been plenty of glorification of the incandescent gas-burner on the part of its advocates; but we have failed to discover any reliable and systematic trials which prove that, when the rapid depreciation of the burner and frequent breakage of the chimneys is included, the cost is less than that of ordinary gas-burners. As might have been expected from the short life of these Welsbach burners, even under the favourable conditions of interior lighting, the experiments at Munich show the utter unfitness of the incandescent gas-burner when exposed to rough treatment, such as is inevitable in open-air lighting. Three different forms of lantern and of igniting apparatus were used in these trials. In the "Berlin" lanterns the ignition was by means of a pilot jet, burning against the Welsbach mantles; and in two months no less than 14 mantles and 25 chimneys were used as renewals for four burners. This represents maintenance at the rate of 21 mantles and 38 chimneys per burner per annum. Electric spark igniters were tried, and gave good results in fair weather, but failed when the air was damp. When the pilot gas jet was placed in the most favourable position, it was found that the depreciation was at the rate of three or more mantles per burner per annum. Moreover, it is found to be necessary to keep two sets of men engaged in looking after the lamps: one set for lighting and extinction, the other set for repairing the defects which frequently manifest themselves. In this way the cost of attendance is raised to a much higher figure than even with ordinary gas burners; while it is, of course, enormously greater than with electric lighting.

The project for the Chicago and St. Louis Electric Railway is getting on as well as can be expected. The mail brings us a batch of American electrical papers, in which we see that the scheme has advanced as far as half-tone illustrations of the passenger car and the motor truck. There is, however, a suspicion about these pictures of their having been photographed from one-inch-to-the-foot models standing on an office table. The distance between Chicago and St. Louis is considerable, but experience will probably show that it is not greater than that between newspaper illustrations of models and the completion of the actual project.

Institute of Chemistry of Great Britain and Ireland.—An examination in practical chemistry for the membership will be held in the laboratories of the Institute, 30, Bloomsbury-square, W.C., on Monday, July 2nd, and following days.

Muirhead v. Commercial Cable Company.—We are informed that the Commercial Cable Company will appeal from the decision of Mr. Justice Kennedy. There are over 50 cases on the appeal list in front of this, so that it will possibly not come on for hearing until after the Long Vacation.

The Zédé Electrical Submarine Boat.—A telegram from Toulon states that a fire has occurred on board the submarine boat "Gustave Zédé," by which two electrical engineers were half suffocated. The boat sustained serious damage, and had to be sunk.

Cable Interruptions and Repairs:—

	Date of Interruption.		Date of Repair.
Cayenne Paramaribo	Oct. 25, 1893	......	May 29, 1894.
Bissao-Bolama	Nov. 24, ,,	......	—
Brest-St. Pierre (P.Q. Co.) ...	Mar. 29, 1894	......	—
Accra-Kotonou	Apr. 1, ,,	......	—
Lagos-Accra	May 21, ,,	......	—

The Hermite Process of Sanitation.—We have received a copy of the "Reports of the *Lancet* Special Analytical Sanitary Commission on the Hermite Process of Sewage Treatment by Electricity," which has been reprinted from the *Lancet*, May 26, 1894. Copies of these reports may, we understand, be obtained at the office of the *Lancet*, 433, Strand, W.C.

Technical Education.—The *City Press* says that in consequence of the large increase in the number of students at the Finsbury Technical College, the Governors of the City and Guilds of London Institute propose to extend the buildings by taking in additional premises at a rental of between £500 and £600 a year. Upon the alteration and adaptation of the premises it will be necessary to expend about £4,000.

Return Currents.—In a recent number of the *Boston Herald*, Mr. H. C. Cushing, jun., an electrical inspector for the Boston Board of Fire Underwriters, cites several instances where electric currents of considerable strength have been carried into buildings through gas or water pipes. Mr. Cushing states that in the basement of one building a man obtained a current of 25 amperes at 8 volts by simply twisting his wires around two different water pipes which entered the building.

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Sunderland.—Prof. Kennedy has presented his report on the proposed electric lighting of this town to the Corporation. From the plans sent him he judges that the suggested arc lighting will replace 80 ordinary street lamps, and about 12 100-c.p. Sugg lamps. At 60 yards apart, he makes out that about 50 lamps will be required. He estimates the cost at £40 a year for all-night lamps, and £20 for half-night lamps. The total would be £1,500 per annum. On the whole, at the lowest estimate, the cost of arc-lighting would be about £550 per annum more than the cost of gas, but the amount of light in the streets would be at least 20 times as great as at present.

Search-Light Manœuvres.—Experiments with the electric search-light were carried out by the naval and military authorities at Cremyll on Friday last and again on Saturday night. On Friday evening the lights were fixed on the beach, but on Saturday night they were removed to the Garden Battery at Barnpool, and the dynamos of H.M.S. "Scourge," moored in the pool, kept the light going. Two torpedo boats belonging to H.M.S. "Defiance," torpedo schoolship, which had been previously sent outside the Breakwater, attempted to force an entrance to the harbour and the light was brought to play on them, not only for the purpose of detecting them but to enable the military authorities to photograph them.

Royal Society.—The following Papers were down for reading yesterday:—Dr. J. Hopkinson, F.R.S., and E. Wilson, "Propagation of Magnetisation of Iron as affected by the Electric Currents in the Iron;" Lord Kelvin, P.R.S., and Magnus Maclean, "On the Electrification of Air;" P. Cardew, "Note on the Possibility of Obtaining Unidirectional Current to Earth from the Mains of an Alternating-Current System;" S. Bidwell, F.R.S., "On the Effect of Magnetisation upon the Dimensions of Iron Rings in Directions Perpendicular to the Magnetisation, and upon the Volume of the Rings;" H. Tomlinson, F.R.S., "The Effect of Mechanical Stress and of Magnetisation on the Physical Properties of Alloys of Iron and Nickel and of Manganese Steel."

Step-Up Centrifugal Pumps.—In order to avoid the necessity of transforming circular into rectilinear motion in the case of electric pumps operating under high lifts, Messrs. Dumont, of Lille, have adopted a rather interesting expedient. On each side of the motor, and fitted to the same bedplate, two centrifugal pumps are mounted, the fans of which are keyed on the armature shaft of the motor. The whole four of these pumps are mounted in series, that is to say, the discharge pipe of the one pump is connected to the inlet of the other, so that the final difference of head between inlet to the first pump and the discharge pipe of the last, is the sum of the heads due to the four pumps taken separately. The plant in question was supplied to the Altai Mines, and the total lift is about 160ft.

Thunderstorms.—On Saturday afternoon last a violent thunderstorm passed over Bridgwater. The captain and mate of the ship "Sarah," of Gloucester, took refuge from the storm under a tree on the river bank, and both were struck by lightning. The latter was killed instantly, his body being greatly disfigured, but the skipper escaped without serious injury. During the storm at Highbridge, in the same district, several sheep which were grazing in a field were killed by lightning, and a deep furrow is said to have been ploughed up for some distance across the field. At Malvern a church steeple was struck, and received considerable injury, and the parish church of Bromsgrove was similarly damaged. At Mollington, near Chester, the thunderstorm did considerable damage, wrecking a portion of a house, and injuring a man and child.

Atmospheric Electrification and Snow.—According to the second yearly report of the Sonnblick Society, in addition to the regular meteorological observations special attention is paid by the observer, P. Lechner, to investigations of atmospherical electricity, and some interesting results have been already obtained. It is found that the electric condition of the earth at the summit remains nearly constant during clear days throughout the year, so that, owing to its height and configuration, it is free from the daily and yearly fluctuations of electricity which are observed on the earth's surface at lower levels. It would be interesting to know whether this has also been observed at other mountain stations. The observations of St. Elmo's Fire have shown the interesting fact that when snow falls in large flakes the electricity is almost always positive; but when the snow consists of dust-like particles, negative electricity is developed.

The Fleuriais Electric Log.—In 1878, Admiral Fleuriais, of the French Navy, brought out an electric log, which was tried on the "Magicienne." It may be described as a small water-mill with a wheel consisting of cross-arms tipped with cups like an anemometer. As the cups revolved in the water while the ship moved, a contact on the axle interrupted an electric current flowing through a wire between the ship and the log, and sounded a telephone. The note given out by the telephone was a measure of the number of revolutions per minute of the log and the speed of the ship. At high speeds, however, the ear was not quick at recognising the note, and Admiral Fleuriais has substituted for the telephone an electric bell, which is struck every 24 revolutions of the mill-wheel or vanes. By timing the interval between two strokes of the bell the speed of the ship is obtained. The apparatus has been tried on board the "Océan" and other men-of-war, and recently adopted by the Minister of Marine.

Electrical Traction and Variable Speed Gear.—The experience of the past few years has been that electrical engineering problems of the greatest difficulty and importance have passed into the hands of mechanical engineers. Electricians have been slow to recognise the importance of the mechanical element in matters of electrical engineering. In connection with electrical traction, we have often referred to the importance, indeed, the necessity, for variable speed gear, if electric traction is to become a commercial thing. Now, we learn that a very powerful rival to electrical traction, namely, the Gas Traction Company, knowing the importance of what we have urged, has secured an exclusive licence to use the Beaumont variable power gear for gas and oil traction purposes on tramways and light railways. For electrical traction it is, if anything, more important that variable power gear should be used. The Gas Traction Company will now only use one gas-engine to each car, instead of two to each car, and in the same way tramcars might be fitted with about half the motor power now required, if this gear were employed, and there would be a corresponding saving in the generating station.

Institution of Civil Engineers.—At the annual general meeting of this Institution on Tuesday, the tabular statement of the transfers, elections, deaths, and resignations during the year showed an effective increase of 188 on the previous total of 5,371, while, as regards the students, the decrease was 28. The total receipts amounted to £25,576. The general expenditure has been £17,489 (including £8,050 for publications). A sum of £10,000 has been placed on deposit to meet the considerable sums which will be required at an early date in connection with the new building. The summary of investments showed that there altogether stood to the credit of the Institution £133,673. A decision has been arrived at to utilise the sites of Nos. 24, 25, and 26, Great George-street, and designs for a new building had been prepared by Mr. Charles Barry, F.R.I.B.A. It is hoped that the work may be commenced early in the recess. The ballot for Council resulted in the election of Sir Robert Rawlinson, K.C.B., as President; of Sir B. Baker, K.C.M.G., Mr. J. W. Barry, Mr. W. H. Preece, C.B., and Sir Douglas Fox as Vice-Presidents; and of Dr. W. Anderson, A. R. Binnie, W. R. Galbraith, J. H. Greathead, Sir Chas. A. Hartley, K.C.M.G., J. C. Hawkshaw, C. Hawksley, Dr. Alex. B. W. Kennedy, Sir Bradford Leslie, K.C.I.E., J. Mansergh, Sir Guilford Molesworth, K.C.I.E., Sir E. J. Reed, K.C.B., W. Shelford, F. W. Webb, and Dr. W. H. White, C.B., as other members of Council.

The Manufacture of Engineers.—A correspondent of *The Engineer* discusses the relation of technical colleges to the present enormous output of "engineers," and we make the following extract from his letter:—

"I have not a word to say against technical education for working men: I speak of something much higher. Take, for example, the engineering schools in connection with University College, King's College, and so on. Every day new workshops with most costly laboratories are being opened

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with a great flourish of trumpets and beating of drums. Lord Kelvin opened one at Cambridge on Monday week, for example. Sir Frederick Bramwell hinted in the course of the proceedings that there might be too many of these things already. I wish he would speak out. All these places compete with each other. They supply employment for professors and demonstrators. The competition for the chairs is enormous; work must be found for these gentlemen, and no stone is left unturned to get pupils. This has gone on now for some years, and is going on still. Now, I hold it is time the truth was made known. The truth is that hundreds of young men are turned out who are believed by their parents, and also by themselves, to be engineers. My standard of an engineer is that the man calling himself one should be able to do work for which he can get paid. Putting this in a very coarse way, I hold that a man is not an engineer unless he knows enough to make his bread by engineering. That is precisely what 90 per cent. of the college-trained youths cannot do. No college can give that training which alone imparts commercial value to a man. But let me suppose that the contrary is the case, and that every youth who has had three years' training in a technical college—not school, observe—is really competent in the fullest sense of the term, what follows? I am sure I am not over the mark when I assert that about 2,000 young men are turned out of the colleges of the United Kingdom every year who are 'engineers.' Where on earth is this host to find work?"

Magnetic Properties of Soft Iron at Different Temperatures.—At a recent meeting of the Société Française de Physique, M. Curie read a Paper on the magnetic properties of soft iron at temperatures between 20deg. and 1,350deg., and for magnetising forces of 25 to 1,350 units. He has drawn a series of curves showing the connection between the magnetising force and the intensity of magnetisation at different temperatures. For magnetising forces up to 1,300 units the different curves do not differ much, but for higher values of the magnetising force they separate to a more marked degree. For temperatures between 756deg. and 1,375deg. the curves obtained are straight lines passing through the origin, showing that between these temperatures the susceptibility is a constant and independent of the magnetising force. The author has also plotted a series of curves connecting the intensity of magnetisation (I) and the temperature, the magnetising force being constant. The value of I is at first constant as the temperature rises, then it diminishes faster and faster till the change becomes most rapid at a temperature of about 745deg. Above this temperature the rate of change of I diminishes. Between 950deg. and 1,210deg. the value of I only diminishes slowly, while at a temperature of 1,280deg. it increases suddenly, and then as the temperature goes on increasing it gradually diminishes. The author finds that at any given temperature the value of I obtained is independent of whether this temperature has been reached by warming the body or by cooling.

Electrical Resistance of Alloys.—An interesting Paper by M. van Aubel, on the electrical resistance of some new alloys, was recently read before the Société Française de Physique. In the first place the author gave some particulars about a form of steel called "kruppin," manufactured by Herr Krupp, at Essen. This alloy has a specific resistance of 84·7 microhms at 18°C., or of 85·5 if the sample has been heated for several days. The mean coefficient of variation of the resistance with temperature decreases slightly with increase of temperature, but is always nearly equal to +0·0007. This body, although it has relatively high specific resistance (that of german silver being 20·76), can be heated to a temperature of 600°C. without change of structure, and can be obtained in the form of wire or sheet. The author also gave particulars of the experiments made on some nickel alloys manufactured by Messrs. Fleitmann, Witte and Co., of Schwerte (Westphalia). One of these alloys (marked I_a I_a) has when hard a specific resistance at 20°C. of 50·2 microhms and a temperature coefficient of −0·000011, while when soft its specific resistance is 47·1 microhms and its temperature coefficient +0·000005. This alloy may prove of considerable practical utility, although if it is found that its thermoelectric power with reference to copper and brass is, as is generally the case with these alloys, at all great, this will in a great measure prohibit its use in cases where great accuracy is required. During the discussion on the above Paper M. Guillaume mentioned that an alloy of 68·6 parts copper, 30 parts manganese, and 1·3 parts of iron has a specific resistance of 108 microhms, while its temperature coefficient is very small, even passing from positive to negative as the temperature rises. He also mentioned that the difficulty of the high thermoelectric power with reference to copper could be overcome if the wires are soldered to plates of the same alloy, which are in turn soldered to the copper connectors of the resistance boxes or Wheatstone bridges.

The Supply of Electricity at the Chicago Exhibition.—The following report on the supply of electricity at the Chicago Exhibition has been presented by Mr. H. D. Wilkinson, the Director of the British Section, to the Royal Commission:—

It was by the division of the whole lighting scheme into sections for which contracts were entered into with different nationalities, that the lighting at Paris in 1889 was such a representative display. With one or two exceptions, notably in the case of Messrs. Siemens and Halske, who had the contract for lighting the terminal station, the whole of the electrical power plant was American. Secondly, in the electrical building, no steam was furnished or allowed, the idea being that electrical power alone was appropriate to use. This secured a grand display for the electrical transmission of power, but was fatal to a large class of exhibits of great importance. Practice in both lighting and power is now almost entirely in direct coupled engines and dynamos, and such coupled plant here exhibited could either not be run at all, or had to be run by making the dynamo a motor to turn the engine. This affected our section in three exhibits. The general lighting of the various buildings was by arc lamps run in series on direct current circuits, but for all incandescent lamps and arc lamps required by exhibitors the supply was by high tension, alternating current with transformers. The high-tension wires at 2,500 volts were carried through subways to the principal points in the grounds, and from transformer pits located at points along the route current at 100 volts was taken into the various buildings. The contract for the supply of this current was in the hands of the Westinghouse Electric Company. The charge made by the Exposition Company for the use of lamps for six months was as follows:—Per incandescent lamp of 16 c.p, $8; per arc lamp of 2,000 c.p. $60. To obtain this service the exhibitor had to pay the above in advance, together with the cost of making connection, wiring and fixing lamps, viz.:—Per incandescent lamp $3·50, per arc lamp $3·50. The New York Insulated Wire Company had the exclusive right of putting in all wiring for exhibitors, and instances occurred in our own and foreign sections in which exhibitors had put in their own wiring, but could not obtain current for their lamps until they had paid the above wiring charges to the Exposition. There was great delay in the fixing of exhibitors' lamps, as the first attention had to be given by the Electrical Department to the general lighting of the grounds and buildings, this being very much in arrear. Up to the expiry of the first three months, the full amount of $8 per lamp had to be paid in advance, and claims for rebate on the time of non-supply claimed formally afterwards; but requisitions for light after August were allowed on an advance payment of less than $8 per lamp, according to the time for which light was actually supplied.

A New Conduit Electric Traction System.—At a recent meeting of the American Institution of Civil Engineers, Mr. Albert Stetson described a conduit system of electric traction which he considers capable of meeting the exigencies of the service in American cities. He asserts, says *Engineering*, that the successful solution of the problem is a much more difficult matter in the States than in Europe. In the first place, the extremes of climate are great; secondly, the roadways are in general badly kept; and, in the third place, the narrow tyres common on American pleasure vehicles limit the width of slot which can be adopted. The conduit he recommends is of small dimensions, one 2in. or 3in. wide by 7in. deep answering all requirements. The conduit is slotted, and through this slot pass the rods attaching a contact shoe, which runs in the conduit, to the car, the attachment being so made that in case of a car leaving the rails, the shoe remains behind, without injury either to itself or the conduit. In the conduit two insulated cables are placed, a metallic return being used. These cables run into contact boxes, placed alternately at intervals of 10ft. on either side. In each box is a contact plug, passing through an insulating bush, which, as the shoe reaches it in its passage along the conduit, is depressed, and makes contact with the cable below, thus placing the car in electrical communication with the cable at that point. When the shoe has passed, the contact plug is raised by a spring clear of the cable, and no leakage can then take place between the plug and any snow mud, or dirt which may be in the conduit. The shoe is long enough to extend over at least three of these boxes at one time, and one side of it is thus connected to the positive main and the other to the negative one. Every precaution is taken to prevent sparking in breaking contact in these boxes. The ends of the shoe are insulated, and thus depress the plug into contact to the cable before the circuit is completed from the box through the car. To insure easy working, the boxes are also filled with oil. A test of the system was made, after filling the conduit for a distance of 75ft. with water and mud; under the conditions, it is said, there was practically no leakage, even after four days' submergence.

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THE BRIGHTON ELECTRIC SUPPLY STATION.

Brighton claims the distinction of being one of the first English towns in which there was a system of electric lighting from a central station. It was at the commencement of 1882 that Mr. Hammond commenced to supply electric light to that town. In the following year his works were taken over by the Hammond Electric Light and Power Supply Company; and in the same year the Corporation was granted its Order. Many years passed, however, before the Corporation made any efforts to use the Order it had acquired, during which time the Company struggled on against numerous difficulties. In 1885 the name of the Company was changed to the Brighton Electric Lighting Company, and three years later saw it the possessor of the name of Brighton and Hove Electric Light Company. Up to 1889 the Company had been working without statutory authority; while the Corporation had held their statutory authority without working. After this date the Company made effort after effort to acquire the necessary Order; but it was defeated on each occasion through the active opposition of the Corporation. At this date, moreover, the Corporation set about erecting a station and supplying a portion of its statutory area, and from time to time the area of supply was extended. The Company never got its working powers, and it was bought out by the Corporation in January last under the understanding that the Company should continue working until September 30, 1894, during which time the customers of the former will be transferred to the mains of the latter. The first system which was in use by the Brighton Company was the series system, with parallels of lamps on a 10-ampere circuit, Brush arc-lighters being used. Probably in no other instance in the history of electric lighting has this system been so carefully and successfully developed as in the hands of Mr. Arthur Wright at Brighton, automatic regulators, gravity electrostatic voltmeters, electricity meters, fault-locating apparatus, several kinds of automatic switches, and other ingenious devices were in regular use until the series system was superseded in the spring of 1888 by an alternate-current plant. The system adopted by the Corporation is the low-pressure, three-wire, continuous-current system for the greater part of the town combined with a high pressure plant for the outlying parts. The cables of the Company had been carried overhead, while the mains of the Corporation were to be placed underground. Considerable extension of the Corporation mains have been made this year.

We have entered somewhat fully into the history of electric lighting in Brighton, because it is necessary to have some knowledge of this in order to understand the present state of things at the Corporation station, which we shall now describe. Partly on account of this condition of things, and partly because of the careful and scientific way in which the consumer has been induced to use his supply, there exists at the Corporation station a condition of economy and a load-factor which is in the highest degree satisfactory. We have already stated that the three-wire continuous-current system is being used, and we may add that both the street arc lighting and the consumers' lamps are supplied from the same network. The public lighting is at present confined to the sea-front, where there are a large number of well-designed lamp standards and 3,000 c.p. arc lamps. One of these lamp standards is shown in Fig. 1.

In its present incompletely developed state the Corporation station might be rated at about 1,280 H.P., this being the total capacity of the existing plant. But extensions are being rapidly pushed forward; there is floor space enough under the present roof for several hundred more horse-power, and plans are being drawn up for the erection of another set of buildings —boiler-house and engine-room—at the back of the station now fronting on North-road. This satisfactory rate of extension is explained by the rapidity with which customers are being connected, to some extent by transference from the other system, and the others in the usual way. At the end of 1892 not more than 210 houses were connected to the Corporation mains; at the end of last year the number was just double this, or 420, and now there are over 500.

Steam is raised, at a pressure of 150lb., in six Lancashire boilers, 28ft. by 7ft., three of which were manufactured by Messrs. Yates and Thom and three by Mr. Danks of Oldbury. No furnace economiser is used, but the feed-water, which is of a very hard quality containing much chalk, is previously heated by the exhaust steam, in two feed-heaters placed at the back of the boiler-house and close to the chimney. The whole of the exhaust steam can be used for this purpose as,

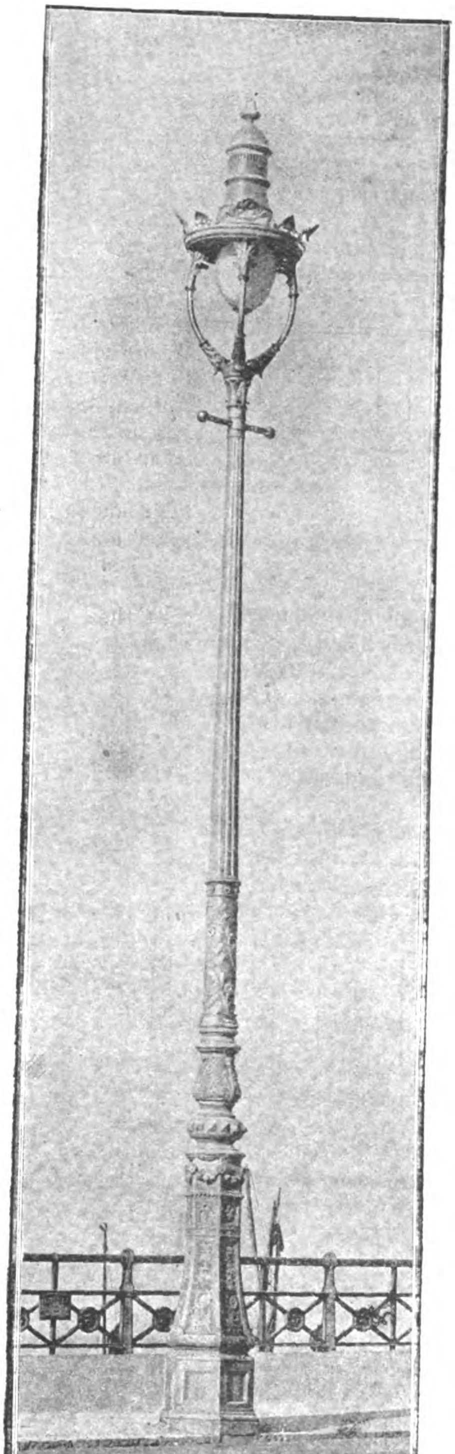

FIG. 1.

at present, none of the engines are condensing. The water is supplied to the boilers by means of direct-acting feed-pumps. The steam mains are of steel, 6in. and 7in. in diameter.

In the engine-room there are, at present, six direct coupled dynamos, driven by Willans engines. Four of these steam dynamos, namely, two large ones and two small ones, are ranged in a row across the width of the room; while the remaining two large steam dynamos form half of a row of four which

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will be placed along the length of the engine-room. The two smaller engines are 2-crank compound non-condensing engines; and each of the smaller dynamos develop 300 amperes at 150 volts, running at 450 revolutions per minute. These dynamos are of the Goolden type, fitted with Latimer-Clark armatures. The two larger machines, which are in the same row with the small ones, are each capable of developing 400 amperes at 300 volts, running at 350 revolutions per minute; and they are of the above-named type. The two other large engines are 3-crank compound non-condensing Willans engines, each of 360 H.P., and they are direct coupled to Latimer-Clark dynamos. The tender of Messrs. Crompton and Co. has been recently accepted for the supply of plant for the two new 360 H.P. steam dynamos. The exhaust steam from all the engines is conveyed to the feed-heaters, and thence to the chimney, by a 12in. cast-iron exhaust main. In the extensions which are in contemplation it is intended to use evaporative condensers. The illustrations, Figs. 2 and 3, show a vertical section and plan of the station respectively.

Sub-stations, at present, do not form part of the Brighton system; but the generating station is equipped with a spacious and well-stocked accumulator room. Here, there are 141 E.P.S cells of the 96 L-plate type and size, and the duty of these cells is to enable the generating station to be shut down in the small hours of the morning, &c., when there is very little load, thus economising the items of labour and fuel. These cells are employed, as at some battery stations, for varying the feeding pressure.

Engineers claim that their especial language is scale drawings and diagrams; and, with a desire to encourage this wholesome belief of theirs, we have prepared a number of illustrations of the Brighton plant. Among these are Figs. 4 and 5, illustrating the switchboard, and we sincerely hope our readers will understand the language which they speak. One may draw a switchboard; one may design a switchboard; one may even make and erect and thereafter work a switchboard; but language fails when the attempt is made to describe a switchboard. Therefore are we glad that the engineer requires not ordinary language, and that he professes to see everything if only it is served up as a scale drawing. Fig. 4 is an elevation of the exterior of the main switchboard, and Fig. 5 shows its internal connections with the feeders, machines, and batteries. The set of middle or neutral wires of three-wire feeders is connected to the middle part of the switchboard, the two outers, the positive and negative sets of feeders, being connected on either side respectively. By means of screw plugs, which are put into tapped holes in the terminal bars before starting the machines, any one machine may be arranged to

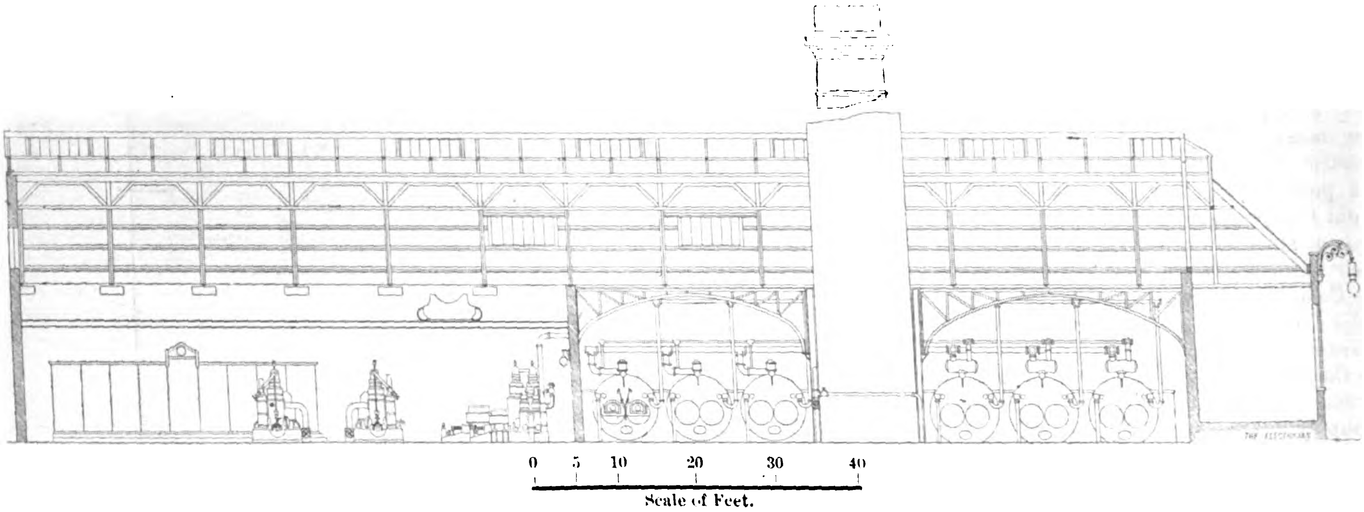

Fig. 2.—Brighton Corporation Electric Lighting Station. Longitudinal Section.

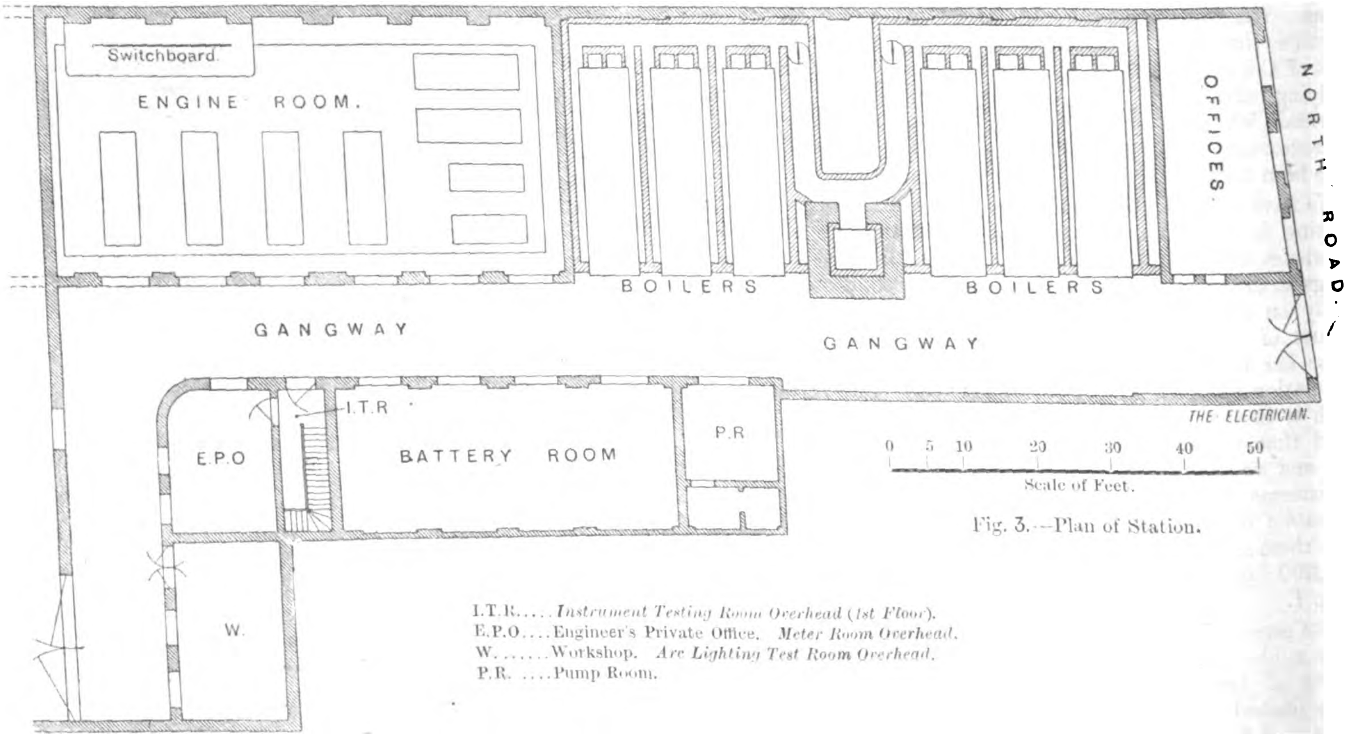

Fig. 3.—Plan of Station.

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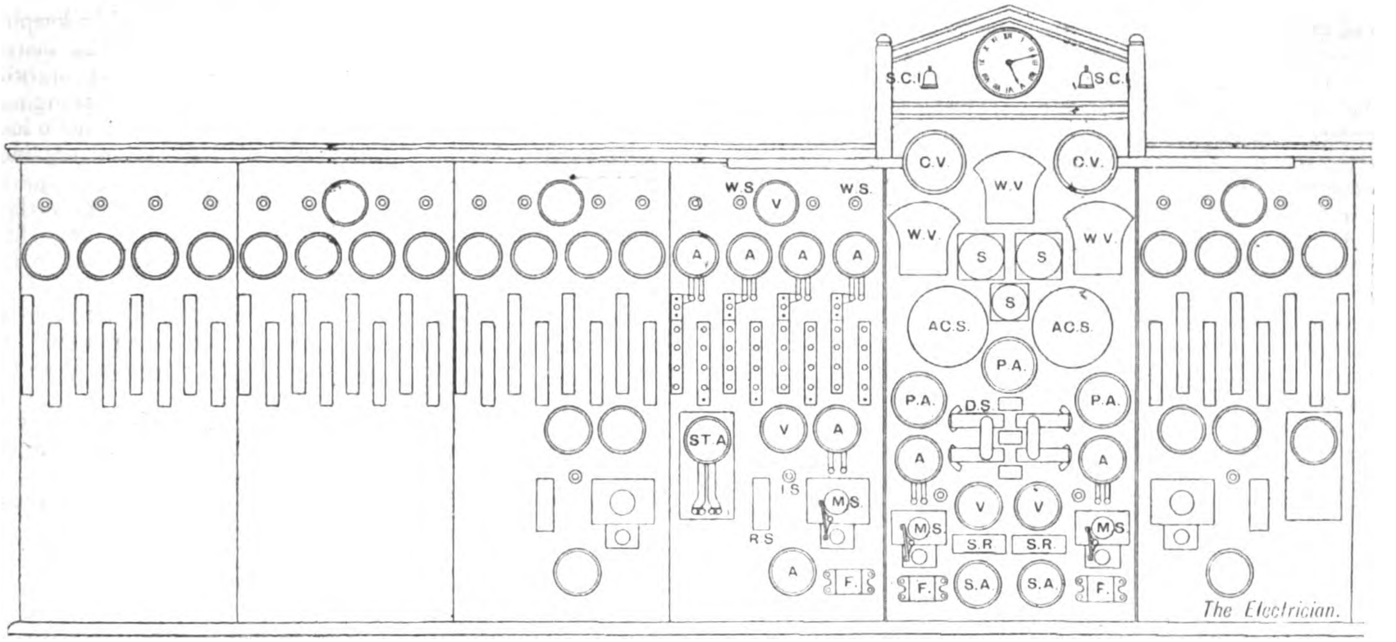

Fig. 4.—Part Elevation of Switchboard.

A., Ammeter.
Ac.S., Accumulator Switches.
C.V., Cardew Voltmeters.
D.S., Dynamo Switch.
F., Fuses.
I.S., Indicator Sockets.
M.S., Main Switches.
P.A., Polarised Ammeters.
R.S., Regulating Switches.
S., 24-Point Switches.
S.A., Shunt Ammeters.
S.R., Shunt Rheostats.
S.C.I., Short Circuiting Indicator Bell.
St.A., Station Ammeters.
V., Voltmeter.
W.S., Wall Sockets.
W.V., Weston Voltmeters.

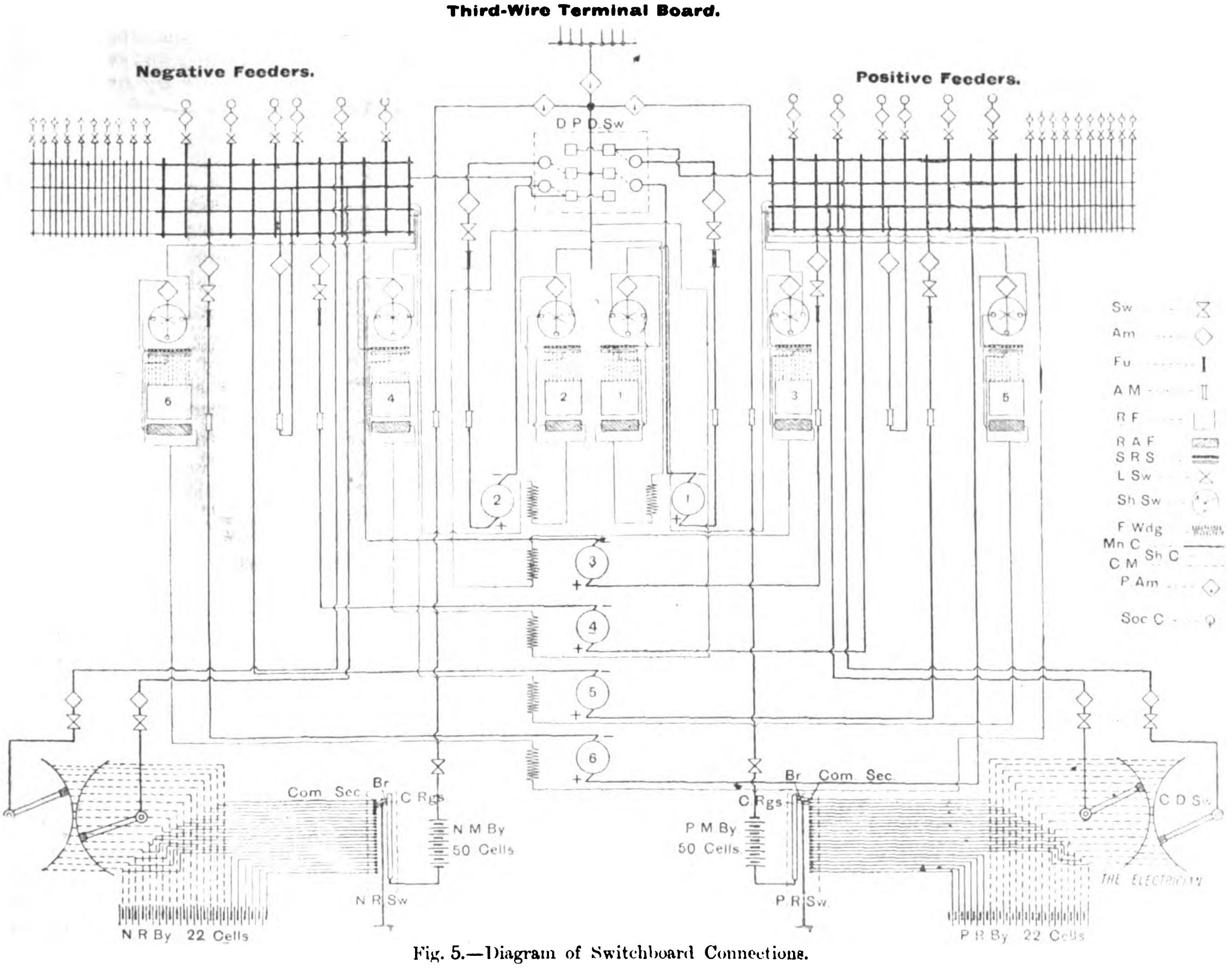

Fig. 5.—Diagram of Switchboard Connections.

Am., Ammeters.
A.M., Aron Meters.
Br., Brushes.
C.D.Sw., Charge and Discharge Switches.
C.M., Connections already made.
C.Rgs., Contact Rings.
Com.Sec., Commutator Sections.
D.P.D.Sw., Double Pole Dynamo Switch.
Dynamos—Nos. 1 and 2, 100 volts, 400 amp.
Nos. 3 and 4, 300 volts, 400 amp.
Nos. 5 and 6, 300 volts, 735 amp.
Fu., Fuses.
F.Wdg., Field Winding.
L.Sw., Link Switches.
Mn.C., Main Connections.
N.R.By., Negative Regulating Battery.
N.R.Sw., Negative Main Battery Regulating Switch, worked by Wheel on Switchboard.
N.M.By., Negative Main Battery.
P Am., Polarised Ammeter.
P.M.By., Positive Main Battery.
P.R.Sw., Positive Main Battery Regulating Switch, worked by Wheel on Switchboard.
P.R.By., Positive Regulating Battery
R.A.F., Resistance Placed Across Field to Prevent Switch Arcing
R.F., Resistance Frame.
Sh.C., Shunt Connections.
Sh.Sw., Shunt Switches.
S.R.S., Shunt Regulating Switch
Soc.C., Socket Connections.
Sw., Switches.

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feed any combination of feeders; and by means of quick-break switches, the ordinary connections or disconnections are made during the run. By this arrangement it is possible to group the feeders together in sets, and to transfer the sets or separate feeders from any one machine to any other at will. The index letters on the illustrations are explained in the notes which accompany them.

In the present network there are 16 feeding points. The feeders are of armoured cable, and have a normal current density of 1,200 amperes per square inch. The feeding points are at an average distance of 500 yards apart, and by the system of regulation which is adopted, a variation of not more than two volts occurs at any point in the network of distributors. In the daytime the pressure between the middle or neutral wire and the two outers is kept at 116 volts, and the pressure of the mid-points between the feeding points is not less than 114 volts. But in the evening, when the load comes on heavily, and when there would be a tendency to reduce the pressure at the mid points below 114 volts, the pressure at the feeding points is raised to 118 volts, thereby compensating for the increased drop in the distributors at high loads. It is found that this gives a much better regulation, as might be expected, than where the pressure at the feeding points is kept constant at all loads.

Great care has been exercised in the design of the three-wire network of distributors. From the exceptional information which Mr. Arthur Wright, the Corporation electrical engineer, is able to obtain through the use of his maximum demand indicator, a description of which we give below, it is possible to so arrange the local loads on each side of the neutral, as that very little current shall pass through the neutral wire. In fact, in many cases there is no return of current to the station, or flow from the station, by the middle wire; and this conductor acts merely as an inter-connection for the lamps. The streets in the area of supply are classified as "standard streets," "half-standard streets," &c., according to their probable demand; and the amount of copper laid down is based upon this system of estimation. A standard street is one which requires one ampere per yard run in the outer conductors.

The distributors once laid, great care is exercised in keeping them balanced. Again the demand indicator is the instrument which renders this possible. Each consumer is carefully checked as regards the variations of his demand throughout the year, and he even is honoured with a separate little load diagram indicating his doings; and the information obtained in this way enables the Corporation's electrical engineer to draw up a chart of the network, dotted over its surface with little circles containing two sets of numbers. The first number in each circle gives the mean of the currents in the two outer mains of the particular branch, and the second number gives the difference between the positive and negative outer currents, or the current in the balancing wire. Of course the new consumers are so placed as to tend to keep the latter number as near zero as possible.

We now come to the demand indicator, which merits some description, as it furnishes a correct means of ascertaining the actual call each consumer makes upon the generating plant of the central station. In order to understand the duty of this instrument it is necessary to describe the system of charging adopted by the Brighton Corporation, which is as follows:—7d. per unit is charged until the quantity consumed amounts to a use of the average maximum demand for 365 hours in half a year, which equals two hours per day, and all current consumed in excess of this quantity is charged at 3½d. per unit. The average maximum demand of each consumer is directly shown by the demand indicator being read once a month and the mean being taken as the consumer's actual demand. The Brighton instruments are calibrated to show directly the number of units to be consumed in the half-year before half price is charged instead of in amperes, as, at the Brighton voltage, each ampere used for two hours per day equals 42 units in the half-year. On this system the consumer is allowed a rebate directly his own load factor exceeds 8⅓ per cent. But the consumer is allowed to have a blaze of light occasionally, without fear of being betrayed by the faithful indicator. In order to prevent any single special demand for electricity raising the number of full-price units, the consumer may, in the event of his intending to burn a number of lamps in

FIG. 6.

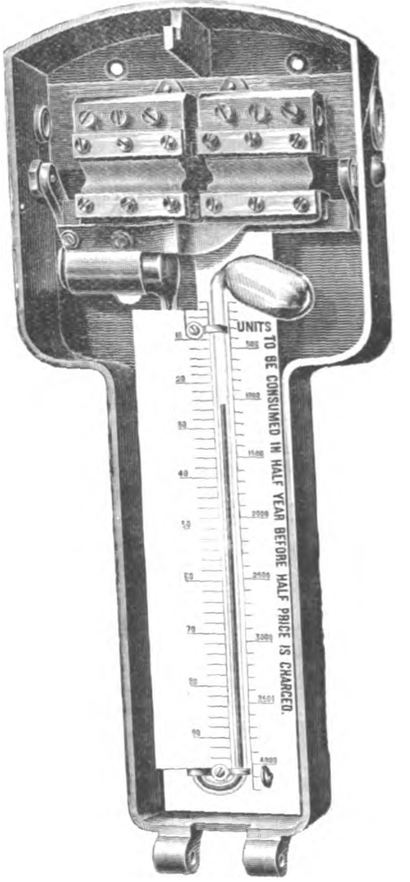

FIG. 7.

excess of his usual maximum on any such occasion not exceeding once in each month, give 24 hours' notice, in writing, of such intention to the Corporation, and they will thereupon short circuit the consumer's "demand-indicator" from registering the demand on the occasion so notified. Two views of this indicator are seen in the accompanying drawings; Fig. 6 shows the front exterior of the instrument, as it is placed in the consumer's house, and Fig. 7 shows the interior arrangements of the latest pattern. The current passes through a heating resistance coil which surrounds a sealed glass bulb, connected to which is a U-shaped tube filled with liquid, with a trap bulb at its further end. On current passing through this heating coil the air in this bulb is expanded and forces part of the liquid in the tube to overflow into the trap bulb where it remains until reset. When the current is cut off the air in the heating bulb naturally contracts, and the liquid in the tube therefore recedes, leaving a part proportional to the maximum current that has passed in the trap bulb, and displaying in the tube against the scale a shortened column of liquid similar to a thermometer. It will be seen that the lower the column of black liquid in the glass stem, the greater must be the number of full-price units consumed before the 50 per cent. rebate commences. The heat developed is, of course, proportional to the square of the current, but, owing to the cushioning due to the air in the receiver bulb, the volume of liquid spilled is practically proportional to the first power of the current.

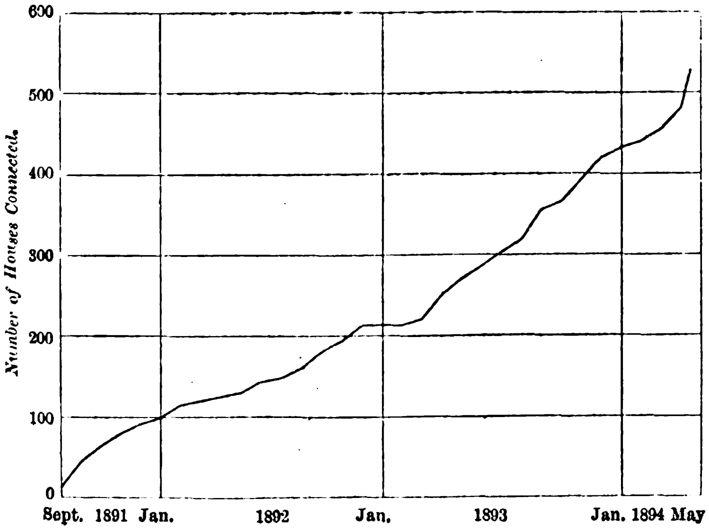

FIG. 8.

Great care is taken to calibrate every indicator, but the scales are almost exactly, if not quite uniform. The instruments are reset very easily, all that is necessary being to tilt the interior part, which is hinged for the purpose, until the liquid in the trap bulb flows back and refills the tube. The loss of pressure does not exceed half a volt even in the smallest instruments, and is quite inappreciable in the larger ones. The influence of this demand indicator upon the habits of the consumer is most salutary. Instead of burning a great many lamps at a time for short periods, he is induced to burn a normal number of lamps for long periods; thereby unconsciously flattening the station load diagram and filling out the work of the plant over an extended period. Mr. Wright informs us that the influence of this indicator has been most marked, and he reports that the station load factor is now 15 per cent. better than during last year. He also informs us that he has great hopes that the satisfactory result of the present year's working will enable the Corporation to reduce the number of hours each consumer has to use his demand from two hours to one hour per day, or in other words, to give every consumer whose load factor exceeds 4·17 a reduction proportional to the excess of his load factor above this figure. We are glad to be able to state that there are no signs either of lamp saturation or of saturation of the first differential coefficient between lamps and time, on the Brighton mains; and that although the load is thus increasing at an increasing rate, the hours per lamp are also on the ascending scale. The accompanying curve, Fig. 8, shows the rates of increase of the total number of houses wired, from September, 1891, to the present time.

Our thanks are due to Mr. Arthur Wright, the Corporation electrical engineer, for his kindness in supplying us with particulars and numerous drawings of the Brighton electric supply system, and for his courtesy in allowing us to explore the station.

SOME VOLTAIC COMBINATIONS WITH FUSED ELECTROLYTES AND GASEOUS DEPOLARISER.*

BY J. W. SWAN.

In this Paper are described several voltaic combinations in which fused electrolytes and a gaseous depolariser were used. The electrodes were the same in all the experiments, viz., lead in a fused state as the positive, and carbon as the negative. The electrolyte used in the first experiments was a fused mixture of KCl, NaCl, but this was changed for one of $PbCl_2$. The depolarising gas used in all the experiments was chlorine, and was so applied as to chemically act on the electrolytic products formed at the carbon pole. Several methods of applying the gas were employed—by forcing the gas through porous carbon, by making the carbon pole tubular, and feeding the chlorine through it, and by nearly wholly surrounding the carbon pole by an atmosphere of chlorine.

The condition found to be most necessary for successful depolarisation was *to alternately expose the carbon pole to the action of the gas and electrolyte in rapid succession.* During the electrolytic action, the lead dissolves as chloride of lead, and lead is deposited on the carbon pole, but is immediately reconverted to chloride by the action of the chlorine gas. The theoretical E.M.F. corresponding to the union of Pb and Cl_2 is 1·7942 volts, the highest obtained was 1·40 volts, this lower E.M.F. was probably due to the incomplete solution of the lead at the carbon electrode.

A noticeable feature of this kind of cell is the very low internal resistance, which makes it possible to obtain a large current density with comparatively small electrodes. In one of the experiments a current of 1·0 ampere was given with an area of the carbon of 10 to 12 sq. cm. It was also observed that the internal resistance, and at the same time the polarisation, *decrease*, when the electrical output *increases*, and that the cell gave an almost constant effect. The best results were obtained with small cells, the action of the chlorine being then more effective than when larger cells were employed. Experiments were also made with oxygen as a depolariser, but a description of them is left for a future Paper.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

TO-DAY (FRIDAY), June 1st.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "The Work of Hertz," by Prof. Oliver Lodge, F.R.S.

MONDAY, June 4th.

ROYAL INSTITUTION.

5 p.m. General Monthly Meeting.

TUESDAY, June 5th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "The Modern Microscope; an Instrument for Recreation and Research," by the Rev. W. H. Dallinger, F.R.S.

FRIDAY, June 8th.

PHYSICAL SOCIETY.

5 p.m. (1) Discussion of the Paper by W. Bally and Prof. Ramsay "On the Relations of Pressure, Volume, and Temperature of Rarefied Gases;" (2) An Exhibition of Photographs of Flames by Capt. Abney.

ROYAL INSTITUTION.

9 p.m. Friday Evening Discourse: "The Newtonian Constant of Gravitation," by C. Vernon Boys, F.R.S.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

The Electric Furnace.—In heating magnesia in the electric furnace, M. Moissan has noted a peculiar phenomenon, viz., that this material apparently contracts with heat, its specific gravity rising from 3·193 when cold up to 3·654 at a bright red heat.

* Abstract of a Paper read before the Royal Society.

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The Electrician.

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CENTRAL STATION IDEALS.

The Paper on "The Cost of Electrical Energy," read before the Institution of Electrical Engineers, is the most important contribution that has been made to the proceedings of this body for some time. The first impression after reading it was that it would perhaps have been discussed in a manner more worthy of its contents before the Institution of Civil Engineers. But the discussion, though far from what it might have been had more supply-station men spoken, did fair justice to the Paper, and was a credit to the Institution. The point of the whole argument, namely, the setting up of a high ideal, and the careful examination of the losses which prevent its realisation, was recognised by a very small proportion of those who took part in the discussion. Even if this ideal should prove to be unattainable before the year 1994, this point does not lose its importance. More than one speaker not only completely failed to grasp the idea of comparison with an ideal, but neglected altogether the basis of 5,000,000 units per annum. In setting up a high ideal of this kind it is natural that the separate ideals of the components should be taken, but as Mr. M. ROBINSON pointed out, some of these are mutually exclusive, and as it is difficult to give weighted values to the different *desiderata*, the ideals must be purely theoretical. There is some satisfaction in this, for, as Mr. CROMPTON observed in his reply, we do not want any more MATTHIESSEN'S ideal coppers and 104 per cent. conductivities. Instead of directing their attention to the examination of the differences between the ideals and actual facts, most speakers tried to excuse their shortcomings, and to make out from this feeble point of view that Mr. CROMPTON was a wild enthusiast.

It is perhaps inevitable that the engineers of some supply companies should be reluctant to take part in such discussions. We cannot believe that the remarkable lack of such men on this occasion was due to the consciousness of the shortcomings of the systems with which they are concerned, but rather to apathy, and in some cases inability to make sufficiently careful measurements on which to base

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their remarks. Not every station is equipped with water-meters, pyrometers, or convenient coal-weighing tackle, and it is to be feared that the electrical measuring instruments, especially in alternate-current stations, are sometimes lamentably inaccurate. So long as the pressure is kept fairly steady throughout the district, there is a tendency to neglect further measurements, and the total output is reckoned by adding up the records of the consumers' meters. Judging by our own experience in collecting statistics, Mr. CROMPTON was very fortunate, especially when the statistics were required for rigid analysis and comparison. From one quarter alone unamiable remarks and sneers were received, and these, unfortunately, in the course of the discussion, nor can the discourtesy be excused on the ground that no statistics of the working of the Chelsea Company have ever been published, with the exception of an utterly ridiculous test of the boilers.

The Paper and the discussion thereon were remarkable as the occasion of two announcements of conversion. The author, once an advocate of Lancashire boilers, now believes in Babcock-Wilcox boilers, and Mr. RAWORTH confesses the superiority of direct-driving over rope or belt-driving. The first of these conversions has been the outcome of long observation and careful experiment, and full, though not perhaps altogether convincing, reasons were given. The second came rather as a surprise. With the exception of ship-lighting plant, the Brush Company have, so far as we can remember, never, until the Bankside station was started, departed from the ancient and time-honoured flapping belts or flopping ropes, but Mr. RAWORTH announced that he had been waiting for an opportunity to do what nearly everybody else has been doing for years. It is true that there is a tendency to run alternators at a high speed, simply because ordinary frequencies cannot be obtained from machines of moderate output without the use of huge armatures, but this must be faced by advocates of alternate currents along with the other difficulties of their system. It is, at all events, satisfactory to learn that all rope-driving engineers are not running their heads against a wall, but that one of them, at least, has the frankness to say that "as soon as they could see their way to do it, they would abandon rope driving, and come to direct driving also." Among the contributions to the subject was the creation in the course of the discussion of the expression "antiquation factor" by Mr. HAMMOND. The idea thus embodied has long been recognised, and many a municipality has declined to entertain proposals for electric lighting because improvements are continually being made, and have argued that the hopeless antiquation of any plant that they might purchase would therefore be only a question of time. A man might as reasonably spend all his life in bed because, owing to the inevitable changes of fashion, any clothes he put on would some day be out of date. This factor is worthy of consideration, though there is nothing alarming in it, and the most important application that has, as yet, been experienced is the abandonment of house for sub-station transformers.

Prof. UNWIN's apology for taking part in the discussion, on the ground that he was only a mechanical engineer, reminds us that the chasm which once separated the electrician from the engineer has been steadily closing up, but there is an indication now and then that a chink yet remains. Some men will always be mechanical engineers, and get some one at three or four pounds a week to do the electrical part for them; others will always be mere electricians, and they will only succeed when they are sensible enough to seek assistance from mechanical men. Prof. UNWIN's remarks on superheating were of great interest, and only on one point was he out of touch with the subject of the Paper. Twenty-four-hour tests of boilers are of little or no use to men who have to deal with a load factor 15, and regard 20 as a happy ideal. Comparisons of boilers on different load factors are worse than useless. The same criticism applies to Mr. CROMPTON's Table IV. of the "Maximum Efficiency of Sundry Types of Boilers at Test Trials." The Babcock-Wilcox boiler is credited with an efficiency of 76·5 per cent. on the strength of a five hours' trial conducted by Prof. ROBINSON on a battery of five boilers, all of which were continuously and fully loaded. The figure for the marine boiler, however, is derived from a totally different kind of trial, and is given by Mr. CROMPTON as only 63 per cent. Mr. CROMPTON derives this low figure from a go-as-you-please two days' trial of the boilers at Glasgow, by Prof. KENNEDY. The boilers took the load as it came on; and, while the mean load during the trial was only 198·7 kilowatts, the maximum load was as high as 669·4 kilowatts. Mr. CROMPTON therefore offers for comparison a trial of the Babcock-Wilcox boiler on a purely ideal 100 per cent. load factor, and a trial of a marine boiler on no higher than 29·7 per cent. load factor. A good many engineers still believe that Lancashire boilers are yet in the running, and we are inclined to think that one reason why they are not pushed is that there are no important patents, and it is worth nobody's while to push them. A boiler patented in principle, patented in design, and patented in detail, pushed by a sole and exclusive agency, and a smart agent who will furnish working drawings of settings and flues, and throw in advice about steam pipes, or will on an occasion design a whole station from the coal store as far as the stop valves on the engines, saves consulting engineers so much trouble that it is sure to be popular. If it chance to be a good boiler, so much the better.

A METHOD FOR THE TREATMENT OF ROTATING OR ALTERNATING VECTORS, WITH AN APPLICATION TO ALTERNATE CURRENT MOTORS.

BY PROF. GALILEO FERRARIS.

(Continued from page 112.)

7 (*b*). *Alternating Vectors of Different Direction.*—If the two given alternating vectors, a and a', are not parallel, the general construction explained in Art. 5, and represented in Fig. 6, leads us to find that the two given vectors are equal to two vectors, one alternating, of fixed direction, represented by O A, and the other rotating, of constant value, represented by S″ S′. But we have particular cases in which of these two vectors there exists sometimes the one and sometimes the other. There exists only the alternating vector of fixed direction when the two component alternating vectors have the same phase.

In fact, in this case the angles O S S′, O D D′ (Fig. 8) are both equal to the supplement of the angle $a\,o\,a'$, and, besides, are equal to one another. Whence the triangles S O S′, D O D′, are equal to one another, and, in consequence, we have O S′ = O D′. Thence, as it was demonstrated [3], they give for resultant a simple alternating vector of fixed direction. This resultant is represented by the segment O A equal to 2 O S′ and to 2 O D′, and situated on the bisectrix O F of the angle S′ O D′. Its phase has the angular value $S'OA = \frac{1}{2} S'OD' = \frac{1}{2} s\,o\,d = \frac{1}{2} s'\,o\,d'$; that is equal to the phase of the component alternating vectors.

If you draw a A′ equal and parallel to $o\,a$ and draw o A′, you have the triangle $o\,a$ A′, which is similar to the triangle O S S′, because the angle a is equal to the angle S and the sides $o\,a$, a A′ are equal to twice the sides O S, S S′. Thence we have o A′ = 2 O S′ = O A.

Moreover, by the equation

$$\widehat{a\,o\,A'} = \widehat{SOS'},\ \widehat{S'OA} = \frac{1}{2} S'OD' = \frac{1}{2} \widehat{s\,o\,d} = \widehat{s\,o\,a}$$

we deduce $s\,o$ A′ = S O A; which signifies that o A′ is parallel to O A. In consequence o A′ is equal and parallel to the resultant vector O A. We may say therefore: Two alternating vectors of equal phase are compounded into a single alternating vector of equal

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phase, of which the amplitude and the direction are represented by the diagonal of the parallelogram made on the straight lines which represent by amplitude and by direction the two component vectors.

8. The composition of two alternating vectors gives, however, as resultant a simple rotating vector when one or other of the rotating vectors O D′, O S′ (Fig. 6, Art. 5) is equal to zero. This case is proved when $o\,s$ and $o'\,s'$ (Fig. 6) or $o\,d$ and $o'\,d'$ have equal magnitudes and opposite directions; then in fact the point S′, or the point D′ coincide with O. The condition $o\,s = o'\,s'$ or $o\,d = o'\,d'$ implies that it may be $o\,a = o'\,a'$ or that the amplitudes of the two given alternating vectors may be equal to one another.

The condition, then, that $o\,s$ and $o'\,s'$ or $o\,d$ and $o'\,d'$ have opposite directions implies a relation between the direction of the two alternating vectors $o\,a$ and $o'\,a'$ and the phases of the same. It is easy to see what these relations are. Let us suppose in fact that $o\,d'$ is opposite to $o\,d$. We call the angle $a\,o\,a'$ between the directions

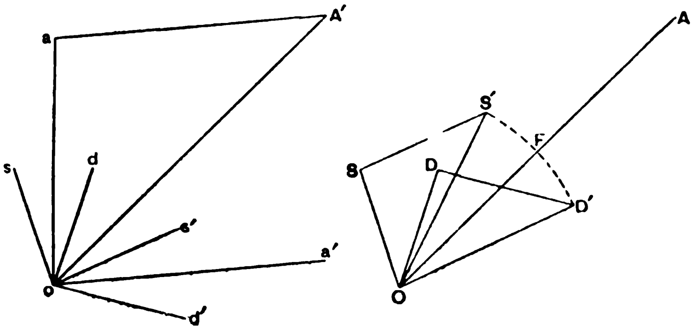

Fig. 8.

of two component alternating vectors, and we represent by ϕ and by ϕ' the angular values $a\,o\,d$, $a'\,o\,d'$ of the phases of the same vectors; we have

$$a + \phi' - \phi = \pi, \text{ or } \phi' - \phi = \pi - a.$$

Thence two alternating vectors of fixed directions give for resultant a simple rotating vector, when they have equal magnitudes and present a difference of phase, the angular value of which is equal to the supplement of the angle comprised between their respective directions.

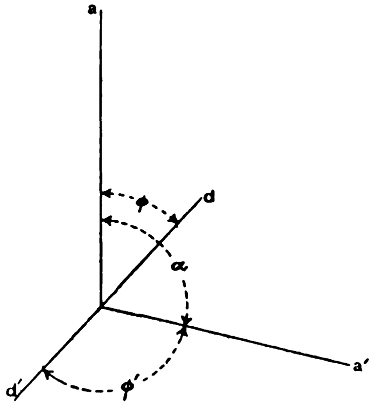

Fig. 9.

9. *Examples.*—As first example, let us consider the case of two alternating vectors, mutually perpendicular $o\,a$, $o'\,a'$ (Fig. 10). The theorem states that, in order that they may be compounded into a simple rotating vector, there should be in the first place $o'\,a' = o\,a$. In the second place, there should be $\phi' = \phi = \pi - a$, and thence being

$$a = \frac{\pi}{2}, \quad \phi' - \phi = \frac{\pi}{2}.$$

If, for example, we take $\phi = 0$ or the angle $o\,a\,d' = 0$, there should be $\phi' = \frac{\pi}{2}$, or the angle $a'\,o'\,d' = \frac{\pi}{2}$.

Now, with these conditions given, that the two vectors a and a' do truly produce as resultant a rotating vector is recognised at once on applying to them the construction of Art. 5, Fig. 6. In fact, to compound d with d' we must draw $O\,D = o\,d$, and then $D\,D' = o'\,d'$, with which it falls again on point O; to compound instead s with s' you have to draw O S and S S′ equal and parallel to $o\,s$ and to $o'\,s'$, by which we find the resultant O S′, which is a left-handed rotation of magnitude equal to $s + s'$, or to $2\,s$, or to a and to a'. The two given alternating vectors produce then as resultant a simple rotating vector of the same frequency and of magnitude equal to their amplitude.

As a second example, let us consider the case of two equal alternating vectors, $o\,a$ and $o'\,a'$ (Fig. 11), the direction of which comprises an angle, $a = \frac{3}{4}\pi$.

In this case the condition expressed by the theorem above demonstrated is that we have $\phi' - \phi = \frac{\pi}{4}$.

If, for example, $\phi' = \widehat{a\,o\,d} = 0$, there should be $\phi' = \widehat{a'o'd'} = \frac{\pi}{4}$. And, indeed, if we apply to this case the construction of Fig. 6 we find that D′ coincides with O. The resultant is reduced to the rotating vector O S′. Its magnitude is represented by the hypotenuse of the isosceles rectangular triangle O S S′; it is, therefore, equal to $s\sqrt{2}$ or to $\frac{a}{\sqrt{2}}$.

10. From the case already considered of only two alternating component vectors, we pass at once to the general case of any

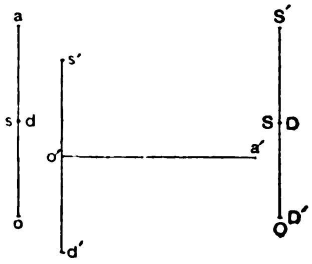

Fig. 10.

number of vectors: Any system of alternating vectors can be equivalent to a simple rotating vector. The necessary condition why that should happen is simply this—that the polygon of the components d, or that of the components s, should be a closed polygon.

An important particular case is that in which the component vectors are equal, and make with one another equal angles. Let there be given in one plane, N, equal alternating vectors, each of which makes with the preceding an angle a, which is neither π nor a multiple of π, and has relatively to the same a lead in phase of angular value equal also to a. Then each of the rotating vectors s makes with the preceding an angle $a - a$, or zero. The polygon of the s vectors has all its sides on the same straight line; the resultant S of all the s vectors is equal to their sum, or $S = N\,s$. The polygon of the d vectors is, on the other hand, a regular polygon, of which the external angles have the value $2\,a$; in order

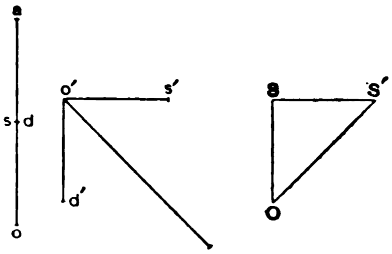

Fig. 11.

that this may be closed it is necessary and sufficient that N of such angles should make a multiple of four right angles, or that we have

$$2\,a\,N = 2\,k\,\pi$$

or

$$a = \frac{k\,\pi}{N},$$

where k is any whole number not divisible by N. If that condition holds good, the N rotating vectors d have a resultant nul; that is to say, that the N given alternating vectors have for resultant the simple rotating vector S. If we call a the common amplitude of the given alternating vectors, the value of the rotating vector becomes

$$S = N\,s = \frac{N}{2}\,a.$$

If instead of supposing, as we have done, that each of the given vectors has a lead in phase a relative to that which precedes it, we might have supposed that it has a lag in phase, we should have found that the polygon of the d vector stands upon a straight line, and gives $D = n\,d$, and that the polygon of the s vectors is closed and gives $S = O$; in this case the resultant of the N given alternating vectors would be a simple vector, D, rotating towards the right. We have excluded the case of a equal to π, or to a

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multiple of π; and, in consequence, we have said that the whole number k should not be divisible by N. If we made $a=\pi$ or to a multiple of π or if we took k equal to N, or to a multiple of N, the external angles of the polygon of d will be equal to 2π or to a multiple of 2π, and the polygon would reduce like that of s, to a straight line. In that case we should have two rotating vectors S and D both equal to $\frac{N}{2}a$ and of opposite senses, which would give as resultant an alternating vector of fixed direction and of amplitude equal to N a. Which is what was known before, because to suppose $a=\pi$ or a multiple of π is equivalent to supposing that the given alternating vectors are parallel to one another. The cases which most commonly have to be considered in the study of electric motors are those in which $k=2$, those moreover in which the considered alternating vectors are regularly distributed, at an equal angular distance all around an axis. Among these cases, then, special mention is required where N=3. Then the angular distances between the given vectors, and the angular values of their difference of phase, are equal to $\frac{2}{3}\pi$, or are of 120deg. The rotating vector, which results from the compounding of the three alternating vectors has the value $\frac{3}{2}a$, or is equal to one and a-half times the amplitude of each of the component vectors.

11. That which precedes concerns the composition, or the sum of vectors considered by us. For the application to those we are considering, it is suitable to add some considerations respecting the products $a\,b\cos\phi$, $a\,b\sin\phi$ of the amplitudes a and b of two vectors by the cosine or the sine of the angle ϕ comprised between the directions of the same;—products of which the first is the scalar with changed sign, and the second is the tensor of the vector of the product of the two vectors.

In the first place it is suitable to set down the following proposition: let there be given two groups of vectors, and at a given moment let there be: a the magnitude of any one of the vectors of the first group, b that of any one of the vectors of the second group, A the momentary value of the resulting vector of all the vectors a, B that of the resultant of the vectors b, ϕ the angle comprised by one vector a and one vector b, and Φ the angle of A with B, we have

$$\Sigma\, a\, b\cos\phi = \mathrm{A\,B}\cos\Phi,$$
$$\Sigma\, a\, b\sin\phi = \mathrm{A\,B}\sin\Phi.$$

In order to demonstrate the first of these equations, already well known, it is sufficient to observe that if we call Ψ the angle between A and one of the vectors b, we have

$$b\,\Sigma\, a\cos\phi = b\,\mathrm{A}\cos\Psi,$$

whence $\Sigma\, a\, b\cos\phi = \Sigma\, b\,\mathrm{A}\cos\Psi = \mathrm{A}\,\Sigma\, b\cos\Psi.$

But $\Sigma\, b\cos\Psi \mathrm{B}\cos\Phi,$

thence, $\Sigma\, a\, b\cos\phi = \mathrm{A\,B}\cos\Phi.$

The second equation, or the $\Sigma\, a\, b\sin\phi = \mathrm{A\,B}\sin\Phi$, is demonstrated in an analogous manner.

12. In the second place it is convenient to see what are the mean values of the products $a\,b\cos\phi$ and $a\,b\sin\phi$, when the vectors a b are of the kind which we were considering here—that is, when they are rotating vectors or alternating vectors. And here we have several cases.

First Case.—If the two vectors a and b are vectors rotating in the same plane, with the same frequency and in the same sense, the angle ϕ made by the same remains constant; that is, equal to the angular value of the difference of phase of two vectors. Thus, by the definition of a rotating vector adopted by us, both a and b are constant, so the products $a\,b\cos\phi$, $a\,b\sin\phi$ are independent of time.

Second Case.—If a and b are still vectors rotating in the same plane, but with different frequency n and m, the angle ϕ made by them passes in every unit of time $n-m$ times from 0 to 2π, or varies between 0 and 2π in the time $\frac{1}{n-m}$. The mean value of $\cos\phi$ and of $\sin\phi$ during such time is equal to zero, and besides the mean value of the considered products is also equal to zero.

Third Case.—A particular case included in that just now considered is that of two vectors rotating in opposite senses: if the frequencies of the two rotating vectors are n and m, the angle ϕ varies between 0 and 2π in the time $\frac{1}{n+m}$, and during this time the mean values of $a\,b\cos\phi$ and of $a\,b\sin\phi$ are equal to zero.

Fourth Case.—Another particular case is that in which a is a rotating vector and b a fixed vector of constant magnitude. This case can be reduced to the preceding, making simply $m=0$. Also in this case the mean products equal zero.

Fifth Case.—If a is an alternating vector of fixed direction and b is a rotatory vector, we can imagine a decomposed into two equal vectors rotating in opposite directions d and s, and making use of the theory recorded in the preceding article (11), put

$$a\,b\cos\phi = d\,.\,b\cos\delta + s\,b\cos\sigma,$$
$$a\,b\sin\phi = d\,.\,b\sin\delta + s\,b\sin\sigma,$$

where δ and σ represent the angles which at that moment of time b makes with d and with s. So we are led back to the preceding cases. If a and b have different frequency, so the products $d\,b\cos\delta$, $d\,b\sin\delta$, also the products $s\,b\cos\sigma$, $s\,b\sin\sigma$, have mean values equal to zero; whence also the means of $a\,b\cos\phi$, and of $a\,b\sin\phi$, are equal to zero. If a and b have a similar frequency, only the products $d\,b\cos\delta$, $d\,b\sin\delta$, or only $s\,b\cos\sigma$, $s\,b\,\sigma$ are zero; the other two are different from zero, and are constant.

If, for example, b is a vector rotating right-handedly, the products $s\,b\cos\sigma$ $s\,b\sin\sigma$ have a mean value equal to zero, and the products $d\,b\cos\delta$, $d\,b\sin\delta$ are constant. We have, therefore, simply

$$\text{mean of } a\,b\cos\phi = d\,b\cos\delta$$
$$\text{mean of } a\,b\sin\phi = d\,b\sin\delta.$$

If we represent by A the amplitude of the alternating vector, we have $d=\frac{\mathrm{A}}{2}$, and whence

$$\text{mean of } a\,b\cos\phi = \frac{1}{2}\mathrm{A}\,b\cos\sigma,$$
$$\text{mean of } a\,b\sin\phi = \frac{1}{2}\mathrm{A}\,b\sin\delta.$$

If we take as the origin of time the moment at which a has the maximum value A, the angle δ which figures in these expressions is the angular value of the difference of phase between a and b.

Sixth Case.—If, finally, a and b are two alternating vectors of equal frequency, we may consider the first as resultant of two rotating vectors d and s, and the second as resultant of two other rotating vectors d' and s'. By virtue of the proposition demonstrated in Art. 11, the products $a\,b\cos\phi$, $a\,b\sin\phi$ are at any moment equal to the sum of those which we have with the combinations $d\,d'$, $d\,s'$, $s\,d'$, $s\,s'$. But by virtue of that which was given before in treating Case 3, the mean values of the products corresponding to the second and to the third combination are equal to zero; thence, we call δ the constant angle between d and d', and σ the constant angle between s and s', we have:

$$\text{mean of } a\,b\cos\phi = d\,d'\cos\delta + s\,s'\cos\sigma,$$
$$\text{mean of } a\,b\sin\phi = d\,d'\sin\delta + s\,s'\sin\sigma.$$

If we call A and B the amplitudes of the two given alternating vectors, and if we note that

$$d=s=\frac{\mathrm{A}}{2}, \text{ and } d'=s'=\frac{\mathrm{B}}{2},$$

we may be able to write thus:—

$$\text{Mean } a\,b\cos\phi = \frac{\mathrm{A\,B}}{4}(\cos\delta+\cos\sigma),$$

and

$$\text{mean } a\,b\sin\phi = \frac{\mathrm{A\,B}}{4}(\sin\delta+\sin\sigma).$$

Then if, calling α and β the phases of a and b, we note that

$$\delta=\phi+\beta-\alpha, \text{ and } \sigma=\phi-\beta+\alpha,$$

we may write again:

$$\text{mean } a\,b\cos\phi = \frac{\mathrm{A\,B}}{2}\cos\phi\,.\cos(\beta-\alpha),$$
$$\text{mean } a\,b\sin\phi = \frac{\mathrm{A\,B}}{2}\sin\phi\,.\cos(\beta-\alpha),$$

(To be continued.)

COST OF ELECTRICAL ENERGY.

At the ordinary general meeting of the Institution of Electrical Engineers, held on Thursday evening, May 24th, Mr. Alexander Siemens, President, in the Chair, the discussion on Mr. Crompton's Paper on the "Cost of Electrical Energy," was concluded. An asterisk denotes that the speakers have returned the abstracts of their remarks revised:—

*Mr. E. C. DE SEGUNDO said as so many had spoken on the essentially practical details, he would confine himself to analysing Mr. Crompton's theories. In considering efficiency in a subject of this sort he thought it was wiser, in order that they might know exactly where they were, to compare the efficiencies with the best possible rather than with the absolute efficiency. Now, Mr. Crompton assumed in his ideal that boilers could be made which would evaporate 12lb. of water at 150lb. pressure per square inch per pound of fuel. That would correspond to an absolute efficiency, assuming a calorific value of 14,500 B.T.U. of 86 per cent. But a boiler could not do more than it possibly could do, and if they took into consideration the minimum amount of air which must be allowed to go into the furnace in order to complete combustion, and assumed

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an average temperature for the products of combustion, some 915 thermal units would be carried away and there would be left a maximum possible evaporation of 13·2lb. of water at 150lb. pressure. Mr. Crompton's estimate of 12lb. therefore meant a relative efficiency of 91 per cent. But it was not always possible to regulate the supply so that only the exact amount really necessary for the complete combustion of the coal was introduced; assuming they admitted 18lb. of air per lb. of coal consumed, the possible maximum was reduced from 13·2 to 12·6lb. of water at 150lb. pressure. Therefore Mr. Crompton's assumption of 12lb. really meant a relative efficiency of 95 per cent. With regard to the engines, Mr. Crompton said condensing steam engines could and would be made which would give them 1 I.H.P. hour per 13lb. of steam at from half to three-quarter load. This assumption amounted to a 19 per cent. heat efficiency. From calculations based on actual practice, he found that 10 per cent. was about the outside absolute efficiency one could count upon for high-pressure non-condensing steam dynamos. The next point he thought worthy of a little consideration was this: People did not care a bit how many watts were used for lamps; they did not buy watts, they only considered candle-power, and when they considered the marvellous efficiencies that had been obtained in the various units in their generating stations, they could not hope for much improvement in boilers or dynamos or engines; but there was room for a great deal of improvement in the distributing system, and above all in the lamps. It was obvious that if incandescent lamps could be made so that they would give 1 c.p. for 2½ watts with the same life and percentage loss of candle-power as they did now, it would be equivalent to bringing the price down to about 3¾d. per unit, as far as the consumer was concerned.

*Mr. J. N. SHOOLBRED said he could not follow Mr. Crompton when he said that Lancashire boilers seemed to produce rather worse results than the water-tube. In the water-tube, there should be taken into consideration the question of the result of the extinction of the fires and the cooling down of the brickwork and connections and the other losses which arose therefrom. With regard to the question brought out in Table VI. of the relative economy of the various systems of "converted alternating," "converted continuous," and "direct continuous," Mr. Crompton drew attention among other things to the economy derived from "storage." He (the speaker), by the courtesy of the Bradford Corporation, had been able to place a number of diagrams on the wall which showed what was the actual visible economical effect of storage batteries on the working of the Bradford station for four years. All of these diagrams showed that there was an appreciable period in the 24 hours, amounting, even in winter, to some eight hours, during which the engines were shut down. The members could not close their eyes to the fact that a considerable economy must arise from the relief granted to the engines and the saving of time, wages, and so forth; and that any system that required the engines to run during the entire 24 hours must necessarily be more expensive in itself than the above with storage. He had been enabled likewise to place on the wall diagrams showing the financial working of the Bradford station for the last four years; and indicating proportions of expenditure to receipts. Mr. Geipel, in his remarks, seemed to say, speaking of the proportion of capital per unit sold, that Mr. Crompton's suggested 2s. was almost an impossible figure, especially for continuous current installations. The result of the working of the station at Bradford had been that during the whole of 1893, the proportion of capital had only been 2s. 6d. per unit sold, and there was good reason to suppose that 2s. might be reached before long. Mr. Hammond also said if 2s. ever was reached, it would require a great many units to be sold. Last year, the figure he had named was attained with slightly under half a-million units.

Mr. HENWOOD said Mr. Crompton had spoken of 2½lb. of coal per indicated horse-power hour being the ordinary work done in 1883. Of course he was perfectly well aware that during the last ten years the consumption of coal in marine boilers had been reduced to 1·7lb. for triple expansion engines. With so poor a fuel as coal there were inevitable losses by ash. Moreover, the system of manual firing was unscientific, and ought to be discarded. Mr. Crompton had expressed the opinion that mechanical firing was still more wasteful and inefficient, and he (Mr. Henwood) concurred. Mr. Crompton also remarked on the heating of the fire bars; even with the ordinary cast-iron fire bars they were often burnt out. A method had been tried of using tubes filled with water as fire bars. He quite concurred with the author's view that it was best to use nothing but the coals of highest calorific values. He was glad to find the author speak so well of the Babcock boiler, and stating that it could be forced without priming. He (the speaker) wished to place it on record that in his judgment it was an utter loss to attempt to use coal when burning oil, because it would not add anything to the effect, but would rather diminish the heat they did obtain from the oil. In a properly-constructed furnace for burning oil fuel the conditions were different from those which obtained when they wanted to burn coal. In the oil fuel furnace they needed to have the admission of air strictly under control, and not to allow a large accession of air to be thrown into the furnace, as was the custom when they were firing with coal; and, moreover, with an oil fuel furnace, they entirely avoided the loss and nuisance occasioned by the constant feeding of the fire. He would ask them not be too incredulous when he told them that with a reliable system of firing with oil there was an evaporation of over three times that obtained by coal.

*Mr. A. H. DYKES said the figures Mr. Crompton had put before them were of the utmost value in enabling them to judge of the value of different system and different pieces of apparatus; but it was important before they compared different systems or different types of engines on the basis of those figures that they should understand any conditions that modified the general result, and he therefore had pleasure in reading a letter from Mr. Tonge, engineer of the Preston Company, in which he gave a few details concerning that station. He did this because in Mr. Crompton's Paper this was the only low-tension station in which double-acting engines were used, and it would appear from that that the comparatively low efficiency of that station might be due to the particular type of engines or the particular system in use. After reading Mr. Tonge's letter, the speaker said it would be evident, on inspection of the figures, that the cost of coal was very largely affected by the strike of last year. It was peculiar that in the North, where coal was very low in value, only costing before the strike 6s. 3d. or 6s. 6d. instead of 20s. or so, they were affected by the strike considerable more than in the South, the cost of coal being nearly doubled. The actual water consumption had been found in practice to be 27lb. per electrical horse-power hour, and the coal consumption per unit sold was 29lb., the coal being small slack burnt in Lancashire boilers. The best consumption of coal for a period of over three weeks in winter was 17¼lb.

*Prof. W. C. UNWIN urged as an excuse for the appearance of a mechanical engineer in the discussion the fact that Mr. Crompton had shown in his Paper how large a part mechanical engineering played in at least the finance of central-station working. Mr. Crompton made some rather strong statements about the relative value of Welsh coal and coal of any other description. He admitted that in calorimeter tests North Country coal was nearly as good as Welsh coal. But Mr. Crompton said there was some difficulty in burning the hydro-carbons of the Northern coal, and that this made it practically much less valuable. A long series of tests was carried out between 1860 and 1870, partly for the Admiralty and partly for other people, the general result of which was that there was practically no difference between Northern coal and Welsh coal. It was smokelessness not calorific value which gave Welsh coal its great market value. Mr. Crompton said that a Lancashire boiler was only half a boiler, and that one had to put an economiser on to it before one made it a whole boiler. There were a good many tests which could be pointed to traversing that statement, but he would only quote one. Two or three years ago he had to carry out some tests of Cornish boilers, which, after all, were only Lancashire boilers with one flue. The boilers were not new, but were taken in the ordinary course of their use. Those boiler tests with Cornish-Lancashire boilers gave an evaporation of 11·87lb., but they were only half boilers without economisers. He (the speaker) believed the Babcock boiler was an excellent one, as good as any made, but in the paper it was especially praised because it would stand forcing. All he would say about that was that Mr. Crompton did not give them a single fact to enable them to judge whether it would or not. He said it was nominally rated at so much, and that it had been worked at 50 per cent. above that. He had not told them what the evaporation was per square foot of its heating surface. A comparison had been drawn between short stroke high speed engines and what Mr. Crompton called long stroke low speed engines. There were four methods of reducing cylinder condensation. They might reduce it 20 per cent. by steam jacketing, 20 per cent. by superheating, 20 per cent. by high speed, and 20 per cent. by multiple stage expansion. Which was the right one to adopt? As Mr. Robinson fairly and frankly said at the last meeting, up to the present it was the long stroke slow-speed enginees which had given the highest economical results, and that required to be borne in mind along with the statements about the necessity of high speed and short stroke. Mr. Crompton had given a formula for station arrangement something like this: Welsh coal, Babock boilers, high speed, short-stroke direct coupling. It was an excellent formula, but he did not think it was the only good one. Every central station designed had to be considered according to its circumstances. Mr. Crompton had very rightly looked to superheating as a method which would in the future have to be adopted in securing further economy in the working of steam engines. He (Prof. Unwin) objected to its being considered as a remedy for steam-pipe condensation, which he thought must be combatted in other ways. It had the more important function of reducing cylinder condensation. In speaking of superheating, Mr. Crompton told them that 20 or 25 years ago, when it was first used, it was easy to adopt superheating, but now it was difficult because steam was now of very much higher pressure; he said, with steam at 375deg. "any further superheating is very much in the nature of passing this steam through pipes at a temperature which nearly amounts to red heat, so that it is little wonder that not many engineers have cared about tackling such a difficult and risky problem." There had been in Alsace for the last 40 years one of the best schools of steam engineering. A year or two ago he (Prof. Unwin) had an opportunity of testing an engine there using superheated steam. He was not exaggerating when he said that there were now many hundred engines working with steam up to 100 or 120lb. pressure which were worked with superheated steam. He tested an engine of 500 H.P., constructed only about four years before, with separate admission and exhaust valves; as good a compound engine, as he supposed, could easily be found, having steam-jackets and every appliance for economising steam. He ran the engine for three days, two days with superheat, and one without, obtaining an economy of 20 per cent. in coal and 20 per cent. in steam, when the superheated steam was used. The steamchest of the engine was at a temperature of 520deg. F., and the engine had been working at that for two years without the cylinder covers being taken off. The fact was, there were difficulties about using superheated steam in modern days, but some of the difficulties which were put forward were not difficulties at all, and some of the difficulties which really existed were not sufficiently appreciated. The one difficulty that was always put forth was that with steam of this high temperature they would destroy their engine cylinder. He believed that was an absolute fallacy. In this engine, with the steam entering the steam chest at 520deg., there was no superheat inside the cylinder, the whole being expended in preventing initial condensation. He admitted that in Alsace they had a rather favourable case for using superheaters. Elephant boilers were largely used, and they dug a pit beneath the boiler and put the superheater down below; they had exceedingly little difficulty under those conditions. As far as he could learn, and he went through many mills, the stokers paid absolutely no attention to the superheaters, and did not even know whether they were on or off. Now, in the old days, when superheating was first introduced and always gave

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a considerable increase of efficiency, he thought two very serious mistakes were made. At that time they invariably placed the superheater in the coldest part of the boiler tubes, in the up-take, or in some part where the gases left the boiler, and then the superheater was cumbrous and unsafe. If they had steam at a high temperature, and were going to superheat, then it was of no use putting the superheater in the coldest part of the flues, where they had not temperature enough to do the work : to use the superheater effectively they must put it somewhere where the gases were of high temperature, and in Alsace they put it immediately behind the bridge. If they put it in a cold part of the flues, they must have an enormously large and therefore dangerous superheater, but if they put it behind the bridge they might use a small and safe superheater. It must be assumed that the superheater would stand all the chances of daily work. If it was to do that it must sometimes, no doubt, approach the temperature of red heat, but he did not think it ever reached it. He thought, but was not sure, that that would exclude them from using a ductile material like mild steel in constructing the superheater ; at any rate, the superheater must be so constructed that it was practically a solid metallic construction without any jointing at all. Unless they could get that he did not think the superheater would remain without being gradually destroyed. There were problems still, no doubt, to be worked out, but he thought the fact that superheating had been so largely used in Alsace, and that wherever used it had shown economies ranging from 10 to 20 per cent., and that in good, new compound engines, was very encouraging.

Mr. PEACH said one boiler mentioned in the Paper was the "Economic," and in Mr. Paxman's absence he would like to make one or two remarks concerning it. The author had mentioned a good many good points of the boiler, but there was one recent improvement which he would like to point out. The tubes were divided into two groups ; they were close together at the back end of the boiler, and separated at the front end of the boiler by a space large enough to enable a man to get in, and there was also a space at the two sides of the back end of the boiler. That arrangement enabled the boiler to be entirely opened to internal examination for boiler inspection purposes, an advantage not shared by locomotive or marine boilers. One other point of big importance in the "Economic" boiler was the combustion chamber at the back, which when heated to a high temperature efficiently provided for the consumption of otherwise unconsumed products, and enabled inferior coal to be used without producing smoke. In the selection of a boiler one very important point was the cost for maintenance and repairs. There was only one instance given in the paper, that of the Kensington and Knightsbridge station, and the figure given there for the last four years' working seemed, on the face of it, rather high.

Prof. A. B. W. KENNEDY, taking the matter of coal first, said he was very pleased to inform Mr. de Segundo that Mr. Grimshaw, at the Eccleston-place Station, had got down to 4¼lb. per unit generated for three months last year. He would just show how he thought they might, perhaps, make a more possible ideal than the noble one he had put before them. If they took the actual working time they could evaporate 10½lb. of steam from and at 212°F., 8½lb. getting to the engines. Working that out on the basis of 16lb. of water per indicated horse-power hour for the 77 per cent. efficiency between the engine and dynamo at three-quarter load, and taking 90 per cent. of the units generated as sold, they got, as a result, down to 3·64lb. of coal per unit sold, or about 3¼lb. per unit generated. He would like, as a matter of his own opinion, to modify that of Prof. Unwin by saying that he believed it was more difficult to get the value out of North country coal, although certainly with proper care the value could be got out of it. As to boilers, it might interest members if he mentioned that in Glasgow they would stand nothing whatever but marine types pure and simple : they used, of course, the cheapest kind of fuel they could get, a kind of char, an inferior type of coke from the gasworks, which cost 4s. 6d. at the gasworks and was certainly not worth more. That worked very well in the marine types if not stirred up too much, and with a very economical result in money, and a very fair result in evaporation. He ought to say with regard to the calorific value of that coke, which Mr. Crompton had given in Table IX., that it should be marked approximate. He could not say that in the trial quoted it had a value of 12,000 thermal units. He would not add more than a word or two to what Prof. Unwin had said about the Lancashire boiler. He had not got any such excellent trials as Prof. Unwin brought before them, a couple of 24-hour trials, but on one particular trial, lasting, he believed, 10 hours, made on a plant of Aston and Dawson at Paddington, in 1890, they did get for a particularly careful test an evaporation of 11·7lb. per lb. of carbon burnt without economisers and 12·4 with a very high result. Of course the boilers were underworked, only burning 6lb. of coal per square foot of grate. Mr. Crompton had referred to the fact that certain figures were unknown to the works engineers themselves. He (Prof. Kennedy) felt sure that they would find it pay them to set to work to measure everything they were doing. It was possible now to get, if not the extremest accuracy, at least as much accuracy as they observed in measuring their coal. With regard to the question of rope-driving, it might interest members to know that there were being conducted just now in Belgium, under the care of a large committee of Belgian engineers, a series of what he hoped would be exhaustive and complete trials with this particular matter ; that was to say, plant had been set up for the particular purpose of measuring the amount of power taken up by belts and ropes as apart from the power actually taken to drive an engine and do its work. Mr. Crompton had referred to a method of getting an accurate report of the engine load factor of the day. He thought that was in the power of all of them with extremely little measurement, if the output of each engine was metred, and the number of hours that engine had run was also noted, they had the load factor of the engine for the day, sufficient for all practical purposes. He got that done as a regular matter week in and week out, so that they always knew the load factor of an engine during the hours it was worked. It was a most valuable thing to know. Then there were those "obscure losses," with which he was sorry to say his name was connected. The measurements were got by running all the water that got condensed in the steam pipes out into the sump and pumping it out and weighing it. Running with light loads quite lately he had found it amount to more that 8 per cent. of the whole, and in other cases it was 5 per cent. and 6 per cent. It was not so high proportionally in the winter, but it was a very serious matter indeed, as anyone who took the trouble to measure it would find. He hoped Mr. Crompton did not mean by his paragraph on slip 13 of the Paper that he really doubted whether there would be any economy due to condensation. Although they might not care to put a positive figure to the actual amount of economy, he thought most of them who had tried it were convinced that there was economy in the use of condensation. He thought in many cases it might amount to 12 to 15 per cent., or something of that kind. Upon the point of wages and superintendence in works, he thought there was a little misunderstanding sometimes as to the effect of size of works on its cost. The cost of works, as everybody present knew perfectly well, was divided into two parts, the actual cost of generating at the works and a series of outside costs. Now, there were certain points in which a small station had a great advantage over a large one. A small station might run with very little superintendence and very small office expenses, and as a matter of fact the actual cost of generation, as anybody knew who knew the details of works throughout the whole of the country, was sometimes as little at an absurdly small station as it was at a very big one ; but the total cost of the large one might be considerably smaller because of the items of interest on plant and other items which came in to reduce the cost at the big stations. However, when they came up, at a very rough approximation, to about 3,000 H.P., possibly 4,000 H.P., in the station, they had got to a point beyond which practically they were not going to reduce anything in their cost per unit. They would find the actual cost would be very much the same whether their larger power was put into two stations or one, and whether one or two was preferable would depend upon other considerations. It might be more convenient to have one, but it would not make any particular reduction in the cost per unit.

*Mr. DE SEGUNDO explained that his estimate of 4½lb. was per Board of Trade unit paid for by the consumer. The corresponding figure per unit generated would have been 3½ to 3⅞lb.

*Mr. DRUITT HALPIN said the first point he would remark on was the statement by Mr. Crompton that he considered the small and dust fuels only less valuable because part was liable to fall through the bars. They were all aware of the mechanical disadvantage of using fuel under those conditions, but he though one very great source of loss in that fuel which was overlooked was oxidation. When disintegrated it became oxidised, and naturally got much less valuable. Mr. Crompton said the locomotive boiler was not efficient on account of the level of the fire bars. Well, it was evident that it could not be efficient. In point of fact, they had taken the locomotive boiler lock, stock, and barrel, and adopted it exactly and absolutely, like the Chinese. In 1872 some beautiful results were obtained by Clayton and Shuttleworth, at Cardiff, which had never been equalled, either before or since. What they did was to carry the foundation ring up semi-circularly instead of having it along the front of the box ; they brought it up in horse-shoe fashion, and got the fire-bars lower down. If they found a boiler evaporating 3lb. per square foot per hour, and doing an evaporation of 10 or 11½lb., and if they multiplied those figures into one another, they would get a curve giving them more light. It was possible to pay too much for a sovereign, and if they had, as Prof. Kennedy had said, an economy of 11½lb. when they were burning only 6lb. of coal per square foot of grate, why that was simply doing nothing. Mr. Crompton told them one boiler was doing 50 per cent. more than its work without getting into trouble ; but all he (Mr. Halpin) said was, "Thank you for nothing." That particular boiler was doing under 3lb., and 50 per cent. more made it almost 4½lb. With regard to the Lancashire boiler, some trials were made by the South Lancashire Company coal owners, some thirty years ago, with boilers 7 × 30, using Northern coal. The tests were very accurately made, and these were the results as the average of 60 trials : The boilers evaporated 7·1lb. per hour per square foot of heating surface. They were using coal with 11,670 units, and doing that from and at 212deg., which, reduced into thermal efficiency, meant 827. So they got 7·1 × 827, and that gave them the figure of merit 5,871. The Babcock boiler he had taken was evaporating on that trial 2·893lb. per square foot per hour. The efficiency of the coal as given by Mr. Crompton was 766. Multiplying those two numbers together they got 2,245 ; that was to say, they got 58 as the figure of merit for one boiler, and 22 for another. He must go one step further. Mr. Rosenthal had given him the price of several of the Babcock boilers, and he had taken out what it came to in heating surface. The Babcock boiler cost on the average 6·21s. per square foot of heating surface. He had also obtained the prices of five standard Lancashire boilers, and their price was very much higher—8·74s. per square foot of heating surface. So that now, if they divided the results of the factors of efficiency they had got, by the prices forming the capital cost, they got something like a final figure for the efficiency. If they divided this 58 by 8·74 they got a figure of merit of 6·6, whilst with the other boiler they got an efficiency of 3·6. And that was quite apart from all questions of the Lancashire boilers being able to use dirty water and smoky coal, which he hardly thought the other people would claim for their boiler, good as it otherwise was.

*Mr. ROSENTHAL said that during the last three or four years a good many electrical engineers had thought that the best thing to do was to put in Lancashire boilers in central stations, particularly in places where coal was cheap, and the question of space was of no consequence. He had not been able to obtain any very complete data as to the results obtained in those places, but the average experience in the north of England of the

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working of Lancashire boilers in ordinary factories certainly went to show that the result was not more than an evaporation, as a rule, of 6 to 7lb. of water per pound of coal. There were trials on record, as Prof. Unwin had mentioned, of magnificent results obtained with Lancashire boilers. But those results were no criterion whatever for the design of a central station, because, excepting in a very few instances, it would not be possible to put as much boiler surface down in Lancashire boilers as would be required to work at such a rate as would ensure the efficiency that was held up. The question of safety, of course, had always to be considered, and the question of upkeep likewise, and it was a very questionable thing whether a Lancashire boiler was under any condition a good boiler for high working pressure. At the Popp compressed air station in Paris an indicated horse-power hour was produced with 500 grammes of coal containing about 14,000 B.T.U., which was equivalent to 1-2/10 per lb. of English coal, and only a day or two ago he received particulars of a plant of Babcock boilers in Calcutta working in connection with a triple expansion condensing engine of 2,000 H.P., where the results amounted to the production of 1 I.H.P. hour with 1¾lb. of Indian coal, about equivalent to 1-2/10lb. of Welsh coal, so that it seemed they were not very far off the figures that Mr. Crompton mentioned as possible. It was said sometimes that a Lancashire boiler was better than a water tube or an ordinary tubular boiler in respect to the prevention of smoke. If they worked a Lancashire boiler very lightly indeed with a class of bituminous coal that easily coked, they could undoubtedly fire it to produce very little smoke. On the whole they might take it that a Babcock boiler or ordinary tubular boiler, to burn bituminous coal smokelessly, required mechanical firing, and so did a Lancashire boiler. Mr. Halpin had given them a number of figures as to the evaporation per square foot of a Babcock boiler compared with a Lancashire boiler. He submitted that it did not matter to the electrical engineer what the surface of the boiler was so long as he obtained a certain quantity of steam for a certain quantity of coal, and the total power he required cost him the same amount of money. With regard to burning oil, he certainly thought that oil fuel would be used to some extent for dealing with some loads in an electric light station. There was no difficulty whatever in applying oil to an ordinary boiler burning coal, and it could be used at a moment's notice, but no such fancy results were to be obtained as Mr. Henwood had claimed, and so far as the wonderful type of boiler he had sketched was concerned, that was simply a Yarrow boiler with the tubes connected in such a way that they could not possibly be cleaned, and that would not do for an electric light station. The question of dryness of steam was one often discussed. The last case in which he had heard of wet steam was at Deptford, and upon investigation it was found that the steam as it came from the boilers contained only three-tenths of 1 per cent. of moisture, and the wetness was produced in the steam pipes, which was the most prolific source of the trouble of wetness of steam in the engine.

*Mr. R. E. B. CROMPTON said he perfectly agreed with Prof. Unwin as to the splendid results got from the Lancashire boilers; but he (Prof. Unwin) left out the very thing which Mr. Halpin supplied, *i.e.*, the rate of firing. It was the high rate of firing necessary in an electric light station which made the Lancashire boiler comparatively inefficient. It was of no use trying to explain results away, and it was the fact that there was hardly a Lancashire boiler station which was doing well; there were exceptions, but they were due to the great skill and unwearying attention of the engineers in charge. There was not the same difficulty with the multitubular boilers of the locomotive, semi-marine or Babcock type. They had all done good service in their stations. Major-Gen. Webber's remarks were nearly every one of them based on misapprehensions. Mr. Robinson and others said his ideal figures were pitched too high. He might possibly be wrong in that respect, but he wished them to be high and difficult of attainment. He thought with Prof. Kennedy that 4¼lb. was reached every day now in some of the best stations per unit sold to the customers. If that was reached already, and as they knew, there were very considerable and preventible losses still remaining, it was to be assumed that they would get 3½lb., but beyond that he admitted it would be a very stiff pull; but why should he not give them 2½lb.? It was absurd for them to have a standard, we should soon be like the old Matthiessen's standard of copper, having a 104 per cent. efficiency. He was interested to hear Mr. M'Laren's remarks. Everyone knew that Mr. M'Laren was the builder of record engines, engines which had done very high duty, and he was especially pleased to hear that he was the builder of the engines at Oxford, where the results were so good. He wished to say that he never intended to throw any doubt on Mr. M'Lean's figures. The results were wonderful, but they were obtained in the proper way, that was, by measuring and watching everything and analysing the losses. That was the sermon he had endeavoured to preach to this Institution almost constantly for the past six years. With regard to the remarks made that evening, he had already stated, in answer to Mr. de Segundo, that it was not so impossible to get to his ideal; he admitted it was difficult, but not impossible. He thought Mr. de Segundo forgot that Sulzer and other Continental makers had been getting 13lb. with condensing engines pretty regularly for some time past, and he fully expected to hear that they had done it in electric light stations. It might interest Mr. de Segundo to know that even in high speed engines, Messrs. Willans and Robinson were giving trade guarantees of 13½lb. per I.H.P. hour. He was very glad to welcome the remarks of Mr. Shoolbred and another gentleman who spoke on the subject of the advantage of using accumulator storage. That was a theme upon which he had harped, and regarding which many strong things had been said of him; but it was well-known that, especially in the smaller class of stations, the saving in the wages account was very considerable from the use of accumulators, and the saving of coal by being able to run the engine at a better load factor was also considerable. He was glad to say they had brought this home to the American mind, and in New York some of the large stations were being worked by accumulators, and they were getting an infinitely better supply of electric current at a lower cost. The information which Prof. Unwin had given was very valuable, especially that with regard to superheating steam. He had listened with great interest, and had learnt a great deal. He had known for some time past that this was a development from which they would get greater economy. He had already pointed out that the flue type of boiler required to be fired regularly, in order to get the high results mentioned. He could corroborate what had been said regarding the advantages of the "Economic" boiler from personal experience. One of the most important points that had been raised, to his mind, was that mentioned by Prof. Kennedy, who said he had noticed that when they got to 3,000 or 4,000 H.P. they had reduced the generating cost almost as much as they could possibly do. That was a thing he had wished to say himself for years past in the old controversy about putting large stations outside a town instead of having smaller stations inside a town. It apparently never struck those who had been urging this great change that there was no advantage gained in making the size of a station above a certain figure, a figure which Prof. Kennedy had put at 3,000 or 4,000 H.P., and with which he perfectly agreed. Several speakers had thrown doubt upon the possibility of the use of liquid fuel being carried out successfully. He thought the peculiar conditions of electric lighting, with that peculiar peak on the curve, in every way pointed to the use of liquid fuel, and also the very rapid rate of evaporisation in the boiler which could be given with liquid fuel. His own Company, and one or two others, were experimenting in this direction, and, no doubt, when next a Paper on this subject was read before this Institution, they would have successful results to record. It appeared to him that if one could call on a second boiler at 20 minutes' notice, and heat it up, as he had seen done with the use of liquid fuel, they were having an ideal state of things as regards boiler plant in an electric light station; and he might say that the introduction of liquid fuel would, in his mind, increase the possible output of many existing London stations, some 40 or 50 per cent., for in nearly all those stations the future limit of expansion was bounded by their boiler power, and not so much by their steam-power. The interest taken in the Paper repaid him in every way for the trouble he had had in writing it, and he could only repeat that his object was to elicit from those who knew the subject best, that was to say, those who worked in those stations, what their real opinion was on the progress of their art, and he thought they had every reason to be satisfied with the progress which had been reported to them, and at getting such figures as Prof. Kennedy had given them of 4¼lb. of coal per unit delivered to customers.

DESTRUCTIVE EFFECT OF ELECTRICAL CURRENTS ON SUBTERRANEAN METAL PIPES.

The following is an abstract of the discussion which took place at New York and Chicago on the Paper on the above subject read by Mr. Isaiah H. Farnham before the American Institute of Electrical Engineers. This Paper appeared in *The Electrician* of May 4th. The full report of the discussion will be found in Vol. XI., No 5, of the *Transactions* of the American Institute.

DISCUSSION AT NEW YORK.

Prof. Geo. W. PLYMPTON: My first experience with electrolysis dates from about a little more than a year ago. In framing the franchise for the trolley roads there was fortunately a clause inserted which placed responsibility upon the trolley companies for any mishaps to any underground pipes, wires, cables or the like. That was placed there, not because electrolysis was thought of at the time, I think, but because it was supposed that in the process of digging up streets they might interfere with gas and water pipes. I am sorry to believe that we have not got the full measure of the damage that has been done. So much as has been exhibited was such as has made itself known through the entire failure of pipes and cables. It is reasonable to suppose that ten times as many examples could be found which would be nearly as bad as those exhibited, because there has been no digging down in the ground in search of such cases of corrosion. Water pipes, gas pipes, and lead coverings of cable have all suffered. Telephone companies were the first to find it because of slight perforations of the insulation. Leakage of water pipes have made themselves known in one or two cases where they were near enough to the surface. In one of the cases exhibited, one pipe had been destroyed in three or four months. It was an iron pipe very near the rail. It was replaced by a larger pipe, and that was perforated in 30 days. So that the rapidity of the action warned us there that it was time to look about quite actively. We have held numerous conferences with the engineers and they have promised to take all proper means for taking care of their own current. One thing I feel a little concerned about, and I take time only to mention it and that is this seventh conclusion:—"A large conductor extending from the grounded side of the dynamo, entirely through the danger territory and connected at every few hundred feet to such pipes as are in danger will usually ensure their protection." True, so long as that connection can be kept up. Will it not be necessary to make such a connection in such place that we can examine it every once in a while? Will it do to make a connection and cover it up? What shall it be—copper wire? Can we solder a copper wire to an iron pipe? Can we make a connection that will remain good and without increasing its resistance? Local action will set up a corrosion, and as to soldering, in the ordinary sense of the term, it seems to me impracticable. So that we have some fears that whatever precautions they take of that kind, may prove insufficient after

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a little while or else that they will need constant attention and that we shall need a large corps of inspectors to prevent serious injury. One, that of making the rails continuous, has been, I believe, tried in Boston. It is about to be tried in Thirty-ninth-street, Brooklyn. The apparatus arrived the other day for welding the rails. The engineer of the Company assured me that they would make their rails continuous within the limits of the city. The question with us, of course, is in the experimental stage. We shall accumulate more within a year, but in that time I fear we shall find a good deal more damage done, for the reason that it is only where the corrosion has been so bad that the pipe or the cable has failed, that our attention has been called to it.

Mr. A. E. KENNELLY: I wish to take the stand that it is not, as stated in the sixth generalisation, necessarily good policy to connect the positive pole of the dynamo to the trolley lines. When you arrange the current, as is suggested as advisable in the sixth conclusion of this Paper, all the distant district is free from danger and all the oxidising and corroding effect is close to you. The danger area is reduced, but the danger is greater, because the activity is consequently augmented in that district. But if, as Mr. Farnham says, we prevent that, as was done so skilfully in this case, by throwing out a ground feeder, which prevents the current from emerging out of the pipes into the surrounding soil near the power house, why then, coupling together the sixth and the seventh conclusions, all is well; you have stopped the corrosive action. But unless you do couple together the sixth and seventh suggestions, you are likely to cause more danger by having the positive pole to line, than if you have the negative pole to line. Furthermore, I would like to point out that the difference of potential as measured by a voltmeter between a cable sheathing and the ground in its vicinity, is not necessarily a criterion of the degree of corrosive activity taking place at that point. For suppose you had a perfectly insulated cable and sheath, but at some distant point, say, half a mile off, the sheathing of lead was exposed to the ground, and that there destructive action was being produced, there might be at that point, half a mile away, a difference of potential between sheath and the ground of three volts; but at the point where you stand the potential difference might happen to be five volts. Now, the five volts could not be so active in producing corrosion as the distant three volts, in fact it could not be active at all, owing to the perfect insulation of the entire cable in the vicinity. Again, while all admit that iron pipes are corroded electrolytically, we all know a given weight of lead is much more readily consumed by electrolysis than a given weight of iron. Roughly, an ampere in a year will dissolve seventy-five pounds of lead by electrolysis. It will dissolve, roughly, only about twenty pounds of iron. The destructive effect of electrolysis, while it is serious, is often exaggerated by not taking into account the actual amount of decomposition that can take place, electrolytically, under the most favourable circumstances. If you have a mile of eight-inch water main, which is half an inch thick, that is, its exterior diameter is nine inches and its interior diameter is eight inches; and a thousand amperes are kept steadily flowing day and night, with uniform density, out of that surface into the surrounding soil, it will take about six years for that current to reduce, by electrolysis, the thickness of the iron to one-half. Of course, it would be unfair to make a positive statement of that kind, because we assumed uniform corrosion, whereas corrosion does not take place uniformly. One of the most interesting observations that ever fell to my lot, in connection with the high resistivity of the ground, is, perhaps worth mentioning. It was occasioned by trouble in an Edison tube, and the fault, a ground, was situated about three-quarters of a mile from the station. We were trying to locate the ground by means of a compass needle moved over the surface of the soil and over the buried conductor, while strong direct currents of about two seconds duration were applied with ground return circuit, every three or four seconds in the power-house. We took the magnetic needle along the surface of the trench and tried to find a point where the needle ceased to respond to the intermittent currents. We came to a spot where the line of Edison tubes departed from the road and entered a field. Round the field there was an iron wire fence with iron uprights, which fence ran for several hundred feet parallel to the road. We knew that the ground existed in the iron Edison tube somewhere in this vicinity. I happened, quite by accident, to stand near the fence, looking in at the field and wondering where the trouble might be, and as I rested my hand on the fence I fancied I felt a shock. I thought this a mere delusion, and paid no attention to it. But presently some one else came up, and without any suggestion on my part rested his hand also on the fence, and declared that he felt a shock, and finding my own imagined sensation corroborated independently, we investigated it and found the reason to be this: within 20ft. of the fence was the "ground" we were seeking in the Edison iron tube. The intermittent current escaping from the conductor into the iron tube 30in. below the surface of the soil, was able to raise the potential of the surface of the road in the vicinity where we stood, to such a degree that we were able to deliver through our hands enough current to the iron fence wire to make a shock perceptible, and, on taking measurements later on with a galvanometer we found the resistivity of the soil, which was damp, but not wet, to be something like 60 ohms.

Mr. FARNHAM: I would like to say in reply to the able remarks just given to us, that there would be no advantage in doing some of the work suggested unless we did other parts of it also. Conclusion No. 6 was intended to go with No. 7. But if that had not been the intention, I can hardly agree with the speaker that it would be more serious to have the corrosion take place in a limited territory, even though it were more rapid, than in a large territory. Would it be more convenient to dig up all the paved streets of a large city once in 10 years, or to dig up a radius of a thousand or of two feet once in a year? It is an open question which hydraulic and gas engineers must pass upon. Whatever we do to remove danger we must watch the electrical conditions constantly, or we shall find ourselves again in trouble. In illustrating this fact, let me say that since the system just described has been applied in Boston, the West End Company has run out in one direction several large return wires in addition to those previously in use in that locality, and thus practically moved the power station, that is, it changed the zero line from its former location to a point very distinct making it necessary to rearrange and extend the cable return wire system.

Prof. HOUSTON: I think one of the most interesting points that has been brought forward in this Paper, and one which has surprised me very much is the exceedingly small potential difference which the Paper states has been necessary to effect electrolysis. I should, however, look very carefully at the source used, and the method by which the experimenter assured himself that he did actually limit the potential difference to the small fraction stated.

Dr. LEONARD WALDO: The coal miners have had much trouble in keeping their valves from disappearing and their pipes from being eaten up, and inasmuch as we have been interested in the metallurgy of that sort of thing lately, we have looked into the question. In several instances we have had valves, parts of pumps, and similar articles sent to us from the depths of the mine, and several gallons of the water which was supposed to do the mischief sent along with them. We boiled the water holding specimens of the metal of which the valves were made, and exposed the specimens for weeks at a time, with no chemical action at all on the metal similar to that used in the valves or in the pipes. When you insert an iron pipe and connect the two specimens through a voltmeter, you will get a very rapid disintegration of one pipe or the other, and you get an indication of anywhere from four to six-tenths of a volt. It is my observation that very efficient deterioration of these underground materials of different potential takes place with differences under half a volt. In all these questions of rapid deterioration of pipe, I think, the most important consideration will have to be given to the actual corrosion which occurs because of the molecular, chemical, and electrical action which take place between the metal and its own impurities.

Dr. CHARLES E. EMERY: In that connection I will say that it is found in practice that a steam pipe covered with a non-conductor, and maintained at a temperature of 250°F. to 300°F. will not corrode underground, whereas a hot-water return pipe similarly covered and kept at about 212deg. corrodes very rapidly. The corrosion is external, and appears to be ordinary rust. A study of the phenomena indicates that there is a critical temperature where the gases in the soil act more intensely than at other temperatures. Apparently ordinary carbonic acid gas has the most important influence. It appears, therefore, that the temperature should be considered in connection with the other influences on corrosion which have been mentioned.

Communicated by Prof. ELIHU THOMSON: May we not be justified in expecting that in many cases the natural corrosion may be even arrested by the negative polarisation of the pipes with respect to earth? Could every line of pipe be relied upon as a complete conductor without bad joints, the problem of protection would be much simplified, but the current in crossing a bad joint in a line of pipe will undoubtedly be partly shunted through the earth around the resisting joint, and cause corrosion to a greater or less extent. Again, if in a line of pipe every joint was of poor conductivity, there would be very little chance of corrosion by electrolysis, as the pipe line would not offer any good path for current. Earnest endeavours will be made in the present year to prove the practicability of continuous rails electrically welded in place. In cities this would give a network containing a vast amount of metal in the rails, acting as a conductor for the return current. Such a track system, or even a track system well bonded, would, if worked with a zone system, in which successive zones of trolley conductor are made positive and negative respectively, remove all possibility of trouble, but might increase the risk in the accidental crossing of wires on the trolley conductors. Another system of working which would remove most of the difficulty in our cities, would be the employment of potential reducing motor generators at various points over the area, the high potential side being fed direct from the power station by metallic circuit, and with either alternating or continuous currents, as found most expedient; while the low potential side, 500 volts or less, would go to trolley wire and track respectively. In this case the return current would never have to travel very far, and the drop on the whole system would be much lessened. Copper would be saved, and the congested districts could be readily supplied with a lower potential than the high speed outlying districts. If alternating currents were used from the power station to the motor generators, the generators in the station could be made of very large capacity, say 5,000 H.P. in a large city, and the motor generators could range from 200 to 500 according to the density of traffic, &c. I mention these facts to show that avoidance of all electrolytic corrosion is within the capabilities of electrical engineering, while still retaining the continuous-current motors on the cars, and the single overhead trolley wire. It is even possible that considerable economy of transmission might be secured over the direct-supply systems as now used.

Communicated by HERMANN LEMP, JUN.: Having been intimately connected with the experiments carried out in Cambridge during last summer and winter, I think a few remarks in reference thereto will be interesting at the present time. The tracks experimented upon were all, before any welding was done, condemned by the West End Company. The original method consisted in welding two U-shaped yokes on either side of the joint through the web of rail. Of the welds made on Main-street, Cambridge, about 10 per cent. have broken through the winter. It was soon discovered that the method of welding first used was not quite satisfactory, as it produced a local strain in the rail by heating only the web part of the rail to a welding heat. Experiments were made at once with a view of welding the rails *right at the joint*, and extending over the whole surface of the rail, including rail and foot. The season being already far advanced when these experiments were concluded, only a part of the track in Cambridge could be provided with new joints. Every one of these

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welds stood through the winter without a break, with the exception of one which broke the day it was made, and showed poor workmanship. From all the experiments made up to date we can draw the following conclusions:—(1st) A continuous rail can be used for electric street rail-car practice with absolute safety if an expansion joint is inserted every 600ft. 2nd) A continuous rail can *probably* be used without any expansion joint by using the latest method of welding. (3rd) The electric conductivity of any joint is as great as the rail itself. (4th) All joints being of the same material and continuous even when elastic, will not change by vibration, heating or electrolysis. (5th) By frequently cross-connecting the rails—making up a track of electrically welded joints, any trouble from interruption in the track can be obviated. (6th) The resistance of the feeders from track to power-house is immaterial aside from *economy*, provided the ground in power-house is taken off.

DISCUSSION AT CHICAGO.

Mr. B. J. ARNOLD: The subject of electrolytic action of the railway current on underground pipes and conductors is now being agitated in almost all cities where railways have been running long enough for the destructive effect of the current to make itself known, and it will not be long before we shall hear from it in our own city, if the many ordinances now being considered by the Council are passed without some stipulations regarding the construction and carrying capacity of the rail return circuit of the roads which the companies propose to build under these franchises. I am of the opinion that if the rails are supplemented by a system of feeders, so that the resistance of it is not greater than that of the outgoing circuit, and the rails joined with a bond equal in conductivity to the rail itself, which is most effectually accomplished by welding the rails together electrically, that the entire difficulty caused by electrolysis will disappear. The suggestion of Prof. Thomson of the application of motor transformers for the purpose of relieving unequal potentials seem to be impracticable to construct, as well as difficult to look after, as it would necessitate numerous electric motors running in various parts of the city, the location of which would have to be changed from time to time to correspond to the fluctuating danger line, and would result in constant expense for maintenance as well as a large additional equipment. Mr. A. C. Balch, of Portland, Oregon, in a communication to one of the railway papers recently, described the method of using the three-wire system on the electric railway in that city. The trolley is divided into sections of about 1,000ft. in length, the positive wire of one dynamo being connected to one section, and the negative of the other dynamo to the adjoining section, while the neutral wire is connected to the rails. It will be noticed that with this arrangement there is a difference of 1,000 volts between the adjoining sections of the trolley wire, but as they are thoroughly insulated and the motor cars pass from one section to the other quickly, there seems to be no difficulty caused by the sudden reversal of the current through the motors when passing from one section to another. So long as the cars are properly distributed on the line, I see no difficulty in the operation of an electric railway with the three-wire system, but if the cars were to become "bunched," as sometimes happens in large cities, the feeder wire supplying that particular section would be overworked, although I do not regard this difficulty as serious. With this arrangement the electrolytic action on pipes is almost, if not entirely, avoided, as there is practically no current flowing from the trolley to the earth when the road is working under normal conditions. I believe there is also a three-wire electric road in operation in Bangor, Maine, and so far as I am able to learn it is working with entire satisfaction.

Mr. A. T. WELLES (of the Western Electric Company): I wish to say that Mr. Farnham has unintentionally misquoted me, as was also the case in the interview in a Cincinnati Paper which brought about my correspondence with him. The statement would lead you to suppose that some electrolytical trouble had developed in cables laid by my Company in Cincinnati, but this is not the case as far as I know. I simply wish to make one other statement. Since Mr. Farnham collected the data for his Paper, we have run across another very peculiar case of electrolysis in Cleveland. A cable which my Company laid there in January last for the Postal Telegraph Company was reported as having given out entirely about two weeks ago. The cable ran from their office down about 1,500ft. and then through a tunnel about 80ft. deep under the river. Through this tunnel a large water main also runs. A splicer located the trouble in the manhole at the mouth of the tunnel, where he found the cable pipe entirely eaten through. Mr. L. L. Summers, of the Postal Company, made voltmeter and ammeter tests at this place and found 18 or 19 volts on the cable, and also on the water main in the tunnel and 45 amperes current. The cable pipe was eaten through in ten weeks. What is going to become of that water main and what is going to become of that tunnel?

Messrs. PAUL BIEFELD and FRED. SILBER communicated the results of an investigation carried on in the laboratories of the University of Wisconsin, and along the line of the electric railway of Madison, Wisconsin, under the direction of Prof. Dugald C. Jackson. The line has been in operation for about a year and a half, having nine car in service, but no troubles due to corrosion have shown themselves thus far. Measurements of potential between water pipes and rails, near power station, show a difference of 4½ to 5½ volts, water pipe being positive to rail, and 2½ to 3½ volts between water pipe and the earth near the rail, water pipe being positive to earth. The potential reversed at a distance of from 1,600ft. to 1,800ft. from the station, the range being zero to four volts outside of this neutral zone, the water pipes being negative to rails and earth. Experiments are at present in progress to determine the actual current flowing between pipe and rail. This is done by means of a modified form of a copper voltameter devised for this purpose. A water-tight box containing a solution of copper sulphate is buried in the ground. This box has for two of its opposite sides, facing the pipe and rail respectively, double copper plates, of which the inside ones are weighed. The gain of cathode will then give in the usual way an integral measure of the current. A series of experiments to determine the minimum potential at which corrosion may go on between iron plates showed that a mere *directive force* was needed; the potential having been reduced to 0·001 of a volt, electrolytic action still went on. In each case the action was manifested by the formation of a ferrous salt at the anode, and the hydroxide of the alkaline metal at the cathode. This phenomenon shows at once the cause of the corrosion. The main object of our investigation has, indeed, been to determine exactly what goes on in an electrolytic cell under parallel conditions to those found in practice. Whenever iron electrodes were used with soil or sand containing small quantities of soluble salts in solution, a layer of ferrous hydroxide was invariably formed at some point between the two plates. The earth used was found to contain small quantities of chlorides and sulphates of the alkaline metals, and showed no trace of soluble iron salts or alkaline action before electrolysis. After the current was put on ferrous salt began to be formed at the anode spreading toward the cathode; the hydroxide of the alkaline metal was formed at the cathode spreading toward the anode; where the two met a layer of ferrous hydroxide was precipitated, recognised at once by its dirty green colour. In all these cells a peculiar heating effect was noticed, reaching a maximum in the ferrous hydroxide layer, and diminishing in general toward the electrodes. Measurements of potential taken within the cell at different points between the plates showed the greatest difference of potential at the zone of maximum temperature, and a diminishing difference in the same way as the thermometer had shown a fall in temperature. It must be stated here that the readings of potential were taken when no appreciable heating effect was noticed, only a very small and constant current flowing at that time. These observations show that the unequal heating was caused by unequal resistances in different parts of the cell due to the formation of the hydroxide layer, together with the unequal concentration of the iron salt and the alkaline hydroxide, which diffuse toward the point where the precipitate of iron hydroxide is formed. A similar variation of temperature, only much less marked, showed itself in a cell containing pure sand (practically free from soluble salts) and distilled water. The theory has been put forth that the corrosion is due to the electrolysis of water, the nascent oxygen attacking the iron at the positive pole. In the first place, there is no electrolysis of water, oxygen and hydrogen being in each case set free at their proper poles by virtue of secondary reactions. The fact, however, that nascent oxygen even then does not attack the anode when the iron electrodes are used is clearly pointed out by an experiment, wherein six such cells were run in series at 100 volts terminal pressure, the current varying from 0·2 to 0·4 amperes during the experiment. The electrolytes consisted of pure glass sand saturated with a one-third of 1 per cent. solution of chemically pure nitrate of ammonia, chloride of ammonia, nitrate of potash, chloride of potash, nitrate of soda, and chloride of soda respectively. The real facts and explanation are given in the following conclusions:—In an electrolytic cell with iron electrodes, having any salt or salts of the alkaline metals or earths in solution in the electrolyte, the salts are electrolysed: their acid radicals attacking the anode, forming an iron salt. The metal set free at the cathode forms with water the hydroxide and liberates hydrogen. The ferrous salt diffuses toward the cathode, the alkaline hydroxide toward the anode, and at the point of meeting the ferrous hydroxide is precipitated and the original salt reformed. As the amount of electrolysis varies directly with the strength of current, a comparatively high current will liberate an excess of the acid radical; the critical point depending on the affinity of the radical for the iron, the surface exposed being the same. This excess forms in the presence of water an acid, and liberates oxygen. Neither the acid nor the oxygen have any effect on the iron, the anode being already engaged in the formation of the iron salt with the acid radical. Hence the oxygen escapes, and the acid diffuses through the electrolyte. The last experiment, together with the fact that the ferrous hydroxide layer invariably forms at some distance away from the anode, points very strongly to the conclusion that the corrosion is *solely due to the attack of the acid radical of the salt originally in the electrolyte*. As chlorides, sulphates and nitrates of the alkaline metals and earths are almost invariably found in street solids, and as a mere directive force in the way of an electric pressure is required to set up an electrolysis of these salts, it can be plainly seen that the iron pipes may be corroded wherever the potential at the latter is positive to the rail. The amount of corrosion in a given time only depends upon the amount of the current and the nature of the salts in the soil.

Mr. C. G. ARMSTRONG: Some years ago I was requested to inspect an electric railroad in Indiana, where I had some experience with the erratic action of electricity under ground, and where I made some measurements of differences in potential between adjacent conductors. Unlike Mr. Farnham I did not use a voltmeter, but used a mule, that is to say, the owners had noticed a variation in the operation and speed of their motors at a certain point. I watched a mule team driven over this place and found that at a certain point one of the mules became very much agitated, to the extent of planting his hind feet on the dashboard of the waggon many times in rapid succession. I had no means of calibrating the mule, but would judge that the potential difference must have been considerable at this point, and upon inspection I found that the rail bonds were broken, and a very disagreeable shock could be felt by touching the ends of the rails at this point. The construction of this plant had been very unscientific, and extreme differences of potential could be found in different parts of the town, but being only a country village with few pipes and fewer scientists, the matter of destruction to anything except the railroad property itself by reason of this faulty work was not thought of. I cannot feel that electrolysis is guilty of all things charged to it. I do not believe that every defective water pipe and gas main was destroyed by electricity. I have seen miles of water and gas pipe that was in much worse condition than that shown to-night, where the nearest electric wire was 20 miles

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away. I believe the gas companies are responsible for two-thirds of the trouble found in pipes to-day. Where we dig up the streets we find the earth permeated with ammonia and other destructive products of the gas retort, which within themselves are sufficient to attack and decompose any metal they come in contract with; in fact, one of the pipes shown was a gas pipe, and there was a serious decomposition of the metal on each side of the union. The author of the Paper attributes this to the resistance of the union; why might it not have been the leakage of the gas? I have found gas pipes that could not possibly be acted upon by electricity that were decomposed in exactly the same manner, from the gradual leakage of the gas. Undoubtedly we are guilty to a certain extent for the destruction of underground pipes, and the cause I believe can be removed. The use of the three-wire system as mention by Mr. Arnold is undoubtedly one solution, but offers complications. The use of the return wire as suggested in the paper is another remedy, but one which I am afraid will greatly interfere with the "returns" at the meeting of the stockholders. As mentioned in the Paper, every additional pipe protected reduces your protection to all others, and to obtain absolute protection it would be necessary to literally fill the ground with copper wire and have the different resistances nicely and mathematically balanced, and even then, with a large number of cars at the extreme end of the line, the resistance might be thrown out of balance, and electrolytic action result therefrom. I think this problem should be viewed just as we do that of wiring a building, viz., to avoid grounded circuits insulate both poles, and thereby dispense with electrolysis, danger from fire, and at once solve the difficult problem of lighting arresters for grounded circuits. There seems to be no practical difficulty in the use of the two trolleys. I really do not see, after all, why it is not the best way out of the present difficulty. It certainly would not cost as much to run a double trolley system as it would to run a complicated system of underground returns connecting to all water, gas, and other pipes, and what not that we meet in the street.

Mr. A. V. ABBOTT, on behalf of the author, said: The double trolley system certainly does afford a perfect solution, but only at the expense of a greater investment of capital. The objections to the double trolley system, other than those of increased capitalisation, are entirely mechanical ones and in ordinary lines can be overcome. The double trolley about three years ago still survived, and it is probably chiefly due to the Thomson-Houston Company that it does not still exist. In all railways which are reasonably straight, and do not encounter a great number of intersecting lines, the introduction of the double trolley is not a serious obstacle. Personally, I have always been in favour of all electrical companies operating entirely upon metallic circuits which should be peculiarly and appropriately their own. A conduit electric road is at the present time perfectly feasible, and its successful construction and operation is merely a question of the amount of capital that the promoters are willing to invest. Ordinarily speaking, an electric road can be built and equipped in running order at an expense of from thirty to forty thousand dollars per mile including all items, excepting that of real estate, franchises and buildings. The cable road is typical of the conduit system, and is always expected to cost from 125,000 to 150,000 dollars a mile. The widespread and rapid introduetion of electric roads has chiefly resulted from the fact that they require so much smaller capitalisation in the outset, and that they, therefore, may be introduced in districts that are not thickly settled, in which the traffic could never be made to pay the interest and depreciation on the more expensive cable plant. In building some 300 miles of electric road I have universally found that the grounded return circuit absorbed more energy from the station than any other part of the line, the car motor only excepted.

THE HATCHET PLANIMETER.*

Planimeters, or area-measurers, are apt to be regarded at first thought as necessarily difficult to understand, and mathematically complicated. When examined more closely, the mystery is resolved into very elementary principles, beautifully simple, and very interesting to engineers, who are always more attracted by geometry than by mathematical analysis. The most ingenious instruments by Amsler are well known to most of our readers, and they will, therefore, not be further referred to in this article; they maintain their superiority over all other instruments of this class. The hatchet planimeter, the invention of H. Corn Kundsen, of Copenhagen, is in construction the simplest of all planimeters. It was exhibited at the Physical Society on March 23rd, by Prof. Henrici, in connection with his Paper on "Integrating Instruments," and it was then remarked, that a mathematical demonstration of its action was still a desideratum. The following exposition of the geometry of the hatchet planimeter will therefore, we hope, be interesting to many of our readers.

The hatchet planimeter is merely a trammel of fixed length, with, at one end, a tracing pointer, and at the other end a tangent keel pointer or knife-edge called the hatchet; the edge is as at F in Fig. 1, curved, so that, although a keel edge, it may still be regarded as a tangent point. Fig. 1 shows the planimeter inverted. Here the length from keel point to tracer point is $1\frac{1}{4}$in., too short for general use, but this length has been chosen now to more clearly exhibit the geometry of its action. The keel edge F is, of course, in the same plane as A.

The boundary of the figure, whose area is to be ascertained, is traced continuously, in one direction, with the tracer pointer A, while the hatchet or keel end of the instrument, describes a path from which the area of the figure can be directly measured.

* Abstract from *Engineering*.

The boundary of any figure can be resolved, elementarily, into ray and arc alternately, *i.e.*, into elements in the direction of the planimeter arm and elements normal to the arm. While tracing a ray element the arm does not alter its direction, and while tracing an arc element the hatchet tangent point does not alter its position. When these are indefinitely minute, the coincidence of outline will be perfect.

In Fig. 2, A B C D is an arc-and-ray figure, B C and D A are arcs, and B A and C D are rays. Draw the straight line G A

Fig. 2.

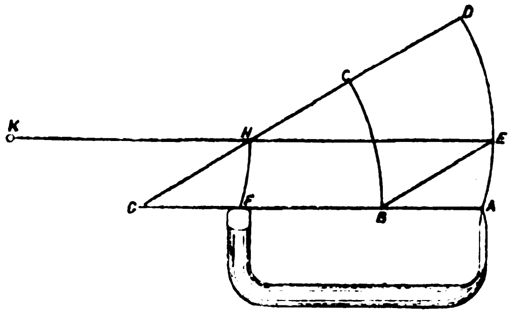


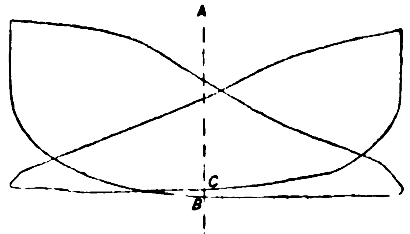
Fig. 1.

through B, and call this the axis. The planimeter has its initial position on this line at F A. Of course the planimeter is applied in the vertical position.

* While the pointer traces .... A B C D A
the hatchet describes........................ F G G H H

To complete F G H draw the straight line K E through H parallel to the axis F A, and describe the arc H F from K with radius K H = F A, the length of the planimeter. Draw B E parallel to C D. The figure F G H, which we may call the keel field, is evidently equal to A B E, and the figure B C D E = the parallelogram B G H E, because the one figure could be changed into the other by shearing parallel to E B. Introduce now L = length of planimeter, and Y = perpendicular distance of the final keel position H from the axis G A. Since H E or G B = L, the area of the parallelogram H B is equal to L Y, and the area of the whole figure C A is L Y + the area of the keel field F G H = A B E.

Fig. 3.



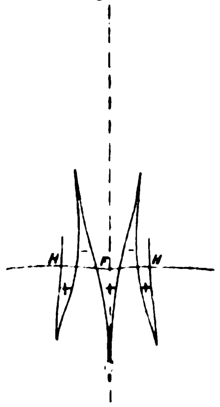


Fig. 4.

In Fig. 2 we have only one arc-and-ray element, but just as the outline of any figure may be regarded as made up of indefinitely minute arc and ray elements, so also any area may be regarded as made up of arc-and-ray elemental bands.

Some engineers who have used the instrument say it is very suitable and quite accurate for indicator diagrams. Fig. 3 is a sketched pair of diagrams, and Fig. 4 is the keel path in the appro-

[* While the pointer traces A B, the hatchet describes F G.
" " B C " " stands at G.
" " C D " " describes G H.
" " D A " " stands at H.—ED. *E.*]

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priate position; G A is the axis, it extends across Figs. 3 and 4. The planimeter is in this instance 8in. in length, or twice the length of the diagrams. The hatchet is placed on the axis at G, and the diagrams are traced in opposite directions, preferably in the same directions as they are drawn by the indicator. The keel paths are then easily manageable, and a little experience teaches at what point in B A the tracing should terminate. Really, the tracing ought to commence at the same point at which it ends, but, as the initial movement down A B would merely describe a portion of the axis, it may, therefore, be always omitted. The arcs H F, H_1F are drawn with radius = 2in., the length of the planimeter, from centres at the distance of H and H_1, from the axis. Practically, these arcs may be made a straight line, but the mathematical demonstration is that the arcs drawn to radius L, and equalising the + – + – + areas, has its ends horizontally apart a distance equal to the mean breadth of the diagrams, when L is twice the length of the cards. The horizontal distance H F, measured with the appropriate indicator scale, is, therefore, the mean pressure. The axis need not be drawn *accurately* perpendicular to the atmospheric line; square to the eye will be sufficient.

This explanation has been written, not because the instrument is of importance, but because the geometry of the problem is interesting, and because vague and erroneous statements have been promulgated regarding its accuracy.

ON THE SIMILARITY BETWEEN THE AFTER-GLOW OF THE GEISSLER TUBE AND THE FIRST GLOW OF SOLID BODIES.*

BY CARL KIRN.

The researches of H. F. Weber on the evolution of light-emission from glowing solid bodies have proved, as is well known, that the first visible light is not, as Draper formerly gave out, dark red, but "dark-fog-grey," which shows itself spectroscopically as a band in the yellow-green, to the eye the brightest part of the visible spectrum, and widens out on either side as the temperature rises. The temperature at which bodies emit this first-visible grey light is much lower than that at which the dark red glow begins, and is different for different bodies. The researches of Stenger and Ebert on the limits of visible light next showed that the phenomenon was conditioned by the different sensitiveness of the eye to the different colours, this sensitiveness being a maximum for that part of the spectrum where the band of the grey light is first seen. It was certainly to be expected *à priori* that generally in the case of luminous phenomena the same order of events would occur, those at extinction being the reverse of those on lighting up. I am not aware, however, that such an investigation has been carried out, so that the spectroscopic observations I have made on the so-called after-glow of Geissler tubes may not perhaps be altogether without interest.

The particular after-glow tube in these experiments was made by the firm of Dr. H. Geissler, of Bonn, and came indirectly into my possession. It had a bent serpentine shape, and was provided with seven globular enlargements. In the inside of the tube, especially in the enlargements, there were delicate flakey deposits, and a few specimens of colourless crystals that probably consisted of sulphuric anhydride.

The tube exhibited after an electric discharge had been passed through it, all the usual phenomena observed by Riess and Morren, the yellowish-white after-glow of the bulbs (the narrow parts of the tube glowed somewhat more feebly, and with a more yellowish-grey tint), lasted for more than half-a-minute in a completely dark room. The end bulb containing the negative electrode glowed more feebly, and went out the first, whilst the remaining six bulbs remained visible somewhat longer, and went out in succession from the negative to the positive pole.

Spectroscopic observations were made with a Desaga prism apparatus. Whilst the electric discharge was actually passing, the tube exhibited a line spectrum, which was most pronounced in the narrow parts of the tube, and the brightest line of which seemed to me, after comparison with a spectrum tube of my own making, to coincide with the nitrogen and carbonic oxide lines. The same spectrum is also clearly recognisable, at the commencement of the discharge, in the bulbs. But the moment the well-known nebulous glow makes its appearance in the bulbs the definition of the line spectrum diminishes, and assumes the character of a continuous spectrum in which the background is becoming brighter.

The feeble spectrum of the after-glow is continuous, without noticeable dark places, and occupies at first the entire space taken up by the previously mentioned line spectrum, but it shrinks tolerably quickly from either side (rather more from the blue than from the red) into a band lying between wave-lengths 555—495 $\mu\mu$, and this band vanishes more slowly diminishing in breadth, and gradually goes out. Nevertheless, the colour of this band is not the clearly defined colour of that part of the spectrum, but a characteristic pale yellow grey, which gradually becomes darker as extinction is approached. The place of the final tint corresponds almost with the E line of the solar spectrum, and coincides closely with the region of greatest brightness of the ordinary visible spectrum. The whole phenomenon of the extinction of the after-glow is, therefore, the exact reverse of what is observed to take place when solid bodies begin to glow.

Opinion is still divided as to what is the true cause of the after-glow of discharge tubes, nevertheless research seems to show that the phenomenon must be considered as the result of chemical modification of the contents of the tube, and as a chemico-luminous phenomenon. It is to be regretted that, owing to the nature of the experiment, it is impossible to investigate the beginning of the fore-glow owing to the previously-mentioned brilliant line spectrum interfering with the observation of the development of the feeble, continuous spectrum. However, one may very well conclude that the order of events on extinction is the reverse of that when the light is generated.

My observations seem to me chiefly worth communicating since they relate to light due to luminescence.

* *Wied. Ann.*, No. 6, 1894, p. 381.

LEGAL INTELLIGENCE.

Muirhead and Others v. The Commercial Cable Company (Limited).

It will be remembered that in the report of this case, which appeared in *The Electrician* of May 4th, it was stated that a day would be fixed for his Lordship to hear counsel's arguments upon the question as to whether or not the plaintiffs—who were the successful parties—were entitled to interest, and at what rate, upon the amount recovered! Judgment was recently delivered in favour of the defendants.

Mr. JUSTICE KENNEDY said that article 5 of the agreement, dealing with the question of time, fixed the royalty in these terms:—"The royalty, determined as above mentioned, shall be payable in London quarterly, and shall commence to run from the expiration of the first period of 15 consecutive days during which the inventors shall have maintained their said apparatus in good working order on the company's cables or cable, and transmission of the cables shall have been determined between the parties," after a realisation of an increase of 30 per cent. at least in the power of and then there was further provision. His Lordship said that, looking at the method of ascertainment of time as prescribed in that article, it seemed to him quite impossible to distinguish this case from the one decided in the Exchequer Chamber (Merchant Shipping Co., Limited, v. Armitage). For those reasons his Lordship said he must disallow the plaintiffs' claim for interest. Judgment would therefore stand for the amount claimed, less, as he understood it, the sum of £135 which had been paid into Court, and which the plaintiffs were entitled to take out.

Mr. POLLARD reminded his Lordship that there was another point on the question of interest, which did not depend upon the written agreement but upon the express claim in the writ.

Mr. JUSTICE KENNEDY said that upon that point he was quite clear that the fact of there being a claim and demand in a writ was not a demand within the operation of the section (3 & 4 Will. IV., c. 42, s. 28) which constitutes a demand. He was, therefore, against him on that point as well.

National Telephone Company v. Morris Brothers.

An action was recently brought in the Sheffield County Court by the National Telephone Company against Messrs. Morris Brothers, chemical manufacturers, of Doncaster, for £50, balance of rent due for telephone service. The defendants lodged a counter claim for £50 damages arising from the defective working of the telephone. It was not denied that the rent claimed was due under the contract between the parties, but it was held that plaintiffs were not, under the special circumstances, entitled to it.

Mr. WILKINSON, for the defence, said some time in the year 1889 his clients were approached by the Company with reference to putting up a private wire between their offices in Doncaster and their works at the village of Stockwith-on-Trent, 20 miles distant, and also a wire between the offices and the residence of Mr. Morris, the senior partner. When the contract was sent for signature, it was accompanied by a letter, in which the Company stated, amongst other things, "We guarantee that the communication between your offices and works will be absolutely satisfactory to you, and that any repairs, should there be any, will be attended to at once by the Company." It was on that strongly worded assurance that defendants signed the agreement in March, 1889. Although it was said the wire would be laid in a few weeks, it was 12 months before it was completed, and it was not until March, 1890, that the defendants were placed in possession of the service. From the very commencement they were subject to great annoyance, because of the imperfectness of the communication. In consequence of this, the Company allowed a deduction of £10 on the rental for the first year. During the succeeding three years the communication continued to be most unsatisfactory. Complaints were constantly made to the Company; in fact, no less than 118 letters calling for a remedy were sent, but with no result. About two years ago the

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Company put up some wires for other parties on the poles used for defendants' private wires, and this added to the confusion. There was (counsel said) no doubt the work carried out for defendants was unskilfully done. The Company had almost continuously sent men to effect an improvement, but they did not succeed, and defendants' business had been interfered with. The contract was made from a company point of view, and defendants, as business men, would not have signed such a one-sided document unless they had had some distinct assurance from the Company, such as that contained in the letter, that the service would be satisfactory, and counsel contended that the guarantee became part of the contract.

A number of witnesses were called on behalf of defendants, whose evidence bore out counsel's statement, and it was finally agreed to adjourn the further hearing to a date to be arranged.

Re the Printing Telegraph and Construction Company of the Agence Havas.

In the High Court of Justice, on Tuesday, Mr. Justice Kekewich commenced the hearing of a motion *ex parte* Elvey and two actions of the Company v. Lord Windsor and Lord Windsor v. Ratcliffe. The case, like many others recently tried, shed a glaring light on the peculiar ways of the company promoter.

Mr. WARMINGTON, for Mr. Elvey, explained that his client was seeking to have the register of the Company rectified by the removal of his name therefrom in respect of shares. Lord Windsor had brought an action against the Company to be similarly relieved, and the Company brought a cross-action against him for calls. The facts in the two cases of Elvey and Lord Windsor were to some extent the same, and it had been agreed that, as far as possible, the evidence should be regarded as applying to both. In the early part of March, 1893, Mr. Elvey was introduced to Mr. Beyfus, solicitor to Messrs. Ratcliffe and Viben Smith, the owners of an American patent and promoters of the defendant Company, whose object was to raise in this country capital for the development and employment of an invention for which a Mr. Wright had taken out, in France, a patent for printing in columns news transmitted by wire. On March 17th Messrs. Slaughter and May, solicitors, who were registering and forming the defendant Company, in London, wrote announcing the appointment of Mr. Elvey as assistant manager in Paris, at a salary of £250 a year, subject to three months' notice on either side. The Directors, the letter stated, were willing, and intended, to proceed to allotment as soon as *bonâ fide* applications for £40,000 of shares had been subscribed. Mr. Elvey had been asked, as a means of procuring the appointment, for an underwriting letter to secure a subscription of 1,000 shares at £5 each; and he made it a condition of giving this letter that he should be appointed, but that his colleagues, who were also to subscribe underwriting letters, should be *bonâ fide* subscribers, and capable of performing their contracts. The learned counsel quoted the details of an agreement between Ratcliffe and Smith and the defendant Company, which recited that a company had been formed, with a share capital of £115,000 in £5 shares, for acquiring the rights and using the inventions relative to printing telegraphs; it also recited an agreement between the American company owning these rights and the vendors, who were to subscribe, or procure subscriptions for, £40,000 of the share capital of the Company. The Directors had also agreed to appoint Mr. Elvey as assistant manager for one year, subject thereafter to three months' notice on either side. So far, however, as could be traced by the minute-book, no such meeting was held on that day. Meantime Mr. Elvey had signed the underwriting letter, and given it to Beyfus and Beyfus, his solicitors, but wired them not to give up the guarantee, but the wire was received after the letter had already been parted with. Messrs. Beyfus were not authorised to part with the letter until the two conditions of Mr. Elvey's undertaking had been complied with, and on receiving an allotment letter from the Company on April 6th he wrote to the secretary repudiating and refusing to accept it. Apart from these facts, the Company, by a resolution of May 27th, rescinded their contract with Ratcliffe and Smith, therefore the Company could not both rescind Ratcliffe and Smith's contract and claim under it. At the time of the commencement of these proceedings there was no legal register of shareholders on which applicant's name could be placed, and from which, therefore, he could be struck off, as he had now formally to ask should be done. Applicant likewise charged such misrepresentation in the prospectus and dealings of the Company as entitled him to repudiate any alleged contract so tainted. He further objected that of the underwriting letters of £52,000 reported to applicant's solicitors on March 23rd, as having been obtained by the Directors, some £25,000 had been subscribed partly by persons of whom some could not be found, and partly by others who were unable to meet any calls that might be made on them. Among the grounds on which the application was based was that the prospectus, as a whole, was calculated to lead people to believe that the invention which the Company held was a monopoly, which was not true, the French Government having in 1892 granted to the Agence Dalziel a concession or authority of exactly the same nature and terms as they granted to the Havas Agence.

Sir RICHARD WEBSTER, on behalf of the defendant Company, said he had advised his clients that, apart from the merits of the case, it raised intricate points in company law which, if threshed out, would consume much time and such heavy costs that victory would be little better than defeat. The Company had some 20 machines at work, and between 20 and 30 more were now on their way from America, and there was every reason to believe that it would prove a success, whereas if litigation should be continued it might result in disaster. He had therefore advised his clients that if any reasonable arrangement could be arrived at it should be done, the more so as there were other parties awaiting the issue of these actions and threatening other proceedings. In these circumstances he asked his lordship to give the parties, say, a week to review the position, and see whether an arrangement could be arrived at, to the great saving of expense, if of nothing else.

This was ultimately agreed to, and the case was adjourned for a fortnight.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

The 1894 Edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is NOW READY. This valuable book contains 1,000 closely-printed pages, and several new and useful features have been added. The price of the Directory and Handbook is 7s. 6d. Postage in the United Kingdom, 9d.; abroad, 1s. 4d.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," being four Lectures delivered before the Royal Institution in April-May, 1894, by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is in preparation, and will shortly be published.

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. (abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application to the Publisher.

"ELECTROMAGNETIC THEORY," by Oliver Heaviside, is now ready, price 12s. 6d. (abroad 13s.). Prospectus on application.

"THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application to the Publisher.

"DRUM ARMATURES AND COMMUTATORS."—This book, written by Mr. F. Marten Weymouth, is also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"INVENTIONS, RESEARCHES AND WRITINGS OF NIKOLA TESLA," by T. Commerford Martin, may be obtained from the Publisher of *The Electrician*, and a copy will be forwarded post free on receipt of 16s. 6d.

"HOW TO WIRE BUILDINGS."—Copies of this work, by Augustus Noll, will also be sent by the Publisher post free on receipt of 6s.

TENDERS INVITED.—The Local Authority of the burgh of Ayr require tenders for the supply and erection of plant and apparatus required for their electric lighting scheme. Tenders can be for any section or sections of the whole. All necessary particulars, specification, &c., can be obtained at the offices of Mr. Robert Hammond, Ormonde House, Great Trinity-lane, E.C., on and after to-morrow (Saturday); and tenders must be sent in to Mr. A. G. Young, Town Clerk, the Council Chambers, Ayr, not later than Saturday, June 23rd. Further particulars are given in our advertisement columns.

——— The Acton Local Board invite tenders for the transfer of their Electric Lighting Provisional Order. Tenders have to be sent in by 6 p.m. on June 5th.

——— The Inspectors for lighting the town of Alford (Lincs.) are prepared to enter into a contract for lighting the town by gas or other illuminant. Tenders must be sent in to the offices of the Inspectors, West-street, Alford, by June 9th next.

——— The Coventry City Council invite tenders for the erection of an electric lighting station, which must reach the Town Clerk by June 13th.

——— The Grimsby Urban Sanitary Authority require tenders for the lighting of the public streets of the borough for one year. Further information can be obtained of the Borough Surveyor; and tenders must reach the Town Clerk by June 8th.

——— Mr. H. N. Mollwo, 72, English Quay, St. Petersburg, is desirous of obtaining from leading electrical firms estimates for supplying electromotors for use on the tramways in the Russian capital.

——— The Directors of the North-Eastern Railway invite tenders for telegraph apparatus, telegraph wire, and line stores for the six months ending December 31, 1894. Tenders must be in by noon on Tuesday next.

——— The Director-General of French Posts and Telegraphs requires tenders for the supply of 350,000 kilogrammes of bronze and copper wire of high conductivity and 4,000 tinned copper connectors (in eight lots). Forms of tender may be obtained from the Direction-Générale des Postes et des Télégraphes (Division du Matériel et de l'Exploitation électrique, 3e Bureau), 103, Rue de Grenelle, Paris, up to June 3rd, and tenders will be received till 11 a.m. on June 14th.

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Tenders Accepted.—The Halifax Corporation have accepted the tender of Messrs. W. H. Bailey and Co., Albion Works, Salford, for the supply of steam pumps for the sum of £1,168.

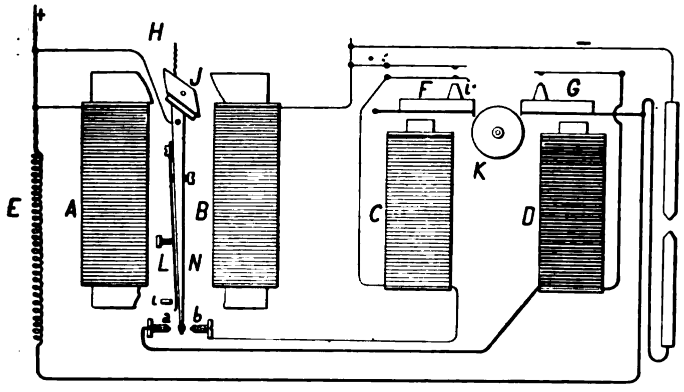
Liquidations.—A meeting of the shareholders of Anders, Elliot and Chetham-Strode (Limited), which is in voluntary liquidation, is to be held at Mr. F. H. Ebsworth's 1, Arthur-street East, London, E.C., on July 12th, at 3p to receive an account of the winding-up.

Removal.—Messrs. Bennett and Druce are removing from 44, Fishergate, Preston, to larger and more convenient premises, at 30, Winckley-square, Preston.

"Snowflake" Composition.—Mr. V. Fabris informs us that this composition has recently been successfully applied to a large number of incandescent lamps at the Oxford Music Hall and at the billiard rooms of the Bedford Hotel, Tottenham Court-road, W.C.

Mechanical Ventilation.—Messrs. Baird, Thompson and Co. have received information that the installation of their mechanical ventilation process in the steamship "Zweena," for Messrs. Forewood Brothers and Co., has resulted so satisfactorily that it is intended to extend the system to the remainder of Messrs. Forewood's fleet. The system is also adopted by the Neptune Steam Navigation Company, and also at Hull by the owners of a large fleet of steamships. A new illustrated catalogue describing the system can be obtained at the Company's offices, 159, Queen Victoria-street, London, E.C.

The "Cock" Arc Lamp.—A successful attempt to design an arc lamp be used in places for which incandescents only have been employed has been made by M. Cadiot, 44, Rue Taitbout, Paris, whose "Cock" lamp is illustrated in the accompanying figure. Between the poles of the electro-magnet A B, wound with thin wire of 500 ohms resistance, is pivoted an iron armature, J, to which is fixed a lever, N. The solenoid C, also wound with wire of the same resistance as the electro-magnet, draws the carbons close to each other, when N makes contact with *b*, while the solenoid D, wound with



thick wire of a resistance of 1·5 ohms, separates them when N, making contact with *a*, puts the lamp in circuit with the resistance E. The solenoids actuate two arms, F and G, which move an endless screw, tangential to a wheel round which is a chain attached to the carbon holder. The current being switched on, the electro-magnet A B attracts the movable armature J, and the lever N, making contact with *b*, the solenoid C is put in circuit, and its armature F causes the carbons to come into contact. The difference of potential at the poles of the magnet becoming very small its force is overcome by the opposing spring H, and N, therefore, makes contact with *a*, so that the current is diverted to the thick-wire solenoid D, the vibration of whose armature, G, continues until an equilibrium is attained between the attraction produced by the magnet A B and the action of the spring H. The difference of potential at the poles of the magnet increases as the carbons consume, and the action goes on as before—the lever N makes contact with *b*, and the solenoid C is put in circuit. To prevent sudden recoils, which may be caused by the impurity of the carbons or by the instability of the armature J, the lever N is mounted a spring, L, whose pull is added to that of the spring H, but which is released before the contact with *b* brings the carbons together. The lamp is small, and, it is claimed, takes but little current. The candle-power may, it is stated, be varied from 100 c.p. to 400 c.p., by the aid of a rheostat, operated according to whether more or less light is required. A suggested advantage of this lamp is that, owing to the recoil movement, it can be successfully used in installations where the dynamo is driven by an engine subject to variable loads, and its small size allows it to be fitted into electroliers, pendants, &c., as well as for public lighting.

New Post Office Telephone.—The Consolidated Telephone Construction and Maintenance Company, of 109, Farringdon-road, London, E.C., issue a circular illustrating their new form of Post Office telephone, which is devised under instructions given by the chief engineer and electrician to the British Post Office, and is manufactured by the Company. The circular also illustrates a new form of transmitter, which can be used on the existing sets of call bells and receivers, and can also replace the Blake transmitter. The circular and other particulars can be obtained on application.

Leakage Indicators.—Messrs. Nalder Brothers and Co. are now making Major Cardew's new recording leakage indicator for high-tension alternating circuits.

Morris's Combined Ammeter and Voltmeter.—This instrument consists of a strong brass case 8in. in diameter, with four terminals; two small terminals are used for the volts, and the two large terminals for the amperes. It has two hands or pointers, on each of which is a disc suitably lettered. By this plan it is claimed that there can be no mistake in the readings. The instrument is patented by Mr. W. R. Morris, of Birmingham.

Domestic Electricity.—The Westminster Electric Supply Corporation have just issued a neatly-printed circular giving particulars and illustrations of a variety of cooking and heating apparatus. It does not appear from the circular that the Company are prepared to supply the apparatus, the cost of which is set out in the circular. The offer made by the Company is to supply current for cooking and heating purposes at 4d. per unit after July 1st through a separate meter.

Acton.—The Works Committee of the Local Board have reported that the negotiations with Mr. Medhurst for the taking over of the Electric Lighting Order are at an end, Mr. Medhurst finding that, with the conditions laid down by the Board, he was unable to float a company to take over the Order. It was decided to invite tenders for the sale of the Order, and advertisements are appearing, as stated elsewhere.

Belfast.—The Board of Guardians having considered the question of substituting electricity for gas in the workhouse, have decided that, although the former must be considered the more healthy light for hospital purposes, the increased cost of £96 per annum which would be entailed prohibits its adoption at present.

Blackburn.—Mr. Thomas Barton writes that—a note in our last issue, stating that the contract for lighting the Free Library and Museum by electricity had been let to Mr. J. McLellan, is inaccurate. The current for the lighting of this building is to be supplied from the Corporation mains, and the internal wiring is already completed, having been carried out by Mr. Barton some time back.——It is stated that it will be necessary to hold another Local Government Board inquiry into the application of the Blackburn Corporation to borrow money for the erection of an electric lighting station.

Blandford.—Many years ago this town was destroyed by fire, and it is not until recently that a satisfactory water supply has been organised. This is now being done, and powerful oil engines are being fixed for pumping purposes. Mr. E. R. Dale, of Sherborne, Dorset, has suggested lighting the town by electricity. As a commencement, the Crown Hotel and the public vehicles of the place have been provided with electric lamps.

Bridlington.—The Local Board have decided to light up the sea-front from the north end of the Prince's-parade to the north end of the Beaconsfield Sea Wall by electricity at an estimated outlay of £275. The Prince's-parade has been lighted electrically for some time past, and has been proved such a success that the Board have decided to extend the electric lighting.

Chelmsford.—An application from "a London company" to establish a telephone exchange at Chelmsford in connection with the proposed line between London and Norwich was at the last meeting of the Town Council referred to the General Purposes Committee. The line is estimated to cost £2,000.

Church and Chapel Lighting. — The Calvinistic Methodist Chapel at Llandinam is now lighted by electricity. The Parish Church of St. Deinol, Itton, is also now lighted electrically.

Church Gresley.—The proprietors of the Cadley Hall Colliery have decided to adopt the electric light, and have placed the contract with Messrs. Hewes and Geary.

Chelsea (London).—Mr. T. W. E. Higgins, Surveyor to the Chelsea Vestry, has issued a report on the dust destructor scheme at Kensal Town, and the advisability of utilising the heat for public baths or electric lighting. He reports that, in response to his invitation for applications from several leading firms of dust-destructor manufacturers, four schemes were submitted, by (1) Messrs. Horsfall, (2) the Municipal Appliances Company, (3) Messrs. Manlove Alliott and Company, (4) Livet's British Steam Generator Company. As regards utilising the heat for electric lighting, Mr. Higgens reports that there are about 200 lamps

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scattered over seven miles of streets, and the laying of cables to cover this extensive area would be an exceedingly costly proceeding, resulting in much waste, therefore, the idea of lighting the street lamps in this district from the heat generated in the destructor, is out of the question. It is pointed out that the Vestry have not yet obtained a Provisional Order for the supply of electric current, and that this would first of all have to be provided for. The demand for current for private lighting would be small, and, therefore, Mr. Higgins is not in favour of this scheme.

City of London.—The Commissioners of Sewers have just issued a scale of fees to be paid in respect of services to be rendered by the electrical inspector within the City boundaries. The scale includes fees for testing under various conditions, the fees ranging from 2s. 6d. to £1. 10s. Any objection to the scale must be lodged before June 22nd.

Dewsbury.—The electric lighting works here are making satisfactory progress, and evidence is not wanting that the light will be fully patronised by the principal residents and tradespeople. Several of the latter have commenced wiring their shops, offices, warehouses, &c., so as to take current from the Corporation mains as soon as ready.

Dover.—An electrical exhibition, organised by the Dover Electricity Supply Company (Limited), was held last week in the Connaught Hall under the supervision of Mr. Alfred Matthews, and proved of considerable interest to a large number of visitors.

Dundridge.—Messrs. Veale and Co., of St. Austell, have just completed an extensive installation of the electric light for Mr. R. Harvey, of Dundridge, near Totnes, whose mansion is now lighted by 153 incandescents of 8, 16, and 32 c.p. The plant consists of a Crompton dynamo, driven by a 7-h.p. Crossley oil engine, and includes a battery of 53 Crompton-Howell cells.

Exeter.—The Devon Standing Joint Committee have accepted an offer of the local electric light company to instal the electric light at the Central Police Station, at a cost of £55, the annual cost of maintenance being £39, as compared with £30. 18s., the present cost of gas.

Hanley.—The arrangements for the public lighting of this town by electricity are nearly completed, and the light is being used in many of the principal shops and in the Free Library. Many of the street lamps are erected, and have been twice tested, and in each case found to be in perfect working order.

The Hartlepools.—In reference to the electric tramways at West Hartlepool, it is now, we understand, proposed to form a local company to carry through the undertaking, a start with which will, it is expected, be made within the next few weeks.

Hospital Lighting.—The electric light has been introduced into the Ophthalmoscopic room at the Moorfields Ophthalmic Hospital, to the great advantage of both surgeons and patients.

Hotel Lighting.—The new Palace Hotel, High-street, Kensington, London, W., which has cost over £200,000 to construct, is 120ft. in height, with a frontage of 224ft., and contains upwards of 350 rooms, has been lighted throughout by electricity.

Howth Tramway.—A meeting has been held to oppose the proposed electric tramway to the Hill of Howth, a suburb of Dublin, one of the principal objections being that the line would disturb the "peaceful beauty which constitutes the chief attraction of the Hill." It was stated by one of the speakers that the district was already invaded by large numbers of people from Dublin, "and it was desirable that Howth "should be protected from further invasion." Two of the principal proprietors of the district, Lord Ardilaun and Lord Howth, are in favour of the scheme, provided certain conditions laid down by them are agreed to.

The Lighting of Model Dwelling Houses.—In the House of Commons on Tuesday, in Committee on the London County Council General Powers Bill, it was proposed by Mr. Naoroji that a new clause be inserted compelling the owner of any buildings designed for use as flats or tenements, in which any staircase or passage is used in common by the occupants, to keep the same lighted from sunset to sunrise to the satisfaction of the Lighting Authority of the parish or district in which the tenement or building is situate, and providing that the Lighting Authority for the district should, by agreement with the owner, undertake the lighting, and to supply the necessary lamps and fittings, &c., on terms to be agreed upon. On the part of the County Council the clause was opposed, and the Council further withdrew the lighting clause as it originally stood in the Bill. It was pointed out by Sir Julian Goldsmid that both the original clause and the proposed new clause would involve an outlay on the part of the Model Dwellings Association of £10,000 a-year. The new clause was by leave withdrawn.

The Lighting of Newspaper Offices.—Very few newspaper offices in the neighbourhood of Fleet-street now remain unacquainted with the advantages of the electric light. The offices of the *Scotsman* are now to be lighted electrically, the work having been entrusted to Messrs. John Bolding and Sons, of Davies-street, London, W.

Lowestoft.—Mr. G. H. Hamby, the borough engineer of Lowestoft has compiled a set of very interesting tables of information obtained from cities and towns throughout the country as to the comparative cost of lighting by gas and electricity. The information has been specially prepared for the use of the Lowestoft Town Council, and, as indicated in our last week's issue, is to be circulated amongst the members of the Council. Seven columns in the Table are devoted to information concerning the lighting by gas, and nine columns to lighting by electricity. The Tables give information which will doubtless enable the Town Council to arrive at a speedy decision as to the advisability or otherwise of applying for a Provisional Order for lighting the district.

Mill Lighting.—The electric light is to be introduced throughout the extensive Brookside Mill at Leigh, the property of Messrs. Gamble and Smith.

——— The flour mills at Bolton, Lancashire, owned by Messrs. Ormrod, Hardcastle & Co. (Limited), are to be lighted throughout by electricity. The plant will consist of a dynamo capable of lighting 1,300 lamps, requiring about 120 h.p. to be driven at slow speed from one of the mill engines. There is to be in addition a small pilot dynamo capable of lighting 100 lamps. The contract has been let to Messrs. Bennett and Druce, the designs and arrangement of plant being carried out by Messrs. Shepherd and Watney, of Leeds.

Newcastle-on-Tyne.—A Special Committee of the Corporation have resolved to report to the City Council that it is desirable for the Corporation to be in a position to supply the City with the electric light.

Norwich.—Notwithstanding the opposition of the Rev. G. H. Cooke, who contended that the money would be better spent on books for the library, the recommendation made by the Committee of the Norfolk and Norwich Library that electric light should be substituted for gas has been carried by a large majority. A report from Gurney's Bank that a considerable money saving had been effected by the substitution of electricity for gas quite upset the opponents of electricity.

Presentation.—At the Claybury Asylum, on Wednesday last, Mr. Ross Cotton, A.I.E.E., was presented by the electric lighting staff with a silver-mounted walking stick, cigar case, and an illuminated address on the occasion of his leaving the station.

Preston.—A Parliamentary Committee, presided over by Sir James Kitson, has, during the week, had under consideration the Bill promoted by the Preston Gas Company authorising the construction of additional works, the raising of £2,000,000 of further capital by shares and £50,000 by loan, and the extension of the Company's operations by power to apply for an electric lighting Order. The Bill is opposed by the Preston Corporation and by several of the principal landowners in the district. Mr. Green, Secretary and Manager of the Gas Company, in the course of his examination, said that he did not think the Electric Lighting Company at Preston, which had prejudicially affected the Gas Company's business to the extent of about 10,000,000ft. a year, would be likely to suffer from the extended powers asked for by the Company, as they now had all the principal customers in the town.

Provisional Orders.—The Electric Lighting Provisional Orders for Buxton, Chesterfield, and Barrow, have passed through Committee, and have been ordered to be reported for third reading. The Electric Lighting Orders lodged by the Shrewsbury Electric Light and Power Company (Limited) for the lighting of Shrewsbury and district, by Messrs. J. C. Howell (Limited) for the lighting of Aberdare, by the Yeadon Local Board, by the Wakefield Corporation, and by the Birmingham Electric Supply Company (Limited), have all passed the examiner of the House of Lords and stand for second reading; and the Provisional Order of the West Hartlepool Town Council has been read a third time and passed, subject to the Royal assent.

Queen's Birthday Illuminations.—Several novel devices in combination with the electric light were noticeable in the illuminations in the West End of London in celebration of the Queen's birthday on Saturday last, but owing to the steady downpour of rain, little or no attention was bestowed upon them.

Salisbury.—The Town Council have unanimously assented to the application of Mr. H. Gramshaw, on behalf of the Salisbury Electric Light and Supply Company (Limited), giving their consent to the Company's application for a Board of Trade licence to supply the district with electric current.

Sheffield.—The Sheffield Electric Light and Power Company have commenced laying their electric lighting mains westward, and this district is expected to be connected up during the coming autumn.

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SHOREDITCH (LONDON).—The Vestry are proceeding with the arrangements for the purchase of the Pitfield-street site upon which the electric lighting central station is to be built in conjunc- with the dust destructor, public baths, library, &c. This piece of land is to cost £33,000, and the whole scheme will cost nearly £100,000.

TAUNTON.—We have received the following from Mr. Harold W. Couzens, borough electrical engineer, in reference to a Trade note in our last issue:—"Just a line to correct a small error in your Note *re* Taunton in this week's issue. It was my quarterly report to the Town Council that you have quoted from. I subjoin a little further information from it which may be of interest. We have fixed the 50 H.P. Bumsted and Chandler engine and 30 unit alternator, and are working them regularly during the hours of light load. No. 1 transformer sub-station is now in full working order, and we have now 960 8-c.p. lamps connected to the low-tension cable. We are erecting the steam drums and piping, and have raised steam in the new (105 H.P.) 'Economic' boiler."

WESTON-SUPER-MARE.—The Town Council have resolved that the Electric Lighting Committee be instructed to choose an engineer to report on the whole question of electric lighting, electric tramways, and refuse destructors, the fee to be 50 guineas.

WORCESTER.—It has been decided to charge 5d. per unit for electric current, subject to a discount of 5 per cent. for cash, 3 per cent. on accounts of from £25 to £50, 5 per cent. from £50 to £100, and 10 per cent. from £100 upwards. It was the opinion of many members of the Corporation that 6d. should be the minimum charge, but the casting vote of the Mayor decided the matter.

BOOKS RECEIVED.

"The Practical Management of Dynamos and Motors." By F. B. Crocker and S. S. Wheeler. Second Edition. (London: E. and F. N. Spon.)

"Journal of the Institution of Electrical Engineers." Edited by F. H. Webb, Secretary. Vol. XXIII., No. 111. (London: E. and F. N. Spon.) Price 3s.

COMPANIES' MEETINGS AND REPORTS.

West Coast of America Telegraph Company (Limited).

The 17th ordinary general meeting of this Company was held on Tuesday at Winchester House, Old Broad-street, under the presidency of Mr. J. Denison Pender.

The SECRETARY (Mr. Fred. L. Robinson) read the notice calling the meeting, and the report of the Directors was taken as read.

The CHAIRMAN said: Before I move the adoption of the report I have one painful duty to perform—in having to record the death of Mr. Henry Roberts. He had been a member of this Board for some time, and I think he took the chair at a meeting which was held not very long ago. Mr. Roberts was a member of one of the leading firms of shipowners, and was, therefore, able to gauge very well the commerce of the country. His death has been a severe loss to this Company, and a personal loss to both Mr. Walters and myself. I will now give you some further information on the various points mentioned in the report. The gross receipts, you will see, are £7,122 less than in the previous year; but in 1892 the receipts included the sum of £4,782, which was received from the Chilian Government, you will remember, in settlement of the Company's claim for damage during the Revolution in 1891, and in that year also the rates of exchange both in Peru and Chili were much more favourable than they have been since. The sterling value of the telegrams received last year was £13,155, against £14,832, showing a reduction of £1,677, which is attributable entirely to the decline in the rates of exchange. The total number of words carried by us in 1893, although they brought in less revenue, as I said, on account of the exchange, was 131,700 in excess of those carried in 1892. If the exchange had remained the same we should have had a very considerable increase in our revenue instead of a decrease. General expenses in London are pretty much the same as they were in the previous year. The general expenses at stations are also about the same, the total amount being rather less than in 1892. The working expenses of the repairing steamer "Retriever" showed a reduction of £1,021 as compared with those of the previous year. This item of course varies. If there are a good many breaks, and the steamer is employed, it means more expenditure for coal and wages, because when the vessel is in harbour she is not fully manned, whereas when ordered out to effect repairs she has to get hands from the shore to a great extent. It is, therefore, hardly fair to look on this item, although it is a considerable one of over £1,000, as being really a reduction in the expenses. I think myself that the item ought to be spread over a period, because next year we might find the figures—although I hope it may not be the case—compare unfavourably with those of last year, when we had little work to do in the way of repairs. Salaries and wages are about the same. The renewal charges for last year amounted to £2,720, as against £3,669 in 1892, being a reduction of nearly £1,000. I will now give you some particulars as to the question of exchange. The decline in the rates of exchange is a most serious matter for the Company, as we have to pay our staff in sterling, and being confronted by competition, we cannot raise our rates. As an illustration of what we have to contend with, I may mention that the rate per word between Valparaiso and Iquique, which is the busiest cable circuit we have, averaged last year only 3½d., and for this we have to provide and maintain a cable 913 knots in length. The tariff for messages over this cable is 25 cents. currency per word. The rate of exchange in Chili was 17d. at the beginning of last year and 12½d. at its close, the traffic being consequently worth to us 4¼d. per word at the former rate of exchange, and 3$\frac{1}{10}$d. per work at the latter rate, the difference between these two rates being about 28 per cent. against us. This is absolute loss to us, which at the present time we cannot possibly make up. That brings this matter more forcibly before you, together with what I have already told you about the number of words we have carried this year as compared with last year, although the revenue is smaller. Another item in the accounts, which is much heavier this year is the legal expenses. In former years they have been very small. This year they amount to over £100, but this is in connection with the formation of the Pacific and European Company, of whose paid-up capital the West Coast of America Company hold one-fourth. That Company, as I told you at the last meeting, really connects us with the outside telegraph companies again, because we were debarred until the Pacific and European line was built and open from communicating with them, as our adversaries, who had the competing cable on the West Coast, also had the line across the Andes. Therefore if we wanted to send any messages they had to go into the hands of those we were competing with, and they did not assist, but rather the reverse. During the year the shore ends of the Antofagasta cable were renewed, and a new land line was constructed between the station at Valparaiso and the northern cable hut, the cables and land lines being kept in the most perfect state of repair. At our last meeting, if you remember, I mentioned some particulars to you about the Talcahuano cable, which was then, I believe, on its way out. This cable was laid and has been opened now for traffic for some months, and the results are certainly satisfactory. It was opened for traffic on October 1st, as were also the land lines connecting the port of Talcahuano with the City of Concepcion. The total cost of the work has been £29,700. The traffic over the line is satisfactory at the present time, and it is certainly likely to increase. There is no doubt that the addition to our net income will be materially increased by this. Originally Valparaiso used to be the one main channel of export and import for the whole of Chili, but that has ceased to be the case to a very great extent. A good deal of the business formerly transacted there is now done for the mineral district of the north in Iquique, and the agricultural district of the south does very nearly all its business at Concepcion. I think it will certainly form an important addition to our cable. At the time we had to do this work, last year, when the Pacific and European lines were not open, and we were living really on our reserve fund, it was not a very pleasant thing to have to undertake an expenditure of about £30,000, knowing that we were losing money at that time, and that we should want all our resources. However, I think your Board would have been wanting in energy and foresight if they had not undertaken it. If we had not done it I am perfectly convinced that others would have stepped in. We, therefore, resolved to carry it out, and the work has been successfully done, chiefly by our own steamer. We sent the cable out in a sailing ship, which we were able to fill with coke, thus really very materially reducing the cost of freight, the coke having sold very well on the other side. I now come to perhaps the most important part of the work last year, the opening of the Pacific and European Company's line. This new line from Buenos Ayres to Valparaiso was opened for traffic on March 19th this year. In my speech last year—I just now referred to it—I see that I said it would be open in three months. At that time I thought that three months was giving an ample date for the work, but there were several causes which occasioned considerable delay. We had, for instance, to get the wayleaves, and there were many other causes which I cannot actually give you here. The share capital of the Pacific and European Company is held by the companies chiefly interested in the traffic going over its line, and the principal and interest of the debentures are guaranteed by the Brazilian Submarine Company, and this Company jointly. You will be glad to know that the service is giving thorough satisfaction to the users of the line. Messages are carried very quickly, the actual time which they take between the West Coast of South America and London being not over an hour, and sometimes considerably less. I do not think that can be beaten, and it is a very fine record. The line is also worked throughout from London to Lima by English operators. I cannot at this meeting give you any information as to the revenue we shall derive from this new line. I think we must wait a little longer for that. It has only been opened for two months, and I have always found in considering the question of traffics that two or three months' working is of no use to take for a record. There are various seasons in these places when trade is very much larger than at other times, and therefore one might give you a misleading idea of the traffic, for the time might have been one of slack trade when it was carried, or it might have been a time when the traffic was active. It is better to wait for six months—or better still, for twelve months—before quoting figures as to revenue I am, however, able to say that the traffic is very satisfactory, and I am pleased with the revenue we are receiving. I may, perhaps, say a little more on this point owing to my interest in the Eastern Telegraph Company, running in connection with this line as far as Lisbon, and my connection with the Brazilian Submarine Company, which carries the messages on to South America, and thence across the Pacific and European Company's system on to our West Coast system. The Eastern Company here is naturally the collecting ground, and I can assure all the shareholders that this traffic is being very energetically worked up, thanks to

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the officials in the Eastern Company. I receive reports constantly about it—sometimes daily, and at any rate every two or three days, and we are canvassing everyone individually who sends messages. It is very seldom that I use the word "glad" in reference to breaks; but I am glad to say that we have had one or two breaks since the line was open. The reason why I use the word "glad" is this: it is all very well to lay a land line, which can be done without much difficulty; but when a break takes place you see the actual value of a land line. If the organisation is good the stoppage of traffic lasts a very short time: if the organisation is not good, and the men are not on the spot to repair a break, you may be down for many days. I am glad to tell you that the breaks we have had have all been put right, wherever they have taken place, in a very few hours. There have been three breaks over the line I think that what I have said will prove to you that the organisation is perfectly good. I do not see the slightest difficulty now in keeping this line in a very efficient state; and if the senders of messages are satisfied with it, there is no question about our not only keeping, but daily increasing the traffic carried by it. It stands to reason, I think, that anyone having a message to transmit would send it by Brazil, and the quickest way. To go to South America across the North Atlantic, and then through America and down the other side, is a roundabout way—at all events, it looks so on the map. I think that I have now put before you all the different points that had to be noticed. I might add that we have changed our offices, and have come into Winchester House. That is a great advantage, because the companies we work with have their offices here also, and I think that the more we can all bound up together the more we shall add to our strength. As regards the rent of our new offices we are on the right side, for the amount is a little less than it was before. I shall now be very glad to answer any question that may be put to me.

Mr. T. R. PACE said that the Chairman had given the meeting so much information that he had not left the shareholders many questions to ask. He thought, however, that they would like to hear a little more as to the time when the Directors thought they would be able to afford them information as to the kind of business they were going to have over the line again. It was not quite like making a new business, of course, but rather the gathering together again of business which had been taken from them. He thought it was rather too long to wait until May, 1895, before they could learn whether they were likely to have any dividend or not. They accepted the Chairman's broad statement that the new connection was working favourably, but the sooner they could have their monthly traffic returns printed the better he thought it would be. The Chairman said that these countries had their slow and their active times, but he had not told them whether the new line was opened at an active time or not. They had suffered for some years in going without a dividend, but things now looked hopeful. The sooner they could have figures to show that they had got on a paying basis again, the more satisfied the shareholders would be.

The CHAIRMAN: I do not like to pledge myself to any figures, for I think it is dangerous to do so. As regards one question which has just been asked, the busiest time out there is, I believe, from September to March, and we opened on March 19th. You may therefore say that we got to work at the slack time. I would give you any figures that I could, but I myself have always found, as I said before, that figures to a great extent are of very little good and are misleading unless one can go on anything substantial. We cannot do that in regard to these figures. We have opened a new line. Remember that you had before one line carrying this traffic, but now it has to be divided into two, there being two lines. All I can promise you is that every endeavour will be made to increase the traffic. I have no fear myself as to the result. I have watched the matter very closely. I am connected with the Eastern Company, and it is my duty on behalf of that Company, as well as on behalf of this Company, to watch the traffic and to get it, and I myself am exceedingly pleased at the way we are getting it. And not only that. In many instances merchants will say, "we will try you, and see your time, and how you can carry a message," and I do not know of a single instance where a merchant has tried us and has left us. I will not give you any figures yet, because they might be misleading. I hope we shall very materially increase the traffic we are now getting, which is very good.

Mr. LAMONT inquired whether a common agreement could not be come to between this Company and its adversary by which the rates might be revised. If they received 4d. or 6d. a word twelve months ago, why should they now receive only 3d. a word? He supposed that their adversaries felt this reduction the same as this Company did.

The CHAIRMAN: Before this line was built the antagonism to us was very severe. They did all they could to thwart us, but since the line has been built we have, I think, carried on a pretty honourable competition. I hope that that will continue, and if it does I think it possible that we may eventually come to some terms with them on certain points, one of which is the exchange question as it affects our revenue. We have mooted the point, but they do not seem inclined to come to any terms with us yet, although I believe they have not absolutely refused to do so. However, your interests on that point will not be neglected.

Mr. DYETT said he thought they ought to meet together every six months, or to get a report once in six months, so that they might know how they were going on.

The CHAIRMAN: I have not been long in this Company, but I believe it has always been the rule to meet once a year. We shall be quite prepared to give you a report, or to meet you as you suggest. It is a pleasure to me to meet the shareholders of any company that I am connected with, but you must remember that our adversaries watch what we are doing pretty closely; and by means of questions which might be put, and that sort of thing, opponents sometimes get information which it would perhaps be best for one's own interests that they should not know. As far as I am concerned, the more the shareholders know about the Company the better I am pleased. I am satisfied that everything is being done that can be done to work up the traffic, and to bring the Company back again into a dividend paying position. In further reply to Mr. Dyett, the Chairman added: I always like straightforward opposition, for it does us all good, but I do not like anything that goes behind our backs in connection with rebates, and things of that kind.

Mr. LAMONT said he thought it might be possible for the Board at the end of six months to issue a circular to the shareholders, stating the position as regarded the traffic; but it was evident from what the Chairman had said, that a six months' report would be misleading, because they had now entered on the dull season, and, probably, in an active season the receipts might be doubled.

The CHAIRMAN: I have often seen that, but we will consider the question of presenting you with a short report in six months' time. The Company has been in a transition state, but we hope to get back our traffic now. For the last two or three years we have been doing nothing. If no other shareholder has any question to ask I will move—

"*That the report and accounts for the year ended December 31, 1893, now presented be received and adopted.*"

Mr. FREDERICK WALTERS seconded the resolution, which was carried unanimously.

The CHAIRMAN then proposed the re-election as a Director of Mr. Frederick Walters, who, he said, had a very intimate knowledge of the West Coast of America, having spent many years of his life there, and being connected with a firm doing business there. Mr. Walters was, therefore, a very important Director for their Company.

Mr. PACE seconded the motion, and said he thought they were very fortunate in having a man of Mr. Walters' experience on their Board. The Directors had had to contend against very adverse circumstances, but he felt sure that everything had been done by them that was possible. He considered that they ought to notice the courage of the Board in undertaking the construction of the new line referred to in such adverse circumstances. To make a new line at a cost of £30,000 at a time when they had been practically living on their reserve fund showed great courage and hope in the future of the Company.

Mr. DYETT thought that two Directors was a very small number.

The CHAIRMAN: I should have mentioned that point. We have not filled up Mr. Roberts's place yet. We are looking round, and when we can find someone who can help us materially, and be of benefit to the Company, we shall ask that gentleman to join the Board, but do not press us in regard to this matter now. He then put the motion, and it was carried unanimously.

Mr. WALTERS, in returning thanks, said he might take the opportunity of expressing his own strong confidence in the future of the Company. Owing to misfortunes, not of their own making, they had been in cold water, but with patience he believed that there was a very good future for them. They must, however, have patience. Even now the time was not altogether favourable for them, because, as they were aware, trade was bad all over the world, and telegraph companies must consequently suffer more or less. Things had been very bad on the West Coast of South America, but they must look forward to an improvement there, and then he believed there was a very good future for the Company. The Chairman retired at this meeting, and he had pleasure in proposing his re-election, which he felt sure they would all agree to.

Mr. PACE seconded the motion, observing that Mr. Pender's experience in the telegraph world was certain to be of great value to the Company.

The motion was carried unanimously.

The CHAIRMAN briefly acknowledged his re-election.

Mr. JOHN FRANCIS CLARKE was then elected auditor for the present year.

Mr. LAMONT afterwards proposed a vote of thanks to the Chairman and his colleague for their conduct of the Company's affairs in the past year. He hoped that at the next meeting the Directors would be able to present a satisfactory statement of accounts. There was no doubt that the Directors had had to pass through a very anxious time; but he hoped they were now getting into smooth water, and that the shareholders' patience would be rewarded.

The resolution was carried by acclamation.

The CHAIRMAN: I hope the worst is over now, and that we may look forward to a prosperous future.

The meeting then separated.

Consolidated Telephone Construction and Maintenance Company (Limited).

The thirteenth annual ordinary general meeting of this Company was held yesterday, at Winchester House, Old Broad-street, Mr. C. L. W. Fitz-Gerald presiding.

The SECRETARY (Mr. Charles Curtoys) read the notice convening the meeting, the report of the Directors, and statement of the accounts being taken as read.

The CHAIRMAN said that it would be in the recollection of the shareholders that in the early part of last year they passed special resolutions for the reduction of capital, which, if they referred to the balance-sheet, they would see had been reduced in the following way:—First, they paid back to the Preference shareholders the sum of £27,637, and to the Ordinary shareholders 2s. a share, which amounted to £22,485. In addition to that they wrote off the Ordinary share capital the sum of £22,485. Of this amount £17,485 was written off goodwill, patent rights, &c., and £5,000 from the securities in the balance-sheet of the Edison Gower-Bell Company, which were valued at £16,000, and now stood at £11,000. The result was that their capital now was represented by 24,850 Ordinary shares of 10s. each. There were one or two items in

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the balance-sheet to which he would like to call attention. The first of these was one which he thought that the shareholders ought to be very much gratified with, and that was the fact that an independent valuation of the plant and machinery having been made, the Directors found that instead of being valued at £5,300, the figure at which they stood in the books, they were worth no less than £7,000. This circumstance showed that the Directors of the Company had been looking very well after the factory, and consequently they thought, with so much in hand, that it was needless to write off anything this year from this item. Their stock of instruments last year amounted to £8,200, and this year it was £7,422—a favourable circumstance, because stock was apt to deteriorate, and the less of it they had in hand the better. The item debtors amounted last year to £8,200, whereas it was now £7,481. Of that sum £5,197 was due by their subsidiary companies. He might mention that the Edison Gower-Bell Company derived all the revenue it received from the Anglo-Portuguese Telephone Company whose position was very satisfactory, and but for the fact that the bringing of money from Portugal here involved such a loss by exchange, they would have received last year double their dividend on the Edison Gower-Bell Preference Shares. This question of exchanges was a comparatively new one, and he hoped the difficulty might by and by be overcome in the interests of all concerned. Their securities were all put down at cost price, and these again were necessarily affected by the difference of exchange. If the exchange were at par, for instance, the United River Plate Company would be paying 13 per cent. As it was that Company was able to pay only its debenture interest. He was very pleased to say that the manufacturing business of the Company had been decidedly improving within the last few months. He did not know whether trade generally was improving or not, but certainly they had no reason to grumble, and he hoped that the improvement would continue to grow. The manufacturing profit this year amounted to £3,070, while last year it was only £1,848. This he looked upon as a satisfactory feature of their accounts. Moreover they had only received £1,830 of the interest from their investments as against £5,799 at the same time last year, and yet they were enabled to pay them the same dividend as was paid then. They had reduced the expenditure from £2,860 to £2,400, which, of course, helped the net revenue. He concluded by moving —

"*That the annual statement of accounts and balance-sheet, with the report of the Directors and auditors as now submitted to the meeting, be received and adopted, and that a dividend at the rate of £2 per cent. per annum be paid, less income-tax, for the year ending March 31, 1894, as therein recommended.*"

Sir ALEXANDER ARMSTRONG, K.C.B., seconded the motion.

The CHAIRMAN in reply to shareholders, said that he had no objection to see the item, general expenses of management £1,890, given in a more detailed form. The fees of the Directors amounted to £1,500, but for three years they had taken only the half of that amount. The question of how to make a larger profit always engaged the attention of the Board; but it was very difficult to see how it could be done. At the same time he saw no object to be gained in winding up the Company. They did pay once 6 per cent., but owing to competition they could afford to pay now only 2 per cent., whether they would ever get up to the higher figure again he could not say, but in the way of manufacturing they had done better this year by something like £1,200.

The resolution was then carried unanimously.

On the motion of the Chairman, seconded by Mr. Henry Grewing, the retiring Directors, Sir A. Armstrong, and Mr. A. H. Baker, were re-elected.

The auditor, Mr. J. G. Griffiths, was also re-appointed, and a vote of thanks having been passed to the Chairman and Directors, the proceedings ended.

The following is the Directors' report:—

In the present accounts due effect has been given to the special resolution of the shareholders passed and confirmed in March, 1893, reducing the capital; £17,485 has been written off goodwill, patents, &c., and £5,000 from the shares in the Edison Gower-Bell Telephone Company. The Preference shares issued to that date have been expunged by their repayment in full; 2s. per Ordinary share has been returned to the shareholders in cash, and 2s. per Ordinary share has been written off in accordance with that resolution.

The operations for the past year show a manufacturing profit of £3,070. 10s., and a net profit of £2,577. 15s. 5d. With the amount carried forward from the year 1892-3, viz., £1,117. 18s. 6d., a balance of £3,695. 13s. 11d. is left for disposal, after making provision for doubtful debts. The Directors propose to pay a dividend of £2 per cent. for the year; to write off a further £63. 16s. 8d. from the cost of the new building, 10 per cent. from furniture account, and £15 from goodwill, patent rights, &c.; to reserve £122. 7s. 11d. for rentals paid in advance; leaving a balance of £1,301. 4s. 6d. to carry forward.

No depreciation of plant and machinery is made in the present accounts. An independent valuation was made on March 21, 1894, by an expert, and his report (which is open to inspection) places the value at an amount considerably in excess of that shown in the balance-sheet. The Directors cannot but think that the shareholders will consider this a valuable testimony to the care taken of their property. This year's accounts exhaust the original expenses incurred in the formation of the agencies.

Business in the latter part of the year became more brisk and profitable; the agencies have been fairly busy, and whilst the Directors see with regret that some large users of the telephone in this country are placing their orders with agents of foreign manufacturers, they trust that ultimately the superior workmanship of the Company's productions will, with fair prices, obtain still more favourable consideration. Every economy that can with prudence be practised is having attention. Friendly relations exist with the various Government and Colonial Departments, and the Directors are using every legitimate endeavour to maintain and increase such. The Directors have again unanimously resolved to relinquish one-half of their fees for the year.

The subsidiary Company, the Anglo-Portuguese Telephone Company, makes progress with its number of subscribers and rentals value. The following table shows the comparison with last year:—

Year ending March 31, 1894.

Subscribers.		Rental.		Increase.	
1893.	1894.	1893.	1894.	Subscribers.	Rental.
2,249	2,320	£14,487	£15,076	71	£589

Gulcher (New) Electric Light and Power Company (Limited).

The following is the long-delayed report of the Directors of this Company. The report is for the period ended June 30, 1893:—

"The accounts from our New Zealand branch, which reached England in November, were insufficient, and had to be returned to New Zealand for completion and correction, involving a delay of nearly five months. Hence the impossibility of calling the present general meeting earlier. Notwithstanding the large order from the New Zealand Electrical Syndicate (Limited), and the hopes thereby raised, the result of the year's working has been a serious loss. The sales in England dwindled down to less than £5,000, and the hire of installations practically ceased. Under the circumstances the Directors have for some time past taken steps to limit the engagements of the Company in view of its possible voluntary liquidation, a course which they will recommend the shareholders to adopt at the ensuing general meeting."

[The balance-sheet which accompanies the above report is a remarkable example of how a trading Company should not be conducted. There is a net loss since the last report of no less than £15,822. 12s. 3d., and there is a strange mixing up of the New Zealand business with that of the business carried on in this country. The stock in England is valued by the Directors at £12,510, off which, by a valuation of the late manager, no less than £4,510 is written. This may be accounted for by the fact that reconstruction is contemplated. The Company appear to have borrowed sums of money at extravagant interest, whereas there is a liability of 5s. per share on 37,723 Ten per Cent. Preferred Shares, which would have realised between £9,000 and £10,000, or even allowing for the calls paid in advance, which represent £3,838, would still have realised nearly the whole of the amount borrowed on mortgage debentures at 6 and 10 per cent interest. Sundry creditors represent no less than £9,794, against sundry debtors £1,740. The only asset of any magnitude possessed by the Company consists of shares in the New Zealand Electrical Syndicate (Limited), regarding which it is not unlikely the shareholders at the meeting at Winchester House, E.C., on Monday next at 11:30 a.m., will require some information. These shares have not earned a penny for the last two years, and the New Zealand branch have, apparently, been allowed to increase their debit by between £4,000 and £5,000. The auditors of the Company, Messrs. Kemp, Ford and Co., certify the balance-sheet "subject to the correctness of the New Zealand account," the valuation of the stock, and to *our report of this day's date*.

A correspondent urges the shareholders to attend the meeting on Monday, and to demand from the Directors a full and particular explanation of the balance-sheet, and certainly the Directors have only themselves to blame if the dissatisfaction now manifested by the shareholders results in some energetic attempt to bring about a more satisfactory state of affairs. The shareholders should insist upon the production of the auditors' report.]

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1894, pages 274-300, *&c., &c.*]

ALEXANDER SHANKS AND SONS (LIMITED).—This Company has been registered in Edinburgh, with a capital of £50,000 in £10 shares, to take over the well-known business of engineers, founders and boiler makers carried on under the title of Alexander Shanks and Sons, at Arbroath.

BINNS GAS AND OIL ENGINE COMPANY (LIMITED).—This Company was registered on May 28th, with a capital of £2,000 in £1 shares, to acquire the business carried on at Halifax, of ironfounders, gas, mechanical and electrical engineers, makers of steam, gas, oil, and other engines and machinery, boiler makers, millwrights, machinists, brassfounders, and metal workers. The first Directors are:—Joseph P. Binns, of Luddenden, Yorks.; Henry G. Binns, of Halifax; Frederic W. Thompson, of Luddenden; and Alfred Yates, of Luddenden.

COWPER COLES GALVANISING SYNDICATE (LIMITED).—This Company was registered on May 25th, with a capital of £2,000, divided into 500 "A" and 1,500 "B" shares of £1 each, to acquire all or any of the patent rights referred to in an agreement made between Sir Baldwin W. Walker, Bart., and L. W. North Hickley, and the Syndicate, and to carry on the business of electrical engineers, electricians, engineers, and contractors, electro-metallurgists, galvanisers, manufacturing chemists, manufacturers of electrical and other apparatus for producing, storing, regulating, and supplying electrical energy, galvanism, or magnetism for any purpose. The first Directors are:—Sir Baldwin W. Walker, Bart., 1, Queen's-place, Southsea; L. W. North Hickley, 10, King's Bench Walk, Temple, London, E.C.; Henry Edmunds, 39, Victoria-street, London, S.W., and Emile Garcke, 21, Priory-road, Bedford-park, London, W.

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ELIESON ELECTRICAL SWITCH (LIMITED).—This Company was registered on May 25th with a capital of £5,000, in £1 shares, to adopt an agreement for the acquisition of the patent rights in Great Britain and Ireland and the English colonies of certain inventions by Mr. C. P. Elieson in relation to electrical switches or circuit breakers, to carry on the business of electricians, electrical and mechanical engineers, suppliers of electricity for the purposes of light, heat, motive power, or otherwise, and manufacturers of and dealers in all apparatus and things required for or capable of being used in connection with the generation, distribution, accumulation, and employment of electricity, and to carry on the business of an electric light company in all or any of its branches. The subscribers, with one share each, are:—Lord Galloway, 17, Upper Grosvenor-street, London, W.; Paolo Polenghi, Larchwood, Horley, Surrey; C. P. Elieson, 75, Edith-road, West Kensington, W.; Thomas Smith, Broad-street-avenue, E.C.; Maximilian Friedman, 8, Regent-street, W.; M. Walton-Thomas, Princes House, Palace-street, Westminster, S.W.; Eugene Pellas, 8, Regent-street, W.; and Loftus T. Long, 17, Porchester-square, Hyde Park, W. The first Directors are:—The Earl of Galloway (Chairman), Paolo Polenghi, and Chaimsonovitz P. Elieson.

ROBINSON AND AUDEN (LIMITED).—This Company was registered on May 23rd, with a capital of £35,000, in £10 shares, to acquire the business of agricultural and mechanical engineers, ironfounders, &c., carried on at the Vale of White Horse Iron Works, Wantage, Berks., and to carry on the business of agricultural, mechanical, hydraulic, electrical, gas, metallurgical, chemical, and general engineers, dealers in and suppliers of electrical, engineering, and other goods and apparatus connected with the production of light, heat, sound, and motive power, suppliers of electricity, contractors for the construction of electrical apparatus, and the laying of cables, wires, &c., and to carry on the business of an electric lighting company in all or any of its branches. The first Directors are:—Arthur S. F. Robinson, Arthur C. Auden, and Charles Price.

E. WALLACE AND COMPANY (LIMITED).—This Company was registered on May 24th with a capital of £1,000 in £1 shares, to act as agents for manufacturers or producers of all classes of goods, and in particular of chemical, mechanical, and electrical goods and appliances, and for firms dealing in or making goods appertaining to mechanical and electrical uses, and to carry on as principals or agents the manufacture and sale of mechanical, electrical, surgical, and scientific instruments or appliances; contractors for the sale, letting on hire, erection, and maintenance of mechanical and electrical engineering and other goods and apparatus connected with the production of light, heat, sound, and power, or any other effects by electricity, galvanism, or magnetism, mechanical, electrical, metallurgical and chemical engineers, and electrical engineers, and manufacturers of and dealers in telegraphic and telephonic apparatus and appliances of all kinds in all its branches. The Company was registered without the filing of special Articles of Association, so that no particulars of the management of the concern are available. The following subscribers are connected with the trade:—M. Smith and W. H. Berry.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).—The annual return of this Company, made up to May 16th, is filed, and shows that the whole nominal capital of £1,300,000, in £10 shares, has been taken up, the full amount called, and all calls paid.

ELECTRIC TRUST (LIMITED).—The annual return of this Company, made up to July 15, 1893, was not filed till May 3, 1894. The nominal capital is £60,200, divided into 6,000 shares of £10 each, and 200 Founders' shares of £1 each. 1,675 £10 and 167 £1 shares were taken up and the full amount called, resulting in the payment of £16,917. A letter from the secretary states that the delay in filing the return is owing to the fact that no meeting has been held in consequence of the death of the Chairman, Mr. Spencer Chadwick. No time will now be lost in winding up the Company.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).—The annual return of this Company, made up to May 2nd, has been filed, and shows that the whole nominal capital of £2,500,000, in shares of £10 each, has been taken up, and the full amount called and paid.

W. T. HENLEY'S TELEGRAPH WORKS COMPANY (LIMITED).—The annual return of this Company, made up to April 5th, is filed. Out of a nominal capital of £100,000, divided into 3,000 £7 per Cent. Preference and 7,000 Ordinary shares of £10 each, all the Preference and 6,837 Ordinary have been taken up and the full amount per share called, resulting in the total payment of £98,370.

INDO-EUROPEAN TELEGRAPH COMPANY (LIMITED).—The annual return of this Company, made up to May 10th, has been filed. 17,000 shares, out of a capital of £450,000, divided into 18,000 shares of £25 each, were taken up and allotted. Upon each of these shares the full amount has been called and paid.

LONDON PLATINO-BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The annual return of this Company, made up to May 15th, has been filed. Out of a nominal capital of £400,000, in £10 shares, 37,548 have been taken up and allotted, and the full amount called.

METROPOLITAN ELECTRIC SUPPLY COMPANY (LIMITED).—The annual return of this Company, made up to May 7th, is filed. The whole nominal capital of £500,000, divided into 49,900 Ordinary and 100 Founders' shares of £10 each has been taken up. Upon 47,868 shares the full amount has been called, while 2,132 shares have been issued as fully paid. The calls paid amount to £478,421. 9s.

PHONOPORE COMPANY (LIMITED).—The annual return of this Company, made up to May 14, 1894, was filed on May 21st. The nominal capital is £150,000, divided into 100,000 Ordinary and 50,000 £5 per cent. cumulative Preference shares, all of £1 each. At the time of compiling the return 90,000 Ordinary and 28,343 Preference shares were taken up, of which 69,025 Ordinary and 10,380 Preference shares were issued as fully paid. Upon the remaining 20,975 Ordinary the full amount has been called, while upon the remaining 17,963 Preference shares a call of 15s. per share has been made, resulting in a total payment of £34,798. 10s., and leaving £4,139. 10s. in arrear. The principal shareholders are:—C. Langdon-Davies, of 45, Redcliffe-square, S.W. (6,300 Ordinary, 1,300 Preference); Joseph W. Goddard, of Station-street, Leicester (5,690 Ordinary, 1,730 Preference); John W. Cooper and Ernest T. Janson, of 32, Abchurch-lane, E.C. (6,500 Ordinary); and John Abbott, of Silverdale-road, Eastbourne, and Henry D. Kimber, of 79, Lombard-street, E.C. (6,075 Ordinary and 350 Preference).

SOUTH AFRICAN LIGHTING ASSOCIATION (LIMITED).—The annual return of this Company, made up to May 15th, has been filed. 4,050 shares out of a capital of £50,000, in £10 shares, have been taken up, of which 105 were issued as fully paid. Upon 3,000 shares the full amount on 677 shares, £4 per share, and on 373 shares £6 per share has been called.

TELEPHONE COMPANY OF EGYPT (LIMITED).—The annual return of this Company, made up to April 17th, has been filed. Out of a nominal capital of £100,000, divided into 16,000 Preferred and 4,000 Deferred shares of £5 each, 12,071 Preferred and 4,000 Deferred have been taken up; and all of these, with the exception of 71 of the former class, have been issued as fully paid.

CITY NOTES.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).—The transfer books of this Company will be closed from June 15th to 21st inclusive, preparatory to the payment of an interim dividend of 3s. per share (equal to 6 per cent. per annum), free of income tax, for the quarter ended March 31st. The dividend is payable on June 22nd.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended May 27th were £931, as against £844 in the corresponding period of 1893, being an increase of £87. The total receipts for the half-year amount to £19,143, as against £18,579 for the corresponding period of 1893, an increase of £564.

ELECTRIC CONSTRUCTION COMPANY (LIMITED).—Notice is given that a drawing of the Six per Cent. Second Mortgage Debentures of this Company will take place at the offices of the Electric and General Investment Company (Limited), 1 and 2, Great Winchester-street, E.C., on Friday, the 8th inst., at 3 o'clock. The debentures are to be paid off on July 1st.

ELECTRIC RAILWAY SHARES.—In common with many other electrical securities the Debenture stock and Preference shares of the City and South London Railway Company have had an upward tendency, and are now quoted:—Debentures 117-119, Preference 12, Ordinary 33-35. Traffics are showing a regular and satisfactory increase.

THE ELMORE COMPANIES.—An upward tendency has recently been shown on the London market in Elmore shares, and the *Financial News*, in calling attention to this fact in its issue of May 25th, dealt with the position of the Elmore Companies generally, and made some special references to the Wire Company, eliciting the following letter from the Secretary:—"Referring to your article to-day, the Elmore Wire Company is not suspended pending the raising of more capital. That was our position some months ago, but since then we have allotted over £30,000 of Preference shares, and, in addition, our bankers will always finance our copper requirements up to £25,000, which, together, gives us a very substantial working capital at our disposal to-day. Our splendid freehold works and plant, capable of turning out 50 tons a week of unequalled product, were long since paid for to the last penny. The Board has been reconstituted, and the name of our new Chairman—Mr. Edward Reynolds, of Sheffield, who is by far the largest shareholder—is a practical guarantee of success. Our sales agents assure us they can readily dispose of four to five times the present possible output at most remunerative prices, and it is now only a question of days before every tank will be fully at work earning a handsome dividend from the first day they start. All our difficulties have vanished. We are to-day closing the London office and concentrating at the works. The present rise is most certainly not a rig, but is, to my knowledge, chiefly due to buying by the customers of the Copper Company, and by the shareholders eager to recoup previous losses."

THOMAS PARKER (LIMITED).—The following advertisement appeared in the *Standard* of Friday last:—

"Thomas Parker (Limited).—The Electric Construction Company (Limited) hold no general or any licence whatever to use the Eickemeyer Patents, or any of them. The only persons entitled to use such Patents (so far as winding is concerned) are the Eickemeyer Company, who have agreed to assign same to Thomas Parker.—A. MacDonald Blair, 5, St. James'-square, Manchester, Solicitor for the Eickemeyer Company, and Mr. Giles Atherton, their Attorney."

This was followed on Monday by an advertisement from the E. C. Company as under:—

"Re Thomas Parker (Limited).—My Board have taken note of the letter from Mr. A. MacDonald Blair and Mr. Giles Atherton, which appears in your paper on the subject of the Eickemeyer patents. I am instructed by my Board to say that they have directed Messrs. Linklater and Co. to issue a writ against Mr. Thomas Parker and Thomas Parker (Limited) to establish our rights.—By order of the Board, the Electric Construction Company (Limited), James Gray, Secretary."

Representatives of Thomas Parker (Limited), including Mr. Parker himself, called at the *Pall Mall Gazette* offices on Friday last with documentary evidence as to the position of affairs. "The documents," remarks the *Pall*

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Mall Gazette, "seemed to show that there were negotiations between the Electric Construction Company and Mr. Parker for the granting by the latter to the former of a licence to use the patents, but that eventually these negotiations were broken off by Mr. Parker."

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended May 25th (after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited), were £2,287.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share	Last Dividend.	Name.	Previous Week's Price, May 23.		Price Wednesday, May 30.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending May 30. Highest	Lowest.
			TELEGRAPHS.					£ s. d.			
£1,012,880	Stock	9/0	Anglo-American	42	44	41	43	5 16 3	Jan., Apr., July, Oct.	42½	41
£2,933,560	Stock	18/0	Do. Preferred	80½	81½	79	80	5 18 10	,, ,,	81	78¾
£2,933,560	Stock	5/0	Do. Deferred	7½	7¾	7½	7¾	..	..	7½	..
£184,500	100	4%	African Direct Telegraph 4% Deb. (Reg. & Bearer)	101	104	102	105	3 16 2	January and July	104	103
130,000	£10	3/0	Brazilian Submarine	12	12½	12	12½	5 4 0	Mar., June, Oct., Dec.	12 3/16	..
£18,700	£100	5%	Do. 5 per Cent. Bonds	100	103	100	103	4 17 1	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	108	112	108	112	4 4 10	June and December	..	..
10,000,000	$100	$1¾	Commercial Cable Capital Stock	140	145	140	145	4 16 7	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	12	13	12	13	6 3 1	February and August	12⅝	..
6,000	10	10%	Do. Preference 10 per Cent.	18	19	18	19	5 5 3	,, ,,	..	..
12,931	5	1/7½	Direct Spanish (£4 paid)	2¾	3¼	2¾	3¼	4 16 8	April and October	..	..
6,000	5	10%	Do. Preference 10 per Cent.	8¾	9¼	9	9½	5 5 3	,, ,,	9¼	9¼
60,710	20	2/0	Direct United States Cable, 1877	9½	10	9½	10	6 0 0	Jan., Apr., July, Oct.	9 11/16	9 11/16
400,000	10	2/6	Eastern	14¾	15	14¾	15	4 6 8	,, ,,	15 1/16	14¾
70,000	10	6%	Do. 6 per Cent. Preference	15¾	16¼	15¾	16¼	3 13 10	,, ,,	16¼	16
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	112	115	113	116	3 9 0	May and November	113¾	113½
£102,100	100	5%	Do. 5 per Cent. Debentures, 1899	107	110	107	110	4 10 11	February & August	..	..
250,000	10	6/6	Eastern Extension	15⅜	15⅞	15½	15¾	4 8 11	Jan., Apr., July, Oct.	15¾	15 9/16
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	114	117	114	117	3 8 5	February & August	..	..
£62,700	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	104	107	104	107	4 13 6	January and July	..	..
£95,100	100	5%	Eastern and S. African 5 per Cent. Mor. Deb., 1900	103	106	104	107	4 3 6	,, ,,	105¼	..
£300,000	100	4%	Do. 4% Mortgage Debentures, 1909 (regd.)	104	107	104	107	3 14 9	February & August	..	..
£200,000	£25	4%	Do. 4% Mauritius Sub. Debs.	105%	108%	106%	109%	3 13 5	May and November	..	..
180,227	10	2/6	Globe Telegraph and Trust	8¾	9	8¾	9	5 0 0	Jan., Apr., July, Oct.	9	8¾
180,042	10	6%	Do. 6 per Cent. Preference	15½	15⅞	15½	15¾	3 17 5	,, ,,	15 11/16	15½
150,000	10	7/2	Great Northern	21	21½	21	21½	3 19 1	Jan., April, and July	21⅛	21
£190,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	104	107	104	107	4 13 6	March & September	..	..
17,000	25	37/6	Indo-European xd & bonus	43	45	43	45	5 11 1	May and November	44¾	43
37,548	10	5/0	London Platino-Brazilian	4	6	4	6	..	,, ,,	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106	109	106	109	5 10 1	March & September	..	..
£100,000	£100	4%	Pacific European Tel. 4% Guar. Debs. "Red" 1942	102	105	102	105	3 16 2		..	..
11,839	8	4/0	Reuter's	5½	6½	5½	6½	..	April and October	..	..
3,381	£100 Cert.	35/0	Submarine Cables Trust 6 per Cent.	112	116	112	116	5 3 5	,, ,,	..	..
15,609	10	5/0	West African Telegraph	3	5	3	5	..	January and July	..	..
£249,900	100	5%	Do. 5 per Cent. Debentures	100	103	101	104	4 16 2	March & September	..	..
30,000	10	2/0	West Coast of America	2½	3	2½	3	..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	104	108	100	105	7 12 5	June and December	104	100
88,321	10	9d.	West India and Panama	1½	1¾	1½	1¾	..		1 5/16	1½
34,563	10	6%	Do. 6 per Cent. 1st Preference	10½	10¾	10½	10¾	5 11 7	May and November	10⅝	10½
4,669	10	6%	Do. 6 per Cent. 2nd Preference	9	10	9	10	6 0 0	,, ,,	9	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	109	112	109	112	4 9 3	June and December	..	..
64,242	15	4/6	Western and Brazilian xd	7½	8	7½	7¾	..	May and November	7⅝	..
33,129	7½	4/6	Do. 5 per Cent. Cumulative Preferred xd	6½	7	6½	6¾	..	..	6¾	6⅝
33,129	7½	4/6	Do. 5 per Cent. Deferred	2	2½	2	2½	..	..	2½	..
£171,900	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	106	109	106	109	5 10 1	February & August	..	..
£214,800	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	106	109	106	109	5 10 1	,, ,,	..	..
$1,211,000	$1,000	7%	Western Union 7% 1st Mort. (Building) Bonds	111	115	111	115	6 1 9	May and November	..	..
£166,900	£100	6%	Do. 6 per Cent. Sterling Bonds	100	104	100	104	5 15 5	March & September	..	..
			TELEPHONES.								
44,000	5	10/0	Chili Telephone (fully paid)	1½	2½	1½	2½	..	..	..	..
224,850	10/0	3½d.	Consolidated Telephone Const. & Maintenance	1/16	3/16	1/16	3/16	..	May and November	..	..
171,504	£1	6d.	Oriental Telephone and Electric (fully paid)	¼	½	¼	½	..	Yearly	..	..
484,597	5	2/6	National	4¾	5¼	4¾	5¼	4 17 7	June and December	5	4¾
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	15	16	15	16	3 15 0	,, ,,	..	–
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	14½	15½	14½	15½	3 17 5	,, ,,	14¾	..
119,234	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	5½	5¾	5½	5¾	4 6 11		5¾	5 3/16
1,000,000	Stock	4½%	Do. Debenture Stock, 4½%	114	116	114	116	3 17 7	January and July	115⅝	114¾
58,000	5	1/0	United River Plate	1½	2	1½	2	..	,, ,,	..	..
£146,733	Stock	5%	Do. 5 per Cent. Debenture Stock	90	100	90	100	5 0 0	,, ,,	..	–
			ELECTRICITY SUPPLY COMPANIES.								
40,000	£10	.	City of London Electric Lighting (fully paid)	12	13	12	13	..	..	12¼	..
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	13½	14	13½	14	4 5 9	..	13¾	13 11/16
19,900	£5		Electricity Supply Co. for Spain					..	..	..	..
£30,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	4½	5½	4½	5½	..	..	..	..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	..		..		..	..	..	..
8,322	£5	–	House-to-House Electric	..		..		..	..	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	..		..		..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..		..		..	January and July	..	..
6,523	£5	1/9	Liverpool Electric Supply (£4. 10s. paid)	5¾	6¼			..	..	..	–
39,477	£5	2/6	Do (fully paid)	6⅝	6½	6⅝	6½	..	..	..	–
111,000	5	..	London Electric Supply	¼	⅜	½	⅝	–	..	..	..
49,900	£10	5/0	Metropolitan Electric Supply (fully paid)	7½	8	7½	8	3 2 6	..	7 13/16	..
£100,000	Stock	5%	Do. 5% Debs. (Bonds of £10, £20, and £40)	108	111	108	111	4 10 1	June and December	..	..
6,452	£10	.	Notting Hill Electric	4½	5½	4½	5½			..	..
19,980	£5	4/6	St. James and Pall Mall	6¾	7¼	6¾	7¼		..	..	..
20,000	£5	7%	Do. 7 per Cent. Preference	8	8½	8	8½	4 2 4	..	8 3/16	..
59,900	5	2/6	Westminster Electric Supply (fully paid)	6	6½	6½	6¾	2 19 3	..	–	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
90,000		1/6	Brush Electrical Engineering	2¾	3	2¾	3	6 0 0	..	2¾	–
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	2½	2⅝	2½	2⅝	5 1 1		2 3/16	2½
£125,000	Stock	4½%	Do. 4½ per Cent Debentures	108	111	108	111	4 1 1	March & September	110¼	110
20,000	5	2/6	Crompton and Co., 7 per Cent. Cumulative Pref.	3	3½	3	3½	–	January and July	..	..
12,139	5	..	Edison and Swan United								
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	..		–		..	..	–	..
120,000	2	..	Electric Construction	¾	¾	¾	¾	..	..	–	½
12,845	2	..	Do. 7 per Cent. Cumulative Pref.	1½	1¾	1½	1¾	..	..	⅝	..
91,195	2	10/0	Elmore's Patent Copper Depositing	1⅜	1⅝	1½	1⅝	..	.	1½	–
20,000	5		Fowler-Waring Cables (fully paid)	⅝	1½	⅝	1½	..	..	1½	1⅛
50,000	10	15/0	India Rubber, Gutta Percha, &c., Works	23	24	23	24	5 4 2	February & August	23½	23 1/16
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103	105	103	105	4 5 9	March & September	..	..
15,995	£10	6/4	International Okonite Ordinary	..		..		..		–	..
16,000	£10	..	Do. 8 per Cent. Preference	–		..		..	December and June	–	..
20,000	9		Manchester Edison-Swan "A" (£1 paid)	—	¾	—	¾			–	..
78,949	5	3/6	Swan United (£3 10s. paid)	1⅜	2¼	1⅜	2¼	3 6 2	May and November	2	
37,350	12	36/0	Telegraph Construction and Maintenance	39	41	39	41	5 17 1	March and July	40½	40
£150,000	100	5%	Do. 5 per Cent. Bonds	104	107	104	107	4 13 6	January and July	..	..
37,514	£5	..	Woodhouse and Rawson Ordinary (£3 15s. paid)	..		..		..	..	–	..
41,098	£5	..	Do. Preference (fully paid)	..		..		..	..	–	..
			RAILWAYS AND TRAMWAYS.								
£630,000	Stock	4%	City and South London Railway	31	33	33	35	1 19 3	May and November	33½	32½
37,500	£10	1%	Liverpool Overhead Railway	8 1/16	8 3/16	8⅛	8⅜	..	..	..	–

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THE ELECTRICIAN:

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NOTES.

The practical man will, we suppose, seize upon Hertzian waves ere long, patent their application to the use and convenience of man, start syndicates, float companies, and so on. Prof. Lodge showed that a bad contact, a metallic microphone in fact, is so delicately constituted that it will respond to feeble electrical oscillations, propagated from relatively enormous distances from the place where it is stationed. By connecting such an arrangement in circuit with a battery and a sensitive galvanometer, indication of the existence of these waves is instantaneously given. This is surely the essence of the ideal lightning guard—the guard which will give warning long before the storm is near enough to do any damage to the line. A number of these sensitive resistances placed at intervals along the route of any electrical conductor, whether for high pressure power transmission or for telephonic purposes, and connected to indicators at the stations at the ends of the line, would give ample warning of the proximity of a dangerous thunderstorm, and would enable the engineers or operators to make all disconnections requisite to ensure the safety of the plant.

In a letter which will be found in the present issue, Mr. R. M. Deeley refers to the subject of electric waves, and asks on what authority it is asserted that a field of varying electric force must give rise to magnetic forces and *vice versâ.* A direct experimental proof of such an assertion has not yet been actually given, but the truth of it is deducible from universally-admitted laws of electricity. All the laws of electricity can ultimately be reduced to two, which Mr. Oliver Heaviside alludes to as the circuital laws. We need only here refer to one. Any wire forming a closed circuit, if enclosing lines of force, has an electromotive force generated in it equal to the rate of decrease of the lines of force enclosed by the circuit. This electromotive force exists, whatever the nature or resistance of the wire. In fact it exists whether the wire is there or not. It has nothing to do with the wire, any more than the electromotive force of a battery has to do with a circuit in which it may be placed. If the circuit is closed, the electromotive force will produce a current in accordance with Ohm's law. If the circuit is not closed, all that the electric force can do is to cause electric displacement in the ether; but in any case the electric forces are present so long as the magnetic field is varying. A varying magnetic field must, therefore, give rise to electric disturbances in the ether, and the converse of this statement can as easily be shown to be true.

Reference is made by our American correspondent, this week, to the adoption of two new names for electromagnetic quantities. These names are "inductance" and "reactance." They were originated by Mr. Oliver Heaviside, and have been adopted with the meanings given to them by their originator. Although we have frequently expressed our disapproval of the multiplication of names of physical quantities, we are inclined to think that considerable value attaches to this decision of the American Institute. There has always been a shadow of doubt about the meaning of the term "inductance," some writers using it to express the coefficient of induction, and others implying by it a quantity of which the coefficient of induction and the current frequency are joint functions. The ambiguity has probably been due to the absence of any name for this latter quantity; but, now that the term "reactance" has been adopted for it in America, there ought to be no longer any doubt about the meaning of "inductance." The term "reactance" is a distinctly good one, conveying, as it does, by contrast with "resistance" the idea of an elastic reaction as opposed to an inelastic or power-dissipating reaction. These two form the two components of the "impedance," or, as some would call it, the apparent resistance of the circuit through which any periodic current may be passing.

Anent the discussion which has recently arisen in various American electrical periodicals, in regard to the possible use of the earth as a means of transmitting intelligence without wires, we may observe that there is no inherent difficulty on account of the fact that an immense number of messages would be required to be transmitted in all directions simultaneously. It is conceivable that either or both of two physical operations might be employed to sift out these simultaneous messages: the operation of conjugate foci, and the operation of resonance. Something quite as complicated as the use of the earth for this purpose goes on in each tiny portion of the surface of a piece of looking glass. Just think of the infinite number of images which are being reflected in an infinite number of directions from every element of the reflecting area, and it will be confessed that the kinetic condition of the ether at this surface is inconceivably complicated. Yet there is no confusion between the various images on account of the complexity of action of the delicate machine

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which propagates them. Just in the same way, there is not necessarily any confusion between an infinite variety of pulsating electromagnetic messages propagated through the earth. But, between the denial of the inherent impossibility and the assertion of the practical possibility, there is a great gulf fixed. Who shall bridge it?

THE ordinary railway engineer may be a little puzzled at the anxiety with which electric railway engineers in America are seeking to obtain continuously welded rail tracks. There are so many practical difficulties in the way of dispensing with the expansion gap, and the cost of continuous welding is relatively so high, that it is not at first sight evident why such strenuous efforts should be made on behalf of welded rails. The secret lies in the pressing necessity which electric railway engineers are under, to provide an efficient rail-return for the current. All sorts of rail bonds have been tried and found wanting, and the only hope lies in an actual metallic union between rail and rail. We describe this week a method of track welding which has been adopted on one of the American lines, and which appears to give a very efficient connection at the rail joints. The method is interesting from the fact that the welding current is not passed through the butt joint from rail to rail, but is sent transversely to the rails between two pairs of clamping lugs of mild steel placed on either side of the butt joint. The actual union with the rails is produced by mechanically squeezing the pasty steel into the fissure between the rails, at the same time the welding metal being case-hardened by a supply of carbon. Enough plastic metal is forced into the gap on either side to make a butt weld in the middle, so that the joint practically consists of an upper and a lower H-piece electrically welded at every point of contact with either rail. The mechanical advantage of this method of electric welding would appear to consist chiefly in the fact that the work of forcing the rails into a true butt contact is not put upon the welding machine, as would be the case if the welding current had to pass from rail to rail; and, thus the uncertainty of a weld over the entire section is removed.

THE orthodox objection to raise against continuous rails, 500ft. or more in length, is the variation of length due to change of temperature. It represents a very serious, but happily, not insuperable difficulty. A metal rail varied between mid-winter midnight temperature and that of an August noon will usually alter considerably in length. But it does not necessarily do so; for it is possible to constrain the rail so that it shall remain at practically constant length. This alternative sets up a stress in the rail and weakens it; it probably also hastens that interesting, but very disastrous, process of deterioration which has been so ably investigated by WÖHLER and others. Moreover, since the rail and the things which hold it in place are not perfectly elastic, there may be set up a gradual process of "creeping," whereby the relative position of the rails may be found at the end of some weeks to have appreciably changed. It is not likely that any serious "hogging" or buckling will take place if the rails are properly secured; but, until there is more certain experience of these things, very careful inspection ought to be made to discover whether any slow-period changes are liable to occur on account of imperfect elasticity.

THANKS to the unwearying vigilance of the County Council, a grave danger which threatened the welfare of the inhabitants of this City has been warded off. On Tuesday last a gang of miscreants were discovered trying to run a steel tube through the London clay. Captured, and put to the question (in Committee Room No. 5), the prisoners alleged that they were merely poor out-of-work company promoters hoping to construct an electric railway from the City to Epping Forest, and thereby relieve the existing lines of some of their superabundant traffic, and secure a minimum of 3½ per cent. for the thrifty investor. The culprits were at once sternly warned that the sovereign people could not be trifled with in this manner, and that their offence could only be purged by at once promising as a votive offering to carry all county councillors and their supporters nine miles for one penny for all time. This magnanimous proposal not being to the liking of the promoters, they were summarily ejected, *i.e.*, their Bill was thrown out.

THE project being, however, of some public utility, we may perhaps be allowed to suggest that the job should be carried out either by the County Council's own staff or by the unemployed, a short Act of Parliament being passed conferring the necessary knowledge upon all concerned. As it is also desirable that the money should not be provided by those in any way likely to be benefited, another short Act might be passed empowering the Council to levy some sort of poll-tax, say one penny on every silk hat entering the City area between the hours of nine and eleven forenoon. Meanwhile, London waits for its electric railways and English capital flows to other lands.

Telephonic Communication in Germany.—It is proposed to establish telephonic communication between Berlin, Tilsit and Memel.

Manchester Ship Canal.—Preparations are now being carried out for lighting the locks at Barton, on the Manchester Ship Canal, by arc lights.

Derby Electrical Exhibition.—This exhibition has been so successful that arrangements are being made for continuing it for another week.

Electricity Supply in Germany.—The authorities of the electric lighting station at Altona have just reduced the price of electrical energy for motor purposes to 2½ pfennigs per hectowatt hour (2½d. per kilowatt hour).

Destruction of an American Power Station.—A boiler explosion occurred at the Southern Electric Light Company's power station at Philadelphia. A loud roar was heard throughout the city, and every light on the circuit was extinguished.

New Books.—Messrs. Longmans, Green and Co. have brought out, in book form, Prof. Unwin's "Howard Lectures" "On the Development and Transmission of Power from Central Stations," which were delivered before the Society of Arts last year.

Royal Society.—At yesterday's meeting the election of Fellows took place, and the following papers were read: Prof. C. V. Boys, "On the Newtonian Constant of Gravitation;" Mr. S. Bidwell, "On the Recurrent Images attending Visual Impressions."

The Electric Lighting of the Embankment.—At the last meeting of the London County Council the Highways Com-

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mittee recommended that the generating station for lighting the Embankment and the Waterloo and Westminster Bridges be constructed by the Works Committee. This was agreed to.

Electrical Trade Section.—At a meeting of the Electrical Trade Section yesterday, Mr Emile Garcke was elected chairman, and Mr. Alexander Siemens, deputy-chairman: Major Flood Page resigning the chairmanship after two years' tenure.

Cable Interruptions and Repairs:—

	Date of Interruption.	Date of Repair.
Lagos-Accra	May 21, 1894	June 6, 1894.
Bissao-Bolama	Nov. 24, 1893	—
Brest-St. Pierre (P.Q. Co.)	Mar. 29, 1894	—
Accra-Kotonou	Apr. 1, "	—

A New Telegraph Code.—A "Weather and Famine" Code has been prepared by Mr. Tucker, Registrar in the Indian Revenue and Agricultural Department, for use between the Government of India and the Secretary of State. The code words are French.

London County Council (General Powers) Bill.—This Bill, which has passed the House of Commons, came on Tuesday before the examiner of standing order proofs in the House of Lords, and was reported to have failed to comply with the standing orders in respect to one clause which was not covered by the notices.

The Electric Lighting of the French Chamber of Deputies. The Palais Bourbon, it is announced, will shortly be lighted by electricity. The firm of Brégeut is ready to do the job for £20,000, and to run and maintain the plant for £2,880 per annum for a period of ten years, against £4,800, the annual amount of the lighting bill at present.

More Fanciful Candle-Powers.—The search light, constructed in France, which was exhibited at the Chicago World's Fair, has been erected at Sandy Hook, and was lighted for the first time on Monday night. The intensity of its light is stated to be 194,000,000 candle-power. How much higher, we wonder, will the rating of search lights be carried?

Prize Essays.—It is announced that the Smith prizes this year have been awarded to Sydney Samuel Hough, B.A, scholar of St. John's, for an essay "On the Oscillations of an Ellipsoidal Shell containing Fluid," and to Henry Cabourn Pocklington, B.A., scholar of St. John's, for an essay "On the Steady Motion and Small Oscillations of an Electrified Hollow Vortex."

Leaflet Instruction in Electrical Engineering.—The *Electrical Engineer* of New York will shortly begin the publication, under the title *Electrical Engineering Leaflets*, of a book written by Prof. Houston and Mr. A. E. Kennelly. The Leaflets will be issued weekly, in three grades—Elementary, Intermediate and Advanced—each grade consisting of 35 weekly parts, all three to issue simultaneously.

Resonating Conductors.—The *Electrical Engineer* of New York, in a leading article stating that Prof. Pupin "has devoted himself specially to the study of 'resonance' effects at low frequencies such as those directly obtainable from alternators or other electric current generating devices," further understands that "Dr. Pupin has carried his experiments involving the same principles into the realms of electric lighting by means of vacuum tubes, and that most promising results have already been obtained as to light without heat."

Telegraph Blunders.—A few weeks a ago a cablegram from London announced that the Government had annexed the Tuesday Islands, and the good folks at the Cape were set wondering, not only at the boldness of the Ministry, but at the unaccountable parsimony of the gazetteers in affording no clue to the position of those coveted possessions. When the mail arrived with the English papers it was discovered that the Government had really annexed no more than the Tuesdays which had been given up to private business in the House of Commons.

Obituary.—We regret to record the death, on the 30th ult., at Park House, Budleigh Salterton, of Vice-Admiral George William Preedy (retired), C.B., aged 77. Admiral Preedy was in command of H.M.S. "Agamemnon" during the laying of the first Atlantic cable in 1857.——We regret to also have to record the death of Mr. Thomas Eccleston Gibb, which occurred on Wednesday at his residence in Lady Margaret-road, Kentish Town. It was largely owing to his initiative that the parish of St. Pancras adopted the electric light. Mr. Gibb was an Associate of King's College and a Fellow of the Statistical Society.

A Telephone Circuit Protector.—Amongst the novel devices at the Southern Bell Telephone and Telegraph Company's new exchange in Atlanta (Ga.) is the Wotton protective device against heavy currents. This circuit-breaker consists simply of a small graphite cylinder capped at both ends with brass caps, to which the circuit wires are connected. A small amount of fulminate of mercury is placed in the ends of the graphite cylinder under the caps. On the passing of an excessive current a small explosion occurs, blowing out the graphite and disrupting the circuit.

London Electric Railways.—The Bill promoted by the Central London Railway Company will pass unopposed through the House of Lords, no petitions having been lodged against it within the time allowed by the Standing Orders. By this Bill, which has already been sanctioned by the House of Commons, an extension of time is granted until 1900 for constructing this railway. The Charing Cross, Euston and Hampstead Railway Bill, which gives power to that company to acquire additional lands, will also pass as an unopposed Bill through the Second House.

The City Engineer.—At the meeting of the City Commission of Sewers on Tuesday the Special Committee brought up a report on the reference to inquire, owing to the death of Colonel Haywood, into the duties and emoluments of the engineer's department. They recommended that Mr. Ross, who since 1882 had been chief assistant to the late engineer, and 22 years in the department, should be appointed chief of the engineer's office, with power to call in consulting advice under the authority of the Court when deemed expedient, and that his salary, now £650, be increased to £900.

Research Fellowships.—The Registrar of Owens College, Manchester, announces that at least two Bishop Berkeley Fellowships of the value of £100 per annum, to date from September 29th next, are offered for award. Evidence must be presented of ability to prosecute some special study or research in one among several of the chief subjects of the college curriculum in arts, science, and medicine. A limited number of appointments will be made on the same date to Honorary Research Fellowships. Applications should be sent on or before June 22nd to the Registrar.

Oil Fuel.—We have received from Mr. Henwood a letter about the marine boiler which he described at a recent meeting of the Institution of Electrical Engineers. He reiterates his claims, and makes a number of general assertions, summing up by stating that:—"This boiler is the very best type that has ever been devised for burning oil fuel, . . . and the life or endurance will probably be about three times as long as the ordinary marine boiler. . . . The weight under steam will be only about one-eighth; the space occupied, the consumption, and the cost of construction per indicated horse-power about half as compared with the ordinary marine boiler in proportion to power." We understand that he does not wish illustrations to be published at present.

The May Island Light in a Fog.—Another instance of the failure of an electric light to pierce a fog is given by the wreck of the Dundee steamship "Jasper" upon the May Island on the night of April 16th. The vessel was carried out of her course by currents; and with only a couple of minutes' notice, the island was struck 500 yards from the lighthouse. It is a powerful electric light, erected about eight years ago, at a cost of £60,000, and in clear weather it is visible for a distance of 20 miles. A fisherman who gave evidence at a Board of Trade inquiry stated that when he was about a mile from the island he could not see the light, although he could see the light on the Fifeshire coast, an oil-light, which was 2½ miles off.

Institution of Civil Engineers Premiums.—Amongst the awards made for original communications submitted during

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the part session are the following:—Telford Medals and Telford Premiums to J. H. Greathead and Francis Fox for their joint Paper on "The Liverpool Overhead Railway;" a George Stephenson Medal and a Telford Premium to Thomas Parker, for his Paper on "The Electrical Equipment of the Liverpool Overhead Railway;" a Watt Medal and a Telford Premium to Bryan Donkin, for his Paper intituled "Experiments on the Condensation of Steam in Cylinders of Iron and other Metals."

Smoke Consumption.—A competition of smoke-consuming apparatus has been decided upon by the Paris Municipal Council, which has set aside a sum of £320 for the purpose. An elaborate programme of conditions is to be drawn up, and the apparatus submitted for competition, which must be practical and not costly, will be subjected to exhaustive tests at the municipal waterworks by a commission composed of engineers attached to the Paris Municipality and members of the Hygienic Council, with power to add to their number a scientific man, a member of the Committee of Arts and Manufactures, a manufacturer, and a member of the Municipal Council.

Thunderstorms.—Violent and prolonged thunderstorms, accompanied in some instances by cyclonic storms, have visited various parts of the country during the past week. Horses and cattle have been killed or maimed in a great number of places in the West of England. At Bath a man was severely injured, and the crew of a boat off Lowestoft were rendered unconscious, it is said, by the violence of a shock with which their craft was struck. Lightning has often given fire brigades enough work to do to extinguish fires at buildings it has struck, but at Rugby this week it has varied the usual course of striking the fire alarm and ringing up the brigade, although it did not want them for any conflagration.

Flood Warnings by Telegraph.—The Birhi-Ganga, one of the Himalayan headwaters of the Ganges, runs down a gorge with cliffs rising to 4,000ft. on either side. In September and October last, certain of these cliffs fell down into the gorge and blocked it up with an obstruction two miles long and one mile broad. The lowest height of this natural dam is about 850ft. above the bed of the stream, so that a lake many hundred feet deep is accumulating behind it. Official inspection has shown that there is no danger of the dam giving way as a whole, but the upper 250ft. is of lighter material, and is naturally less thoroughly consolidated than the base, and a sudden giving way of this portion would result in a bad flood. A watch has, therefore, been set upon the obstruction, and a special telegraph line has been run to enable prompt warning to be given to the threatened inhabitants.

London, Walthamstow, and Epping Forest Railway.—On Tuesday it was announced to Sir John Kennaway's Committee on the above Bill that the negotiations with the London County Council with regard to the terms imposed upon the promoters as to workmen's trains had failed, and Mr. Balfour Browne asked the Committee to insert a suspensory clause providing that they should not come into operation until 3½ per cent. had been paid upon the Ordinary shares, stating that without such a clause they would not be able to raise the capital, and must withdraw the Bill. Mr. Pember, for the County Council, asked that if a suspensory clause were introduced it should be for a definite limited time, the term he suggested being three years. The Committee expressed their willingness to insert a suspensory clause for five years, but this did not satisfy the promoters, and the Bill was withdrawn.

Jubilee of the American Telegraph.—The *Electrical Engineer* of New York calls attention to the fact that the present year is the Jubilee of the United States system of telegraphs. In 1843 Congress voted £6,000 for tests of the electric telegraph, and on May 24, 1844, the historic message "What hath God wrought?" was despatched by Miss Annie G. Ellsworth, now Mrs. Roswell Smith, from Washington to Baltimore. In a characteristically interesting little article, our New York contemporary recalls to mind the various episodes of that classic period in the history of land line telegraphy. In a minute dated June 26, 1844, Morse deals with the question of the repair of aerial lines, and makes the—to us—quaint-sounding suggestion that "very little interruption would take place if the train that discovered a break would stop not more than five minutes, and being furnished with pieces of wire already prepared for the purpose, anyone could simply unwrap and scrape the broken ends, and unite them by twisting the ends of the pieces of wire to them; and then give notice of the place to the inspector at either terminus, that a more permanent repair may be made." We commend the suggestion to the passengers by, and officials of the South-Eastern Railway, who have many such opportunities of useful leisure.

Great Northern Telegraph Company.—On Thursday last week the Great Northern Telegraph Company completed the 25th year of its existence. The event was commemorated wherever the Company has stations 18 in all, the London staff being entertained at dinner at Seyd's Hotel. In Copenhagen the King of Denmark sent his congratulations on the event to the Chairman of the Company, and a banquet was held in the evening—on June 1st. At the same time a large company dined at the Savoy Hotel, among those present being the Danish Minister, the Swedish and Norwegian Minister, Sir John Pender, G.C.M.G., M.P., Mr. Lamb, C.M.G., Mr. Benton, the Danish Consul-General, Count Ahlefeldt-Laurvig, and representatives of other telegraph companies. The Danish Minister proposed "The Great Northern Telegraph Company." He believed that the work of the Company would bear comparison with that of any other telegraph administration. Practically, direct cable communication between Great Britain and the North of Europe had not been totally interrupted for a single day during the 25 years of the Company's existence. In China the Company were the pioneers of the telegraphs. They overcame the resistance of the most anti-progressive power on the face of the earth, the superstitions of the Mandarins and people, and the difficulty of adapting the Chinese language to telegraphic correspondence. Mr. Nielsen, the representative in England of the Great Northern Telegraph Company, who presided at the dinner, in responding, spoke of the kindness and assistance which his Company had met at the hands of the Post Office and English cable companies. Mr. Lamb, in replying, referred to the cordial relations which existed between the General Post Office and the Great Northern Company, and paid a hearty tribute to Mr. Nielsen's great ability and integrity. The next toast was "Sir John Pender," which was proposed by the Danish Minister. Sir John Pender, he said, had been connected directly or indirectly with every submarine cable enterprise during the latter half of the century, and his name would appear on almost every page when the history of those enterprises came to be written. Sir John impersonated those resources of genius, enterprise, and perseverance which had secured to Great Britain the place it occupied amongst nations, stimulating other nations to that competition from which all progress sprang. Sir John Pender said in his reply that the evening's celebration carried him back over almost the whole period during which he had been actively connected with submarine telegraphy. He asserted that there had been no more important factor in the progress of civilisation and the extension of commerce than the development of submarine telegraphy, and this he was sure would be borne out by those who would write the history of the present century. The importance and practical value of these connections were admitted by some of the European governments, but he thought the companies should be more fully recognised by the administrations and consulted. It gave him much pleasure to be present on this occasion, and to testify to his admiration of the good work done by the Great Northern Company. They had worked very well together—sometimes with a little friction—but on the whole with a good understanding. He hoped they would continue to work together in harmony and in unity. The Chairman and the Managing Director of the Company have each received valuable presents from the Board of Directors and from the staff. The Directors of the Company, in order to mark their appreciation of their employés' services, have given to each a present equal to from one to six months' salary, according to the length of service. Everyone in the service is included in this mark of appreciation—clerks, messengers, coolies, and housekeepers.

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ON HERR LENARD'S EXPERIMENTS ON THE MAGNETIC ACTION OF CATHODE RAYS.

BY GEO. FRAS. FITZGERALD, F.R.S.

In a former communication upon Herr Lenard's experiments (*The Electrician*, Vol. XXXII., p. 573, March 23, 1894) it was pointed out that the experiments so far would be consistent with the supposition that cathode rays were rays of light of a very high frequency, except for the fact that they are deflected by magnetic force, a phenomenon of which we have no other evidence, and which makes it practically impossible at present to suppose that cathode rays are of this nature. It was further pointed out that if this deflection were an action on the emitting surface, and not on the ray, it might be again possible to explain these cathode rays by the supposition that they are rays of light. Herr Lenard's more recent experiments seem entirely at variance with any such supposition, while there is nothing in them that, in the same conclusive way, proves that they are not streams of electrified molecules or atoms.

Years ago Messrs. Spottiswoode and Moulton showed that it was possible to start from one side of a glass plate what they considered to be the same as the cathode part of electric discharges, by a sufficiently sudden charging of the opposite side of the plate. They showed that it was thus possible to produce these rays in air at considerable pressures, and they seemed to consider the phenomenon quite analogous to the production of the electric aura from points. They showed that these discharges could be driven partly along an exhausted tube without reaching the far end, and considered that the discharge went out and returned by the way it came. If this were the case with cathode rays in general, it would account for their not appearing to electrify bodies, though it would also require the assumption that the returning discharge returned in an irregular way, so that its deflection by a magnet was imperceptible. Certainly Herr Lenard's observation that these cathode rays do not electrify a conductor placed in them proves that either the quantity of electricity concerned is very small, or that the charges cannot leave the gas. Either of these suppositions is possible. The phenomena of phosphorescent illumination, heating, and pressure, that have been attributed to projected molecules have been ascribed to their kinetic energy, and not to the electric energy they possess, and there are many experiments that show that a charge cannot leave the gas easily.

It is to be regretted that Herr Lenard does not seem to have observed whether the phosphorescence or the spectrum of the cathode light depends at all on the nature of the gas. If it does it might finally decide whether the molecules can be projected through these thin windows. That there is no increase in pressure in the vacuous tube only shows that the same number go out as come in, and although it is *extremely* improbable that any gas is carried through glass and mica, yet it would be desirable to finally disprove the supposition, especially as there are several experiments by Mr. Daniell, Dr. Shields, and others, showing that electrolytic ions can penetrate considerable thicknesses of metallic plate.

From Herr Lenard's most interesting and important observation, that the deflection of the ray depends on the pressure of the gas in the tube in which the ray is generated originally (he does not seem to have changed its nature), and not on the nature and pressure of the gas in which it is deflected, it follows that, if the rays are paths of projectiles, they must either pass through the window or else be projected from it by some action which behaves like a blow given to it from the other side. The action may, of course, be electrolytic in its nature, or it may be an ordinary blow accompanied by some electric action which accounts for the magnetic action on the projected molecule. Blows delivered to one side of a plate would project molecules from the other side, with different velocities depending on the nature of the blow and on the mass of the molecule, so that a hypothesis of this kind would be quite accordant with Herr Lenard's observation. The fact that the magnetic effect is independent of the mass of the molecule struck is explicable by supposing the electrical charge to be the same for all molecules. Some of these molecules in traversing the gas would collide with others, so that their paths would not be quite straight, and their velocities would be less than that of the unstruck molecules, and so would produce the penumbra Herr Lenard has observed when the vacuum is not perfect, and this penumbra being due to more slowly moving molecules, would be more deflected by the magnetic force than the more quickly moving central core.

There does not seem anything in these observations at all at variance with the supposition that we are dealing with rapidly moving molecules of matter, and until this hypothesis is *disproved* it is hardly safe to venture on new properties for the ether. The way in which the emission theory of light explained refraction, accounts for the ease with which Herr Lenard is able to give an optical turn to these observations. Even though it can be shown by rotating the tube and thereby producing aberration, or by some other method, that the velocity of projection must be comparable with that of light, and consequently improbably great for matter molecules, yet we really know nothing to prove that such velocities are in any way impossible. The velocity of the molecules in a comet's tail, which polarise light and are almost certainly material, is very great indeed, and if only a few molecules are concerned the amount of energy required to produce, even very great velocities, is not very great. A hydrogen molecule moving with the velocity of light has an energy of less than half a millionth of an erg, a very small quantity, and it is evidently possible to regulate the numbers of molecules involved so as to account for whatever energy is required to explain the phenomena.

Even though sufficient reasons were forthcoming for rejecting the theory that these rays are due to projected molecules, there are other possible suggestions such as that they are straight Grotthüs chains of molecules, which bend under magnetic force. This might account for a velocity of propagation of actions along them, comparable with the velocity of light, without requiring the component matter to move with this velocity. In fact, until the matter present has been reduced very much beyond what has been attained, and it has been shown that these phenomena increase instead of diminishing, and that there is no very slow projection of the material of the plates, such as darkens the glass in glow-lamps, it will be very difficult indeed to prove that any of the phenomena hitherto observed, are due to the ether, and not to the matter present, because so far the phenomena are quite like those that would be due to moving electrified matter, and especially the magnetic actions, are quite unlike anything we know of the properties of the ether.

It would certainly be very much more interesting to find in them a new property of the ether. It has, quite possibly, many properties of which we know very little. It is, possibly, the cause of gravity, and of chemical forces, though the former of these is certainly and the latter are probably quite different from electric and magnetic forces. It has been often pointed out that upon almost any vortex atom theory there should be actions which are simultaneous throughout space, which are not propagated in the ordinary sense of the word, but are due to the motion constituting each vortex atom being extended throughout all space. If the ether has structure, which is almost certain, electromagnetic actions are probably due to an average change of structure, and in that case there may be actions due to the changes whose average we observe. Just as the pressure of a gas is due to the average velocity of its molecules, while its rate of diffusion depends on these actual velocities themselves, and on the sizes of the molecules. It would undoubtedly be much more interesting to see in these cathode rays, in auroral streamers, and possibly in the solar corona, and in comets' tails, a new etherial phenomenon rather than an example of the old humdrum electromagnetics of the last twenty years; but notwithstanding Herr Lenard's experiments, and Lemström's auroral streamers reaching the earth, and observations of their extending hundreds, if not thousands, of miles from the surface of the earth, notwithstanding the help it would give us in explaining magnetic storms by cathode rays from the sun, without filling space with an undue amount of matter, nevertheless we must make sure that the known laws of the old humdrum electromagnetics cannot explain the observations before framing additional hypotheses. Science generally advances by reducing the number of, rather than by multiplying hypotheses.

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A METHOD FOR THE TREATMENT OF ROTATING OR ALTERNATING VECTORS, WITH AN APPLICATION TO ALTERNATE CURRENT MOTORS.

BY PROF. GALILEO FERRARIS.

(Continued from page 131.)

Part II.—Application to Magnetic Fields and to Electric Motors with Alternate Currents.

13. We can apply the general considerations above explained to the special case in which the vectors treated of are magnetic forces.

In this case the propositions of articles 8, 9, and 10, show at once how, by means of two or more alternating magnetic fields of fixed direction you can produce a rotating magnetic field. Moreover, we show how a rotating magnetic field can be produced by means of two or more alternating currents of different phases. In other words, therein is comprised the fundamental principle of electric motors for alternating polyphase currents.

Vice versâ, the proposition of Article 3 shows how an alternating magnetic field, or a flux of alternating induction can always be considered as resultant of two or of more fields, or of two or more fluxes of constant value rotating some in a right-handed sense and the others in a left-handed sense. Now, this mode of considering a magnetic field or a flux of alternating induction may prove very useful in the study of induced currents in conductors placed in the magnetic field, and in the study of the force which this latter exerts on them. It may, in consequence, prove useful in the study of fundamental phenomena in many kinds of electric apparatus, and especially in electric motors for alternating currents. To give an example of such application we shall here treat of these last.

14. *Synchronous Motors.*—Let us consider first an armature formed of a single coil, of which the spires are in planes perpendicular to a common axis $o\,a$ (Fig. 12), and let us suppose that it

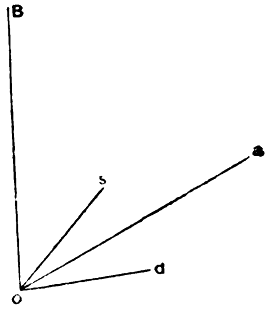

Fig. 12.

can rotate in the plane of the figure round an axis o in a magnetic field where the magnetic induction has the uniform value B and the constant direction o B. If such a coil is traversed by an electric current, it is equivalent to a magnet of axis $o\,a$, the magnetic moment of which is obtained by multiplying the sum of the areas of the turns by the strength of the current in absolute electromagnetic measure. We can represent this magnet, and therefore also the coil traversed by the current by means of a vector having the direction $o\,a$ and a magnitude equal to the aforesaid magnetic moment. If the current is alternating with the frequency n, the vector also is alternating with the same frequency, and we can represent it, according to our method, by $o\,a\,s\,d$. Making use of this representation is equivalent to substituting for the alternating magnet $o\,a$ two rotating magnets, the magnetic moments of which are represented by $o\,d$ and by $o\,s$. Calling the amplitude A, $o\,a$ and d and s the magnitudes of the two rotating vectors $o\,d$, $o\,s$, we have $d=s=\dfrac{A}{2}$.

This being assumed, let us consider the forces exercised on the coil by the magnetic field in which this is situated. The forces are reduced to a couple whose moment is $B\,.\,a \sin B\,o\,a$, and by the theorem set down in Art. 11 is equal to the sum

$$B\,d \sin \delta + B\,s \sin \sigma,$$

where by δ and by σ are represented, as before, the angles which the two rotating vectors left-handed and right-handed d and s make at the given moment with o B. If the coil is at rest, the vectors d and s turn with the same frequency, n, the one in a right-handed sense, the other in a left-handed sense, and by the proposition in Article 12 (4th case), the mean values of the products $B\,d \sin \delta$ and $B\,s \sin \sigma$ are equal to zero. Whence the mean value of the moment of the said couple is equal to zero. If we make the coil rotate round the axis o, with a frequency m, the vector $o\,a$ turns with it, and the two vectors $o\,d$ and $o\,s$ begin to turn with angular velocity equal to the algebraic sum of the velocity which they have relatively to the armature, and of the velocity which they have common to this. If, for example, the armature turns to the right, the rotating vector d turns in space with the frequency $n+m$, and the vector s turns with the frequency $n-m$. Meanwhile, since m is different from n, the mean values of the moments of the couple are again equal to zero. But if $m=n$, the frequency of d becomes equal to $2\,n$, and that of s is reduced to zero. The current of the armature is equivalent then to two magnets of constant magnetic moment, one of which, d, turns in the direction of the armature with a double frequency, and the other, s, remains fixed in space. The fixed direction of this last is that through which there passes the axis, $o\,a$, of the rotating coil at the moment in which the alternating current in it has the maximum strength. Such a direction makes, with o B, a fixed angle, which we shall represent by ς. In this case the moment of the couple acting on the armature has no longer a mean value equal to zero; then, in fact, only the mean moment of the couple acting on $o\,d$ is equal to zero, or the mean value of the product $B\,d \sin \delta$; whilst the moment of the couple acting on $o\,s$ has the constant value

$$B\,s \sin \varsigma,$$

or

$$\frac{1}{2}\,A\,B \sin \varsigma.$$

This couple tends to close the angle $s\,o$ B. If such angle is, as in the figure, to the right of o B, or on the side towards which the armature turns, the couple opposes itself to the movement, causes the expenditure of energy, the apparatus acting as a dynamo. If, instead, the angle B $o\,s$ lies to the left of o B, or on the side opposite to the movement, the couple acts in the direction of the rotation, it does work; the apparatus works as an electric motor; it is, in the simplest form, a synchronous motor.

The motor couple of this motor varies between 0 and $\frac{1}{2}$ A B when ς varies between 0 and $\frac{\pi}{2}$. For values of ς less than $\frac{\pi}{2}$ the action of the motor is stable. If, in fact, the resisting couple is augmented the armature is somewhat retarded, the angle ς increases, and the moment of the motor couple increases with it. If, instead, the resisting couple is diminished, the armature tends for a moment to be accelerated, thus the angle ς diminishes, and the motor couple diminishes with it.

15. *Asynchronous Motors. Closed Armatures placed in a Rotating Magnetic Field.*—Let us consider in the second place an armature formed of N windings, or of N elementary spirals closed on themselves in short circuit, and arranged regularly at equal angular distances in opposite diametral planes, all about an axis of rotation. Let us call S the area, r the resistance and L the coefficient of self-induction of one of the spirals. Let us imagine then that the armature is in a rotating magnetic field, in which the magnetic induction, constant and uniform, has the value B, and turns *relatively to the armature* with a frequency u.

In the elementary spiral the normal of which makes with the induction B, at the end of the time t an angle a, there passes at that moment a flux of induction $B\,S \cos a$; whence by the variation of a due to the rotation of B in respect to the armature, we have in the spiral an electromotive force

$$2\,\pi\,u\,B\,S \sin a.$$

This electromotive force produces in the elementary spiral a current of strength i given by the formula

$$i=\frac{2\,\pi\,u}{\rho}\,B\,S\,\sin\,(a-\phi),$$

where ϕ is the angular value of the retardation of phase of the current in respect to the electromotive force given by the relation

$$\tan\,\phi=\frac{2\,\pi\,u\,L}{r},$$

and ρ is the apparent resistance of the spiral, or

$$\rho=\sqrt{r^2+4\,\pi^2\,u^2\,L^2}.$$

Such a current is equal to a magnetic shell, whose magnetic moment is equal to i S, or to

$$\frac{2\,\pi\,u}{\rho}\,B\,S^2 \sin\,(a-\phi).$$

And can be represented by a vector having the direction of the normal to the plane of the spiral, or, as we may say concisely, the direction a.

Now, if this vector is projected on the straight line which B makes with the angle ϕ, and then on the perpendicular to it, we have, repectively,

$$\frac{2\,\pi\,u}{\rho}\,B\,S^2 \sin\,(a-\phi) \cos\,(a-\phi),$$

and

$$\frac{2\,\pi\,u}{\rho}\,B\,S^2 \sin^2\,(a-\phi)\,;$$

and if we calculate the mean values of these projections for a, comprised between 0 and $2\,\pi$, we find that these mean values are,

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respectively, zero and $\frac{1}{2}\frac{2\pi u B S^2}{\rho}$. Thence the N spirals are equivalent in the main to a magnet of magnetic moment—

$$A = \frac{N}{2}\frac{2\pi u}{\rho} B S^2,$$

the axis of which makes, with the direction of B, the constant angle $\phi + \frac{\pi}{2}$. Such a magnet follows B in the rotation, being always behind at the angular distance $\phi + \frac{\pi}{2}$. If in Fig. 13 it is supposed that the magnetic field turns *relatively to the armature* in the direction of the arrow u, and if O X is perpendicular to the direction O B of the magnetic induction, the direction of the equivalent magnet to the armature is that of O A, which makes with O X the angle X O A $= \phi$.

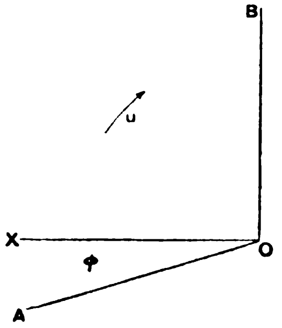

Fig. 13.

16. *Motors with Rotating Field.*—An armature like that which we have just considered, situated in a rotating magnetic field produced by means of a system of polyphase currents, constitutes a motor with rotating field. The motor couple is that which the magnetic field would exert if, in the place of the armature, there were substituted the equivalent magnet previously considered. The moment (or torque) of this is thus (Fig. 13) A B sin A O B, calling it K, and substituting for A the value found in the preceding article, we have

$$K = \frac{N}{2} B^2 S^2 \frac{2\pi u . \cos\phi}{\rho}.$$

Remembering that $\cos\phi = \frac{r}{\rho}$, we can also write

$$K = \frac{N}{2} B^2 S^2 r \frac{2\pi u}{\rho^2},$$

or

$$K = \pi N B^2 S^2 \frac{r u}{r^2 + 4\pi^2 u^2 L^2} \quad . \quad . \quad . \quad . \quad (1)$$

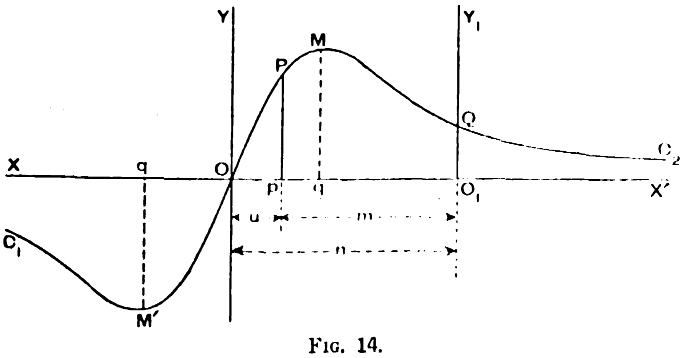

Fig. 14.

In this expression the letter u represents the frequency of the *relative motion* of rotation of the magnetic field with respect to the armature. The formula gives the relation between the couple of rotation K and the frequency u; and it is easy to see what would be the form of the curve with which the formula is translated when we take u as abscissa and K as ordinate.

The (1) can be written

$$K = \frac{\pi N B^2 S^2 r}{\frac{r^2}{u} + 4\pi^2 u L^2},$$

wherefore it appears that K changes sign without changing value when u changes into $-u$. It has the value zero for $u = 0$, and also for $u = \pm\infty$; and it has a maximum numerical value when the two terms of the denominator, the product of which is constant, are equal to one another, or when

$$u = \pm\frac{1}{2\pi}\frac{r}{L}.$$

Meanwhile the line $C_1 C_2$ (Fig. 14), the points of which have for abscissa the values of u, and for ordinate the corresponding values of K, is composed of two branches similar with respect to the origin O. It passes through the origin, is asymptotic to both the parts of the axis of abscissa, and presents two points M M' of ordinate numerical maximum, which correspond to the abscissa $+\frac{1}{2\pi}\frac{r}{L}$ and $-\frac{1}{2\pi}\frac{r}{L}$. The value of the maximum is $\frac{\pi N B^2 S^2 u}{2}\frac{u}{r}$.

The origin O is a point of inflection, and in its vicinity the line cannot be distinguished from a straight line, the inclination of which is $\frac{\pi N B^2 S^2}{r}$. The abscissa of the maximum and minimum points M and M', and also the length of the part, which practically is indistinguishable from a straight line, increase with the diminution of $\frac{L}{r}$. At the limit, where $\frac{L}{r} = 0$, the points M and M' would be removed to infinity, and the line would be transformed into a straight line, passing through O, with the inclination

$$\frac{\pi N B^2 S^2}{r}.$$

Given the value of u, and maintaining L constant, the couple K varies with the resistance r. The law of the variation appears clear if we put the expression of K in the form

$$K = \frac{\pi N B^2 S^2 u}{r + \frac{4\pi^2 u^2 L^2}{r}}.$$

For $r = 0$ and for $r = \infty$ K is zero; for $r = \frac{4\pi^2 u^2 L^2}{r}$, or for $r = 2\pi u L$, it is at a maximum. The value of the maximum is $\frac{\pi N B^2 S^2 u}{2 r}$, as above. It may be noted that the value of r, to which corresponds the maximum of K, is proportional to the frequency u, of the relative motion between the field and the armature.

(*To be concluded.*)

THE WORK OF HERTZ.*

The untimely end of a young and brilliant career cannot fail to strike a note of sadness and awaken a chord of sympathy in the hearts of his friends and fellow-workers. Of men thus cut down in the early prime of their powers there will occur to us here the names of Fresnel, of Carnot, of Clifford, and now of Hertz. His was a strenuous and favoured youth; he was surrounded from his birth with all the influences that go to make an accomplished man of science—accomplished both on the experimental and on the mathematical side. The front rank of scientific workers is weaker by his death, which occurred on January 1st of the present year, the thirty-sixth of his life. Yet did he not go till he had effected an achievement which will hand his name down to posterity as the founder of an epoch in experimental physics.

In mathematical and speculative physics others had sown the seed. It was sown by Faraday, it was sown by Thomson and by Stokes, by Weber also doubtless, and by Helmholtz, but in this particular department it was sowed by none more fruitfully and plentifully than by Clerk Maxwell. Of the seed thus sown Hertz reaped the fruits. Through his experimental discovery, Germany awoke to the truth of Clerk Maxwell's theory of light, of light and electricity combined, and the able army of workers in that country (not forgetting some in Switzerland, France and Ireland) have done most of the gleaning after Hertz.

This is the work of Hertz which is best known; the work which brought him immediate fame. It is not always that public notice is so well justified. The popular instinct is generous and trustful, and it is apt to be misled.

The scientific eminence accorded to a few energetic persons by the popular estimate is more or less amusing to those working in the same lines. In the case of Hertz no such mistake has been made. His name is not over well known, and his work is immensely greater in every way than that of several who have made more noise. His best known discovery is by no means his only one. I have here a list of eighteen Papers contributed to German periodicals by him, in addition to the Papers incorporated in his now well-known book on electric waves. I would like to suggest that it would be an act of tribute, useful to students in this country,

* A lecture delivered at the Royal Institution on Friday, June 1st, by Prof. Oliver Lodge, F.R.S., ably assisted during both preparation and performance by Mr. Edward E. Robinson.

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if the Physical Society of London saw their way to translate and publish a collection of, at any rate, some of these Papers.*

Portrait Slide.

The portrait (Fig. 1) which I show is not a specially pleasing one. It is from a photograph taken by Mr. Yule, one of the band of foreign students who flocked to Hertz's laboratory at Bonn. It is excellent as a photograph, though it fails to represent Hertz at his best; perhaps because it was not taken till after the pharyngeal trouble had set in, which ultimately carried him off.

In closing these introductory and personal remarks, I should like to say that the enthusiastic admiration for Hertz's spirit and character, felt and expressed by students and works who came into contact with him, is not easily to be exaggerated. Never was a man more painfully anxious to avoid wounding the susceptibilities of others; and he was accustomed to deprecate the prominence given to him by speakers and writers in this country, lest it might seem to exhalt him unduly above other and elder workers among his own sensitive countrymen.

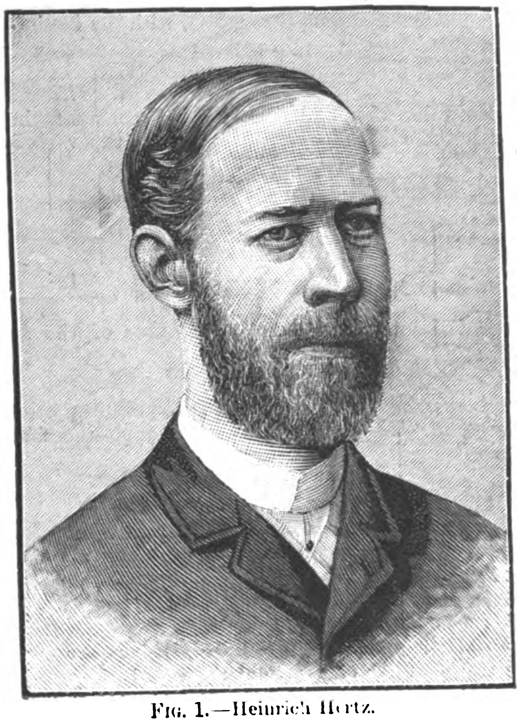

Fig. 1.—Heinrich Hertz.

* *Hertz's Papers.*

1878-79. *Wied. Ann.*, 1880, vol. 10, p. 414. Experiments to establish an Upper Limit for the Kinetic Energy of Electric Flow.

1880. Inaugural Dissertation (Doctor Thesis) on Induction in Rotating Spheres.

1881. Vol. 13, *Wied. Ann.*, p. 266. On the Distribution of Electricity on the Surface of Moving Conductors.

1881. (?) Crelle, vol. 92, p. 156. On the Contact of Solid Elastic Bodies.

1881. Vol. 14, *Wied. Ann.*, p. 581. Upper Limits for the Kinetic Energy of Moving Electricity.

1882. *Verhandlungen des Vereins des Gewerbfleisses* (Sonderabdruck). On the Contact of Solid Elastic Bodies and on Hardness.

1882. *Wied. Ann.*, vol. 17, p. 177 On the Evaporation of Liquids, especiallv of Quicksilver, in Air-Free Space, and on the Pressure of Mercury Vapour.

1882. *Verhandln. d. phys. Gesellschaft in Berlin*, p. 18. On a New Hygrometer.

1883. March. *Schlömilch Zeitschrift*, p. 125. On the Distribution of Pressures in an Elastic Circular Cylinder.

1883. *Wied. Ann.*, vol. 19, p. 78. On an Appearance accompanying Electric Discharge.

1883. *Ib.*, vol. 19, p. 782. Experiments on Glow Discharge.

1883. *Wied. Ann.*, vol. 20, p. 279. On the Property of Benzine as an Insulator and as showing Elastic Reaction (Rückstandsbildner).

1883. *Zeitschrift für Instrumentenkunde.* Dynamometric Contrivance of Small Resistance and Infinitesimal Self-Induction.

1884. *Met. Zeitschrift*, November, December. Graphic Methods for the Determination of the Adiabatic Changes of Condition of Moist Air.

1884. *Wied. Ann.*, vol. 22, p. 449. On the Equilibrium of Floating Elastic Plates.

1884. *Ib.*, vol. 23. On the Connection between Maxwell's Electrodynamic Fundamental Equations and those of Opposition Electrodynamics.

1885. *Ib.*, vol. 24, p. 114. On the Dimension of a Magnetic Pole in different Systems of Units.

1887-1889. Papers incorporated in his book, "Ausbreitung der Elektrischen Kraft," translated under the title of "Electric Waves."

1892. *Wied. Ann.*, vol 45, p. 28. On the Passage of Cathode Rays through Thin Metal Sheets.

Speaking of the other great workers in physics in Germany, it is not out of place to record the sorrow with which we have heard of the recent death of Dr. August Kundt, Professor in the University of Berlin, successor of von Helmholtz in that capacity.

When I consented to discourse on the work of Hertz, my intention was to repeat some of his actual experiments, and especially to demonstrate his less known discoveries and observations. But the fascination exerted upon me by electric oscillation experiments, when I, too, was independently working at them in the spring of 1888,* resumed its hold, and my lecture will accordingly consist of experimental demonstrations of the outcome of Hertz's work rather than any precise repetition of portions of that work itself.

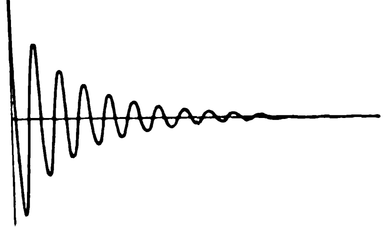

Fig. 2.

In case a minority of my audience are in the predicament of not knowing anything about the subject, a five minutes' explanatory prelude may be permitted, though time at present is very far from being "infinitely long."

The simplest way will be for me hastily to summarise our knowledge of the subject before the era of Hertz.

Just as a pebble thrown into a pond excites surface ripples, which can heave up and down floating straws under which they pass, so a struck bell or tuning-fork emits energy into the air in the form of what are called sound waves, and this radiant energy is able to set up vibrations in other suitable elastic bodies.

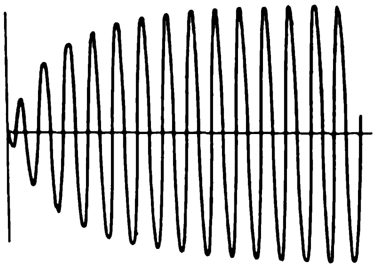

Fig. 3.

If the body receiving them has its natural or free vibrations violently damped, so that when left to itself it speedily returns to rest (Fig. 2), then it can respond fully to notes of almost any pitch. This is the case with your ears and the tones of my voice. Tones must be exceedingly shrill before they cease to excite the ear at all.

If, on the other hand, the receiving body has a persistent period of vibration, continuing in motion long after it is left to itself (Fig. 3) like another tuning-fork or bell, for instance, then far more facility of response exists, but great accuracy of tuning is necessary if it is to be fully called out; for if the receiver is not thus accurately syntonised with the source, it fails more or less completely to resound.

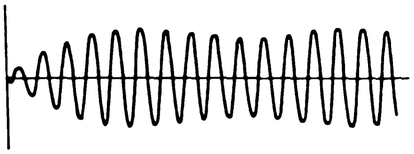

Fig. 4.

Conversely, if the *source* is a persistent vibrator, correct tuning is essential, or it will destroy at one moment (Fig. 4) motion which it originated the previous moment. Whereas, if it is a dead-beat or strongly-damped excitor, almost anything will respond equally well or equally ill to it.

What I have said of sounding bodies is true of all vibrators in a medium competent to transmit waves. Now a sending telephone or a microphone, when spoken to, emits waves into the ether, and this radiant energy is likewise able to set up vibration in suitable bodies. But we have no delicate means of directly detecting these electrical or etherial waves, and if they are to produce a perceptible effect at a distance, they must be confined, as by a speaking tube, prevented from spreading, and concentrated on the distant receiver.

* *Phil. Mag.*, XXVI. pp. 229, 230 August, 1888; or "Lightning Conductors and Lightning Guards" (Whittaker), pp. 104, 105; also *Proc. Roy. Soc.* Vol. L. p. 27.

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This is the function of the telegraph wire; it is to the ether what a speaking tube is to air. A metal wire in air (*in function*, not in details of analogy) is like a long hollow cavity surrounded by nearly rigid but slightly elastic walls.

Sphere Charge from Electrophorous.

Furthermore, any conductor electrically charged or discharged with sufficient suddenness must emit electrical waves into the ether, because the charge given to it will not settle down instantly, but will surge to and fro several times first, and these surgings or electric oscillations must, according to Maxwell, start waves in the ether, because at the end of each half swing they cause electrostatic, and at the middle of each half swing they cause electromagnetic effects, and the rapid alternation from one of these modes of energy to the other constitutes etherial waves.* If a wire is handy they will run along it, and may be felt a long way off. If no wire exists they will spread out like sound from a bell, or light from a spark, and their intensity will decrease according to the inverse square of the distance.

Maxwell and his followers well knew that there would be such waves; they knew the rate at which they would go, they knew that they would go slower in glass and water than in air, they knew that they would curl round sharp edges, that they would be partly absorbed but mainly reflected by conductors, that if turned back upon themselves they would produce the phenomena of stationary waves, or interference, or nodes and loops; it was known how to calculate the length of such waves, and even how to produce them of any required or predetermined wave-length from 1,000 miles to a foot. Other things were known about them which would take too long to enumerate: any homogenous insulator would transmit them, would refract or concentrate them if it were of suitable shape, would reflect none of a particular mode of vibration at a certain angle, and so on, and so on.

All this was known, I say, known with varying degrees of confidence, but by some known with as great confidence as, perhaps even more confidence than, is legitimate before the actuality of experimental verification.

Hertz supplied the verification. He inserted suitable conductors in the path of such waves, conductors adapted for the occurrence in them of induced electric oscillations, and to the surprise of everyone, himself doubtless included, he found that the secondary electric surgings thus excited were strong enough to display themselves by minute electric sparks.

Syntonic Leyden Jars.

I shall show this in a form which requires great precision of tuning or syntony, both emitter and receiver being persistently vibrating things giving some 30 or 40 swings before damping has a serious effect. I take two Leyden jars with circuits about a yard in diameter, and situated about two yards apart (Fig. 5). I charge and discharge one jar, and observe that the surgings set up in the other can cause it to overflow if it is syntonised with the first.†

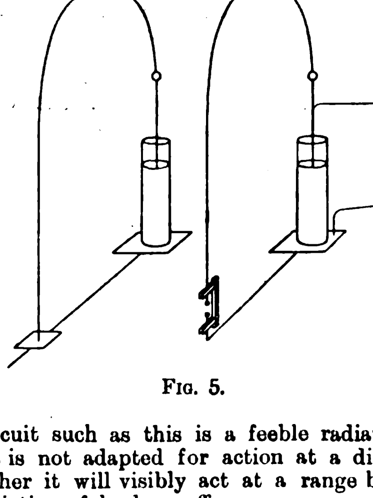

Fig. 5.

A closed circuit such as this is a feeble radiator and a feeble absorber, so it is not adapted for action at a distance. In fact, I doubt whether it will visibly act at a range beyond the $\frac{1}{4}\lambda$ at which true radiation of broken off energy occurs. If the coatings of the jar are separated to a greater distance, so that the dielectric is more exposed, it radiates better; because in true radiation the electrostatic and the magnetic energies are equal, whereas in a ring circuit the magnetic energy greatly predominates. By separating the coats of the jar as far as possible we get a typical Hertz oscillator (Fig. 6), whose dielectric extends out into the room, and this radiates very powerfully.

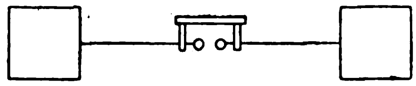

Fig. 6.

Ordinary Size Hertz Vibrator.

In consequence of its radiation of energy, its vibrations are rapidly damped, and it only gives some three or four good strong swings. Hence it follows that it has a wide range of excitation, *i.e.*, it can excite sparks in conductors barely at all in tune with it.

The two conditions, conspicuous energy of radiation and persistent vibration electrically produced, are at present incompatible. Whenever these two conditions coexist, considerable power or activity will, of course, be necessary in the source of energy. At present they only coexist in the sun and other stars in the electric arc and in furnaces.

Two Circular Vibrators sparking in sympathy.

The receiver Hertz used was chiefly a circular resonator, not a good absorber but a persistent vibrator, well adapted for picking up disturbances of precise and measurable wave-length. I find that the circular resonators can act as senders too; here is one exciting quite long sparks in a second one.

Electric Syntony.—That was his discovery, but he did not stop there. He at once proceeded to apply his discovery to the verification of what had already been predicted about the waves, and by laborious and difficult interference experiments he ascertained that the previously calculated length of the waves was thoroughly borne out by fact. These interference experiments in free space are his greatest achievement.

He worked out every detail of the theory splendidly, separately analysing the electric and the magnetic oscillation, using language not always such as we should use now, but himself growing in theoretic insight through the medium of what would have been to most physicists a confusing maze of troublesome facts, and disentangling all their main relations most harmoniously.

Holtz Machine, A and B Sparks; Glass and Quartz Panes in Screen.

While Hertz was observing sparks such as these, the primary or exciting spark and the secondary or excited one, he observed as a bye issue that the secondary spark occurred more easily if the light from the primary fell upon its knobs. He examined this new influence of light in many ways, and showed that although spark light and electric brush light were peculiarly effective any source of light that gave very ultra-violet rays produced the same result.*

Wiedemann and Ebert, and a number of experimenters, have repeated and extended this discovery, proving that it is the cathode knob on which illumination takes effect; and Hallwachs made the important observation, which Righi, Stoletow, Branly, and others have extended, that a freshly-polished zinc or other oxidisable surface, if charged negatively, is gradually discharged by ultra-violet light.

It is easy to fail in reproducing this experimental result if the right conditions are not satisfied; but if they are, it is absurdly easy, and the thing might have been observed nearly a century ago.

(To be continued.)

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

TO-DAY (FRIDAY), June 8th.

PHYSICAL SOCIETY.

5 p.m. (1) Discussion of the Paper by W. Baly and Prof. Ramsay "On the Relations of Pressure, Volume, and Temperature of Rarefied Gases;" (2) An Exhibition of Photographs of Flames by Capt. Abney.

ROYAL INSTITUTION.

9 p.m. Friday Evening Discourse: "The Newtonian Constant of Gravitation," by C. Vernon Boys, F.R.S.

WEDNESDAY, June 13th.

ROYAL SOCIETY.

Ladies' Conversazione.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

* Strictly speaking, in the waves themselves there is no lag or difference of phase between the electric and the magnetic vibrations; the difference exists in emitter or absorber, but not in the transmitting medium. True radiation of energy does not begin till about a quarter wave-length from the source, and within that distance the initial quarter period difference of phase is obliterated.

† See *Nature*, Vol. XLI., p. 368; or J. J. Thomson, "Recent Researches," p. 395.

* The experiments shown in the lecture was on the lines of those described in my book, "Lightning Conductors," pp. 314 and 340; the connections being much as on p. 285, or as depicted in *Proc. Roy. Soc.* Vol. L. p. 4.

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The Electrician.

(The Oldest Electrical Journal, 1861—1878.)

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HERTZIAN WAVES AT THE ROYAL INSTITUTION.

The triple task which Dr. OLIVER LODGE set himself to perform on Friday evening last at the Royal Institution was no easy one; to discourse upon "The Work of HERTZ," to perform a number of delicate experiments, and to interest a large and mixed audience. Many who were present would have been well content to listen to Dr. LODGE for an hour on the main subject of his discourse, with only a diagram or two to illustrate his words. The notes which he so soon laid aside were, however, only to be held over, for we are enabled to print a first instalment of them in our present issue. The experiments were performed under very unfavourable conditions; although Dr. LODGE confined himself to qualitative results, and, with one exception, made no attempt at producing waves of definite length, the effects were not perhaps as clearly demonstrated as was possible in the short time at his disposal. How much was due to the fact that the receivers were of a very sensitive kind, and liable to be disturbed by Hertzian waves of any character, how much to the undue strength of the oscillators, and how much to the very lively kind of galvanometer, it is difficult to say. Some of the experiments were evidently very difficult to carry out in a popular lecture; but there can be no doubt that many of them would have been much more successful with a tolerably dead-beat galvanometer, and there was no apparent reason why an aperiodic instrument could not have been used in these instances. Those of the audience who had some acquaintance with the subject were aware that the wave-length used in HERTZ's own experiments was considerable, and that not only very large prisms and reflectors were needed, but large halls and open spaces were also necessary. It is, however, clear that the experiments have now become more manageable, and some of them, at all events, may be repeated with the most homely apparatus. This important improvement introduced into the experiments consists in using oscillators giving waves of much shorter wave-length than those used by HERTZ. Dr. LODGE was the first to use spheres

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as electric oscillators, and to show that the waves they gave rise to were shorter than could be easily obtained by the ordinary forms of oscillator. The advantage of using them to reproduce Hertz experiments on reflection, refraction, lens action, polarisation, &c., arises from the fact that if the wave-length of the oscillations is large, the mirrors, lenses, and prisms used have to be enormous, whereas Dr. Lodge has succeeded in reducing his apparatus to reasonable dimensions for a lecture-room. The oscillating sphere and the sparking apparatus were completely enclosed in a wooden box lined with tinfoil, the waves set up being only allowed to escape in a particular direction through a circular aperture in front. In this way a new form of electric lantern was constructed and exhibited for the first time. The waves projected from it were invisible, and could traverse solid walls. They cannot, therefore, be called light waves, but they can be focussed by an ordinary glass lens, reflected, polarised, and subjected to all the treatment of which light rays are capable. It is highly probable, as Dr. Lodge suggested, that Hertzian phenomena may have often manifested themselves in physical laboratories to the annoyance of workers, and it is well known that several experimenters (Edison amongst others) have actually observed them, but were unable either to account for them or to follow them up and intelligently examine them. Two carbons placed close together, but not actually touching, were connected with the mains of an electric-light circuit. Directly sparking was caused at a large Hertz oscillator hung up on the wall of the lecture-room, the arc was struck owing to the surgings set up in the carbons, causing a minute spark to pass between them, and thus starting the arc. This experiment has a practical interest, owing to the fact that electric light leads for glow lamps are generally twisted together, so that the copper wires are quite close. If the surgings caused by any electric disturbances in the neighbourhood are sufficient to give rise to a minute spark between the adjacent wires, an arc will form and the fuse will go, even if nothing worse happen. It is possible, then, some cases of assumed short circuit have been really caused in this manner. It is not, however, probable that such cases have often occurred, but it is worth while pointing out that if the positive and negative leads of a building were so laid as to be separated for some distance before being brought near together at the lamps, such cases might be frequent. Adjacent parts of two wires laid parallel and close together tend to be at the same potential, whatever the character of the electric waves impinging on them. It will be remembered that several rules for wiring order that wires shall be laid at a considerable distance apart. The Phœnix rules propose a distance of 6in. to 12in. between primary conductors of high-pressure alternate-current supply; the 7th rule of the Institution of Electrical Engineers says: "Conductors should be kept as far apart as circumstances will permit, the spacing between them being governed by their potential difference." It is the universal neglect of this rule which probably protects ordinary house wiring from danger due to such a cause.

The comparative lack of enthusiasm which, however, characterised the Royal Institution gathering last Friday, the vast scientific potentialities and extreme beauty of Dr. Lodge's experiments notwithstanding, shows once more that a mixed gathering requires its doses of science to be dashed with theatrical effect. Most of us still retain a vivid and pleasing recollection of the Nikola Tesla lecture. Who could fail to be carried away by the ingenuous enthusiasm of the lecturer, or remain unimpressed in face of the weird waving of glowing tubes in the suitably darkened room, and the mysterious voice issuing from the midst of an electrostatic field? Such scenic setting prepared us for the subsequent unqualified success with a Royal Institution audience. It is not, of course, desirable that these Friday evening discourses should, as a rule, be tinged with quite so much of the dark *séance* style, but it is, we think, much to be desired that the lecturers should not altogether forget "the deep infinitude of nescience" around them. For instance, had it been impressively and reiteratedly brought home to the spectators last Friday evening that what they were witnessing in the experiment necessarily involving so much shouting but resulting in a minimum of sparking, was the transmission of electromagnetic waves right through three brick walls and across the staircase and the room adjoining the theatre, it is possible that even the most uninitiated would have left the Royal Institution that night with a tolerably concrete idea of the importance of the experiment. To Maxwellians, no doubt, the opacity of stone walls to such ether disturbances would be a far more astonishing phenomenon than their transparency. But the majority of mankind, and even indeed of those who gather together at the Royal Institution on a Friday evening, are not Maxwellians, and they, not unnaturally, would find much food for reflection in the transparency of a wall to Hertzian waves; the every-day opacity of a brick wall being to them a matter of so-called "common knowledge." After all, these lectures are largely intended as a pleasant means to a highly respectable end—to wit, the permeation of the intellectual public with a lively interest in the latest births of science. To that end a clear idea of the import of the experiments greatly conduces.

THREE MUNICIPAL SUPPLY STATIONS.

There are points about the municipal electric supply stations at Portsmouth, Burton, and Derby which render it probable that some interest and instruction may follow from a comparative study of them. In many respects all three of these stations are departures from the usual, almost stereotyped pattern of design into which modern English central stations seem to have fallen. It is not frequently that the rambler among supply stations discover points of very striking novelty. He generally finds himself surrounded, in the boiler house, with water tube boilers; in the engine room, with the so-called steam dynamos or alternators, with a well-known type of steam engine driving one or the other of well-established types of electric generators. Nor, if he examines a little more closely, does he discover any very much less similarity about the details. We are not wishing to convey the idea that crystallisation of design is a deplorable feature of modern electric supply stations. Far from it; for it is in the natural course of events that ripening experience should lead the electrical engineer to eliminate untrustworthy patterns, and to fall into the groove of one or the other of the lines of design which are considered to be the most successful. Nevertheless, novelty of design, however risky on the part of the engineer, is refreshing to the visitor and student.

We shall make no apology for not entering into a full categorical account of the plant to be found at each of the three stations we are now studying, nor for taking the various items together, instead of describing each system from the office door-handle to the terminals of the remotest consumer. Inventories of cocks, cables, and coal bunkers have their place and value. Mere photographs of engine rooms probably have a fascinating effect on a vestryman who thinks that they tell him everything; unfortunately, they tell the engineer little or nothing. We must refer our readers to other sources than our columns if they seek such information. The real interest attaching to these three stations lies in one or two details of design, rather than in the general outline. Certain interest also attaches to two of them on account of the fact

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that they have been formally "inaugurated" only during the past week. The dinner given by the contractors, Messrs. Fowler and Co., to the Corporation of Burton took place last Friday, and the official opening of the Portsmouth station by the Mayor of that town occurred last Wednesday. The Derby station was opened on October 10th of last year, but in many respects it may be regarded as practically a new station.

At Portsmouth, Mr. Ferranti has been led to introduce such numerous and radical departures from any practice at other stations, that electrical engineers will watch with great interest the result of his fearless and original designs. Before considering these let us devote a little space to the mechanical plant. The general arrangement of the plant is shown in the accompanying plan of the station, Fig. 1, for which we are indebted to the consulting engineers, Messrs. Kincaid, Waller and Manville. Lancashire boilers, by Messrs. Yates and Thom, supplied with cheap bituminous slack by Vicars' mechanical stokers, are used, and the publication of their performance after some months of

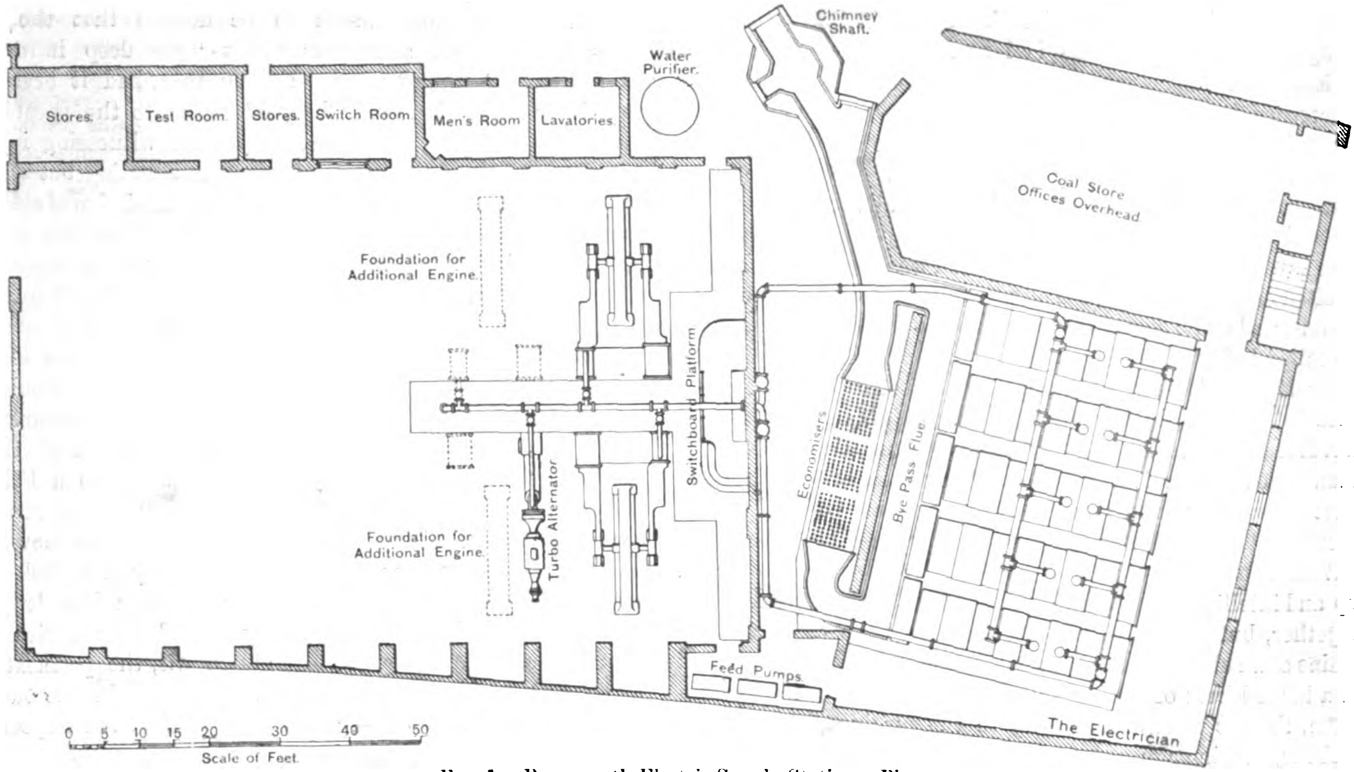

FIG. 1.—Portsmouth Electric Supply Station. Plan.

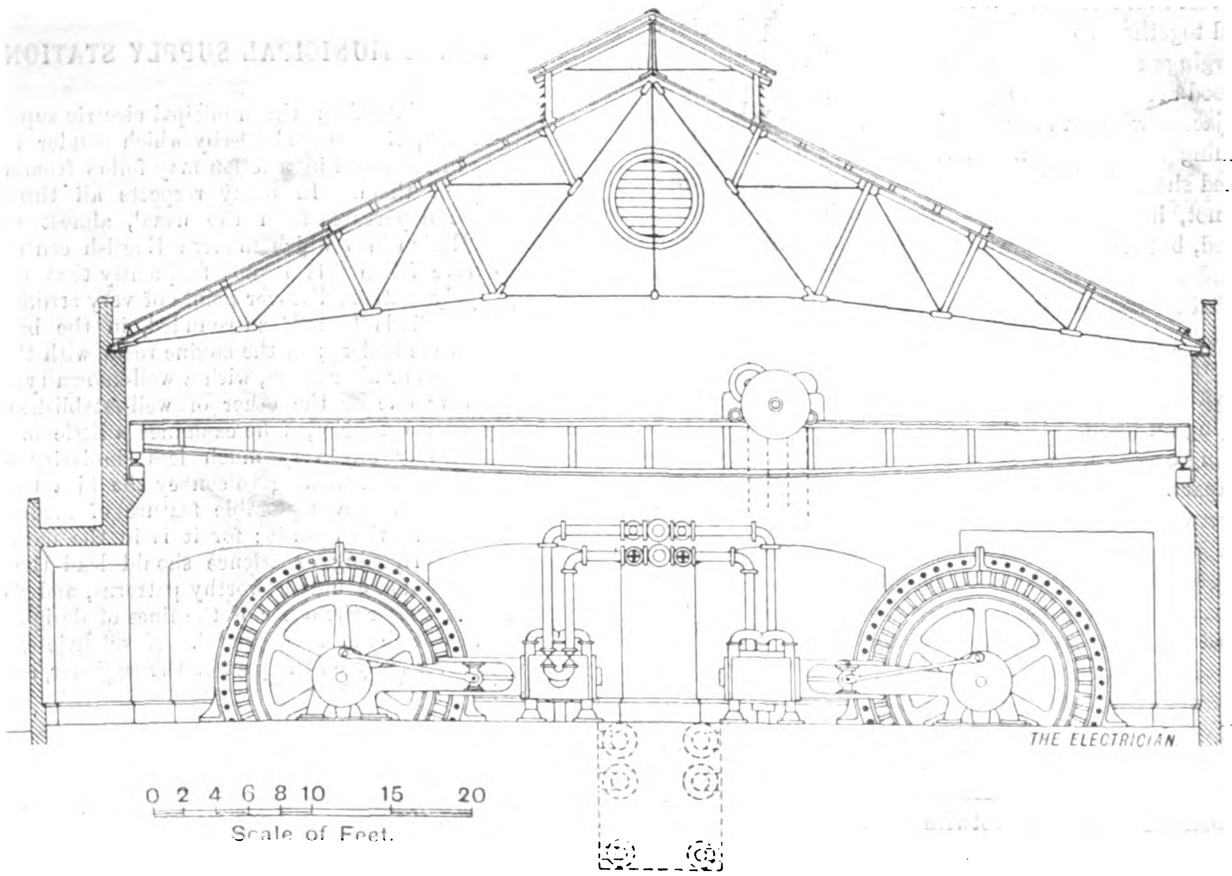

FIG. 2.—Transverse Section of Engine Room, Portsmouth.

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work will be awaited with interest. In the system of steam mains there is undoubted safety, but it is not so certain that there is economy. Each boiler and each engine has a duplicate connection with the steam range; but the length of steam pipe is much longer, in proportion to the capacity of the station, than at Manchester, where a much more efficient system of Tee duplicate steam mains is used. We are in accord with some leading engineers, who have designed important stations, in doubting whether, in this mania for duplication of plant, especially of steam ranges, the insurance of safety is worth the loss of economy. One such engineer recently expressed to us the opinion that it would be far more advisable to put the amount of money that would be spent on duplicate mains into a single main of extraordinary reliability. The engines are horizontal, side-by-side, compound condensing steam engines, by Messrs. Yates and Thom, with cranks at 90deg., and Corliss valves and gear. The condensers and pumps are underneath the engines. The condenser pumps are operated by rods driven from the crosshead of the low pressure piston-rod. Owing to the impurity of the harbour water, town water is used for feeding the boilers, but harbour water is employed for the condensers. Nevertheless, strange to say, jet condensers are used, and the whole of the heat from the exhaust steam is ejected into the harbour. Accordingly, the feed water, before it enters the economiser, has to be warmed with live steam from the boilers.

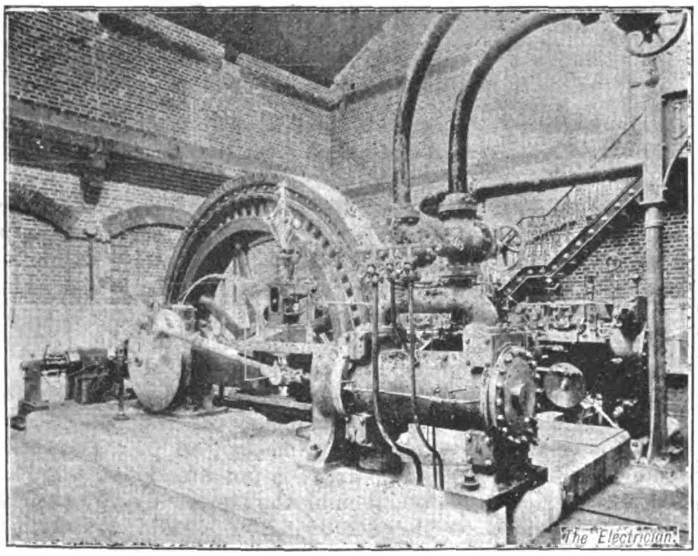

Fig. 3.—212-kilowatt Ferranti Flywheel Alternator.

Following the lines of his Continental practice, Mr. Ferranti has introduced into Portsmouth direct-driven alternators of low speed and low frequency. The speed of the two machines now in Portsmouth station is 96 revolutions per minute, and the frequency is 50 periods per second. This design gives a relatively larger unit of plant than is usual, owing to the necessity for a large diameter of the coil circles. Fig. 2 shows these two alternators in elevation, and Fig. 3 gives a perspective view of a corner of the engine room occupied by one of these units of plant. The armature of this alternator is fixed, and the field rotates. The axes of both armature and field coils are radial; and the magnetic field is reversed in the armature, not merely varied between zero and a maximum. The field coils are of bare copper strip, with the metal exposed to the air of the engine room, the successive layers of strip being insulated by means of thin vulcanised cloth. The copper strip for these coils is drawn and wound exactly in the shape required to fit the coils. The armature coils are wound through thin iron stampings, which form the core. These stampings are segmented in shape, as shown in Fig. 4, and they fit into the coil circle so as to expose only a continuous metal face towards the revolving field poles. The clearance between the armature and field poles is $\frac{3}{16}$in., but as the surfaces are both practically of solid metal this small clearance involves no risk of injury. In Fig. 4, the circular hole is for the bolt by which the stampings are clamped together and to the cast-iron frame of the armature; and the windings are passed through the oblong holes in the lower part. A word or two about the alternators at Burton will here be of interest, and will enable the reader to compare the two types. In the "Leeds and London" alternators, erected by Messrs. Fowler and Co. at Burton, the revolving field-magnets are arranged as shown in Fig. 5, while the armature coils and core are as illustrated in Figs. 6 and 7. Fig. 6 shows the interior surface of the armature circle, and Fig. 7 the exterior surface; it will be noticed that the armature coils are not "hole-wound," as at Portsmouth, but are exposed on the inner surface of the armature circle.

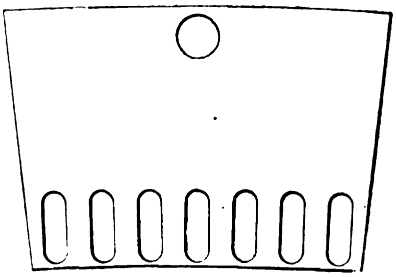

Fig. 4.

At present there are, at Portsmouth, two 212-kilowatt alternators of the new Ferranti type, which, together with a 150-kilowatt Parsons' steam-turbine alternator, make up the complement of generators at this station. What the effect of such relatively large units of plant upon the economy will be, remains to be seen; but considerable increase of the load must take place before a single unit can be run all day with nearly full output. The alternators, whenever more than one is required, will be run in parallel, all the generators feeding the same pair of bus bars. The switchboard arrangements are

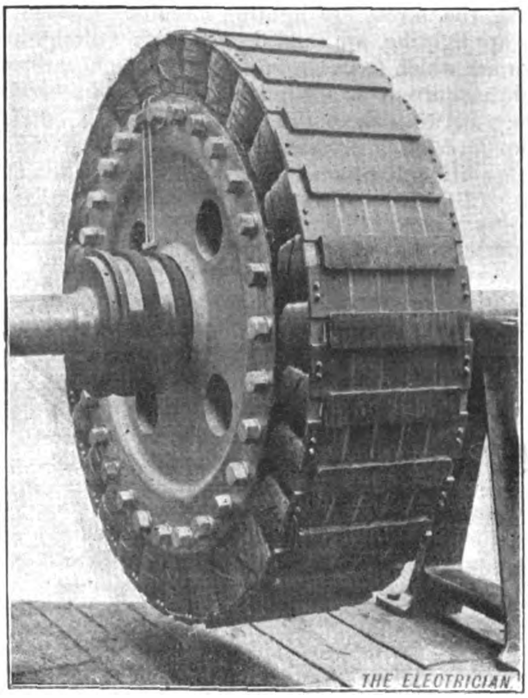

Fig. 5.—Alternator Field Magnets, Burton.

unique. Each machine has only one switch, each circuit has a similar number. The pole of the machine, or the main feeder, not connected to this switch is *permanently earthed* at the station. This ensures that the particular detail thus earthed shall be permanently at zero potential. All the cables are concentric, the outer conductors being earthed in the manner described. The feeders supply a network of high-pressure mains, on which the primary coils of the transformers are placed. The secondary coils feed the low-pressure network. In putting any one machine on to the circuit, the switch belonging to it is first raised into an intermediate

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or "half-cock" position. In this position it is synchronised, after which it is snapped over to "full-cock," *i.e.*, on to the bus bars. The pressure of the machine is regulated by means of rheostats in the exciting circuit, and the rheostat handle is formed into the shape of a circular ring placed round the exciter ammeter, and so arranged that while reading the ammeter the hands may be used for adjusting the rheostat to which the particular ammeter belongs. This, as well as every other detail in the switchboard design, is introduced for the purpose of simplifying manipulation and rendering mistakes

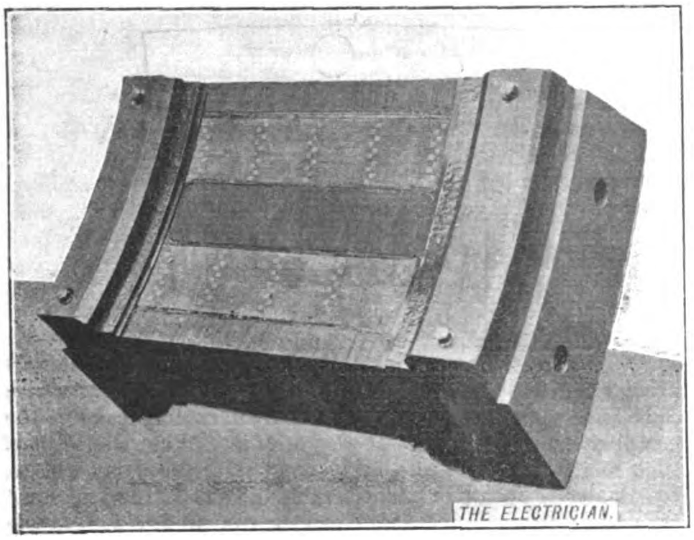

Fig. 6.—Portion of Alternator Armature, Burton.

as nearly impossible as can be. The main switchboard is 6ft. wide and about 3ft. 6in. deep, and controls the entire system, including the street arc lighting circuits. Concentric mains for the arc lighting are carried from this switchboard to the transformer which feeds the special arc switchboard, where the arc lighting current is subdivided among the several arc lamp circuits. Between these two switchboards the current undergoes two interesting processes of change: (1) It is converted from a condition of constant pressure to a condition of constant current; (2) it is rectified from an alternating current to an

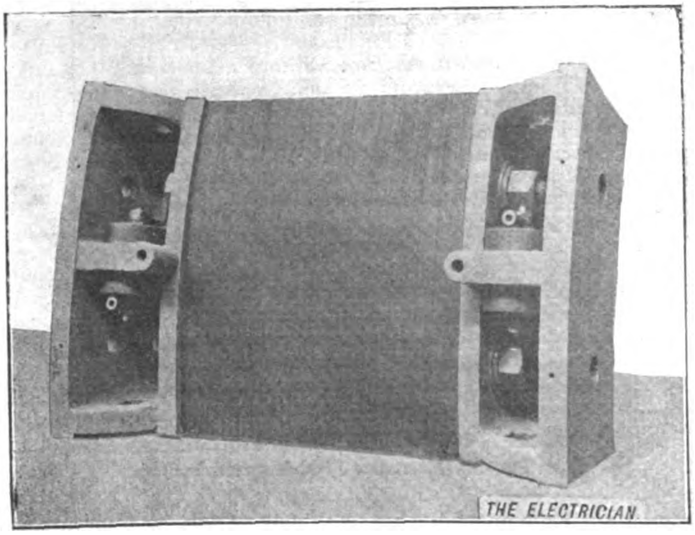

Fig. 7.—Portion of Alternator Armature, Burton.

unidirectional intermittent current of nearly harmonic variation. The first-named change is effected by means of a transformer, which is so designed that the secondary induced electromotive force shall vary directly with the load, *i.e.*, with the number of arc lamps in series in the circuit. The action of this transformer may be explained by reference to Fig. 8. The middle coil, B, is fixed to the frame of the transformer; the upper and lower coils, A and C, are movable and their weight is opposed to a counterpoise on a lever. When no current passes through the middle coil, or when the circuit of the two outer coils, which form the secondary coil, is open, the weight of the counterpoise causes them to come into contact with the middle coil. But, if the secondary circuit is closed by a number of arc lamps in series, and if an alternating current is now sent through the middle coil, the secondary induced current will be repelled by the primary current, and the movable coils will move away from the middle coil until the electromagnetic force just balances the difference between their weight and that of the counterpoise. In this position of equilibrium, which, whatever the load on the circuit, is one of constant electromagnetic force, there must be just sufficient magnetic induction through the two outer coils to induce in them an electromotive force which will develope the requisite current in the arc circuit. Since the force exerted is constant in all positions when the machine has once been adjusted, the induced current will be constant at all loads. The machine is a leaky transformer, designed to vary its leakage (has not

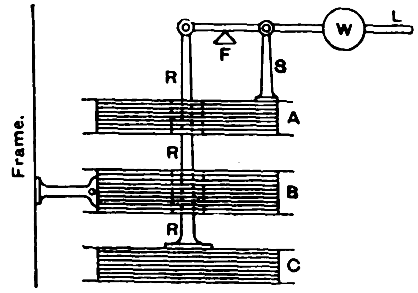

Fig. 8.—A and C = Secondary Coils. B = Primary Coil. W = Counterpoise. L = Lever. F = Fulcrum. S = Strut for A to L. R = Tie Rod supporting C.

someone called it "leakance"?) inversely with the load. The secondary current thus induced is now passed through a Ferranti rectifier, which comprises a synchronous alternate-current motor and a pair of commutators, after which it is taken to the arc switchboard. A front view of one of these rectifiers is shown in Fig. 9. The form of the current given by the rectifier is illustrated in Fig. 10; and it is found that the intermittence and absence of steadiness of the current promotes steadiness of the arc light, by keeping the lamp regu'ating mechanism in a perpetual state of agitation. As the current is uni-directional, a crater is formed on the positive carbon of the lamp. By means of a direction-indicator on the arc switchboard, and a reversing

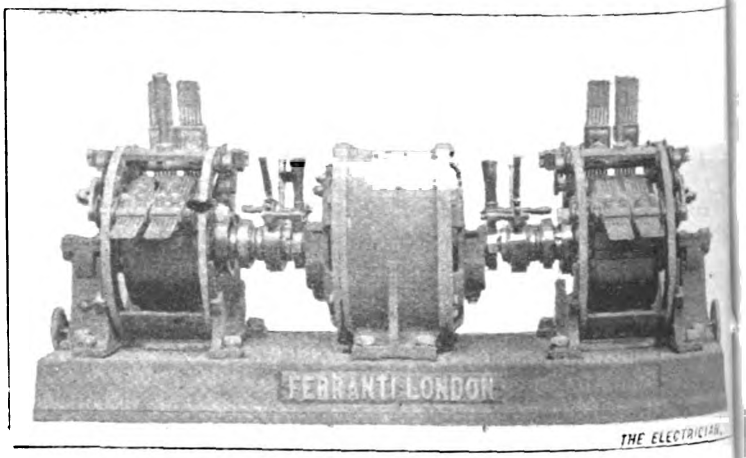

Fig. 9.—50-Light Ferranti Alternate-Current Rectifier.

switch, it can be arranged that the crater is formed on the top carbon, thereby obtaining the advantageous distribution of light which has hitherto been the exclusive possession of the continuous current arc. We do not remember to have seen more steady nor better distributed arc light than we saw at Portsmouth a few days ago during a trial of the various circuits. It is also worth mentioning that the low frequency of the alternations—adopted in order to render motor work more simple—has no injurious effect upon the light. The method

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of wiring the arc lamps to the concentric arc-light cables is shown in Fig. 11, and possesses some novel features. It will be seen that the lamp leads are all connected to the outer conductor of the cable, which conductor alone is severed. The inner conductor and the insulation separating it from the outer are not disturbed. This arrangement is designed to give high insulation resistance. As many as 50 arc lamps may be wired to the same cable, the highest number at present being 37. Two cables are usually run in series on a single rectifier.

The new Ferranti transformers merit a few words of description. These are placed in street transformer pits, as at Scarborough, Derby, and Burton; but they differ from any of the latter in that they are arranged so that they may be adjusted either for full or half load. The adjustment is made by means of a key, carried round the circuit by a man; and by means of this key two coils on the primary portion of the winding may be put either in series or parallel, and simultaneously two coils

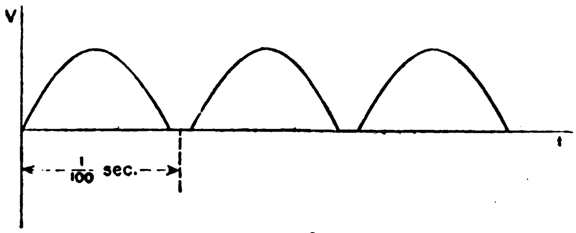

FIG. 10.

on the secondary portion are similarly coupled. When the load is high, both sets of coils are placed in parallel; when the load is low, both sets are put in series. At Burton, also, the practice of turning off and on the transformers by means of a key has been introduced; but the transformer is either wholly on or wholly off. At low loads there are fewer transformers on the high-pressure network. We understand that it is the intention of the contractors at both places ultimately to introduce some system of automatic or electric control of the transformers, in place of sending a man round with a key. Perhaps, however, the prosaic method of sending the man may be found to give sufficient satisfaction, indeed the main difference between the automatic and the manual method will probably be found to lie in the fact that the one will frequently stick while the other will occasionally strike.

Burton electric supply station derives considerable advantage from the fact that both it and the gas works are under the control of the municipality; besides which, the two works are

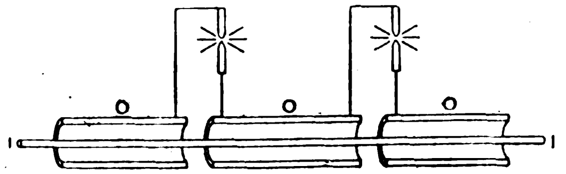

FIG. 11.—I = Inner Conductor. O = Outer Conductor.

next-door neighbours. Owing to this arrangement, the electric plant obtains fuel for nothing, and the gas works gets rid of its refuse—in the shape of this fuel—for a like figure. The fuel consists chiefly of dirty coke breeze. Plenty of it is required in order to produce a small quantity of steam; but, we understand, the Corporation used to pay a considerable sum to get rid of the material, before the commencement of the electric supply. The class of fuel is just such as might advantageously be stoked mechanically; but hand firing has been adopted, and stoking must constitute a considerable item of the works costs. Like Portsmouth, the Burton station lies close to a supply of natural water which might be used for condensing. Condensers have not been introduced, however. The existing generating plant is laid down on the lines of the plant supplied by the same firm to the Brompton and other "House-to-House" stations; but we are informed that in making extensions Messrs. Fowler and Co. intend to abandon rope-driven alternators, and to introduce a type of direct-driven fly-wheel alternator of their own design.

Little space remains to us to make any remarks on the electric supply station at Derby. This station resembles the other two in many respects; it also differs in some important details. Alternating current of a frequency of 40 periods per second is employed for the general supply, and continuous current for the street arc lighting. We need not enter into any consideration of the purpose which the consulting engineers could have had in view in specifying so low a frequency, but it is worth remarking that in some temporary arc lighting which we saw while in Derby recently, the arcs being run on the alternate current circuit, there was a perceptible, not to say painful, flicker of the light, due to the low frequency adopted. This makes it probable that arc lighting in shops will not be popular in Derby.

The mechanical plant at Derby comprises Lancashire boilers, mechanically stoked—as at Portsmouth—and high-speed steam engines, direct coupled to the dynamos and alternators. The engines are of the open type, inverted, vertical, compound condensing, varying from 50 to 100 H.P. They appear to have this disadvantage, as compared with the enclosed type, that they splash large quantities of oil about the engine room. Surface condensers are used, the condensing water being too impure for feeding the boilers. The electrical plant comprises 2,000-volt alternators for the general supply, and continuous-current machines for the arc lighting. Transformer sub-stations are used, the transformers being placed in street boxes, many of which are immediately below the arc lamp standards. There is no provision for cutting transformers out of the circuit on light loads. Each transformer has a capacity of about 1,200 lamps of 8 c.p. The secondary circuit consists of a 105-volt ring main, with numerous cross-connections for equalising the pressure over the entire system.

ELECTRIC TRACK WELDING AT ST. LOUIS.*

BY RICHARD M'CULLOCH.

To build a track which would obviate the ceaseless trouble with joints, and to perpetually insure a smooth and easy riding roadbed, was the object of the management of the Baden and St. Louis Railroad when, last February, it closed a contract with the Johnson Company to weld together the rail ends of its reconstructed road. In the past few years there have been several experiments with continuous track, and all tend to show that the difficulties which would be supposed to arise from contraction and expansion can be neglected. The most scientific and thorough experiment along this line was made by A. J. Moxham, president of the Johnson Company, early in 1892, and reported to the American Street Railway Association, at Cleveland, in that year. In this case the rails were so bolted together as to be practically continuous. Previous to this Philip Noonan laid some track with hot riveted rail joints, on the Lynchburg and Durham Railroad, near Gladys, Va. Some time ago C. W. Wason, of the Cleveland Electric Railway, laid some track with hot riveted rail joints. All of these trials gave satisfactory results. Last year the Johnson Company, having procured a suitable electric welder from the Thomson Electric Welding Company, several miles of track were welded on the West End road, of Boston. There was some trouble from rails breaking near the welds, but the Johnson Company persevered with its experiments and entered the field this year prepared to guarantee its work. Street railways have shown a great willingness to try welded track, and this season will be one of great activity along this line. The road under consideration is the first to begin welding operations this season.

The Baden and St. Louis Railroad is one of the oldest street railways in St. Louis, its charter having been granted in 1870. The road was formerly operated as an independent horse road, having a single track with turn-outs, but as it has recently passed under the same management as the Broadway Cable, it was decided to operate the road by electric power and use it as an extension of the cable road. The road is about three and a-half miles long, and is to be double track the entire distance. There are no crossings with other roads, and although there are no sharp curves, it has a number of long bends of 800 to 2,000ft. radius. In making the sharper bends, the rails are curved in a rail bender and then welded in place. The street in which the track is laid is an old macadam road, varying in width from 60ft. to 80ft., and is used very much by farmers in bringing their produce to the city.

* From the *Street Railway Review*, of Chicago.

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The terminus of the Baden road is about 2½ miles from the power house. Five No. 0000 wires are run from the station, four of them being overhead and one a track feeder. As there is no direct rail return to the power house, an additional track connection is secured in the following manner:—The terminal sheave of the cable is well bonded to the first rail of the new electric road, and at a point where the cable track crosses an electric track, the carrying pulleys of the cable are bonded to the rails of an electric road which runs directly to the power house. In this manner the cable and conduit act as return conductors.

Preparatory to the welding operation, it was found necessary to lay the track, tamp it, line it, and surface it completely before the joints were welded. At the start an attempt was made to weld the joints first and tamp and surface the track afterwards, but the weight of the welding car was such that the rail was bent down in the middle and raised at the ends, making joints welded in this manner high. The road-bed is first ploughed out to the necessary

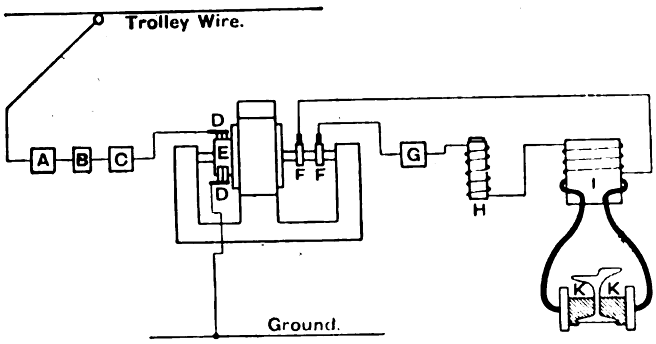

Fig. 1.—Diagram of Welding Circuit.

A. Automatic Circuit Breaker. B. Switch. C. Ammeter. D. Brushes. E. Commutator. F. Collector Rings. G. Break Switch. H. Induction Coil. I. Welding Machine. K. Lugs Welded to Rails.

depth. Then 6in. of macadam are thrown in and rolled. Upon the rolled surface are placed the hewn white oak ties, 3ft. apart. The rails are then spiked to the ties, and the track tamped to grade and filled in to the tops of the ties. The rails are then ready for the welding of the joints.

The welding car is equipped with two W. P. 50 motors, with the rheostat, reversing switch, &c., of an ordinary street car. In addition to this it has the welding circuit shown in Fig. 1. The current from the trolley passes through an automatic circuit-breaker, switch, ammeter and starting rheostat to a transformer which transforms from the 500-volt continuous to an alternating current. This transformer resembles an ordinary four-pole general electric 100-kilowatt dynamo. To obtain the alternating current four leads from the windings are taken off at equal distances around the armature, and led to two collector rings on the

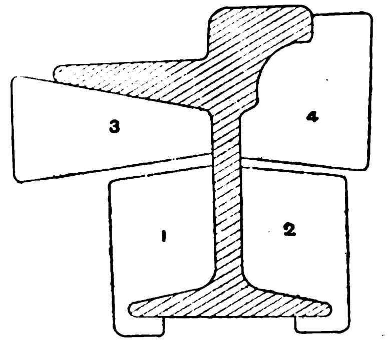

Fig. 2.—Lugs Welded to Rails.

armature shaft. The speed of the transformer is about 1,100 revolutions per minute, so that the periodicity of the alternating current is about 4,400 per minute. The alternating current from the collector rings passes through a regulating induction coil with a movable iron core to the welding machine. This machine is hung on a crane so that it may be set over either rail, and is simply an alternating-current transformer on a huge scale, in which the rail joint completes the secondary circuit. It was made by the Thomson Electric Welding Company, and operates on the same principle as its well-known machines. The insulation of the coils is paraffin oil, and the secondary consists of a single turn of an enormous bundle of sheet copper strips. These strips lead to two copper contact plates, between which the welding is done. The distance between the plates is controlled by a toggle joint operated by a screw, so arranged that by a slight turn of the screw a great pressure may be brought to bear upon the weld. In addition to this circuit, the welding car contains a motor for operating the crane, and another for driving a pump which circulates water in the welding machine. The car is very heavy, weighing about 30 tons when equipped for work. There is also a small car which carries two motors, operating emery wheels attached to flexible shafts for polishing the joints preparatory to welding.

The welded connection between the rails is made by means of lugs welded to the web of the rail. A section at the joint is shown in Fig. 2. It is intended that enough plastic steel shall enter the joint to make a butt weld, and that additional security be afforded by the lugs welded to the web. The bottom lugs, Nos. 1 and 2, are first welded. After they are in position, the operation is completed by welding Nos. 3 and 4. It requires from one to two minutes to make each weld. The potential at the welder is transformed down to four volts. The direct current transformer takes from the line about 250 amperes at 500 volts.

The operation of welding is as follows: The ends of the rails are butted together by driving a wedge in the joint ahead. The welding car is then run over the joint to be welded, and the welding takes place at the rear of the car, so that it is never necessary to run over a hot joint. The webs of the rails are polished with emery wheels for about two inches on each side of the joint. The joint is then clamped by means of a gunmetal casting, which holds the rails in proper position while the weld is being made. The bottom lugs (Nos. 1 and 2 in Fig. 2) are then placed in position and the contact clamps screwed down upon them. When the circuit of the secondary coil is thus completed, the switch on the welder is closed, and the iron core of the induction coil slowly raised. Almost instantly a dark, ruddy colour appears in the lugs, which gradually brightens until the welding heat is reached. A quick turn of the screw which operates the toggle joints brings the lugs firmly up against the rail and forces the plastic steel into the joint between the ends of the rails. The upper lugs (Nos. 3 and 4) are quickly inserted, the contacts raised and screwed down upon them, and they are welded in the same manner as the lower lugs. Pieces of carbon are previously placed upon the top of the rail, so that this portion is carbonised and hardened by the process. After the lugs are welded, the tread and flange are smoothed up by hammering. The welding has been so perfect in many instances, that after the track has been filled in it is impossible to see the joint in the tread.

The greater portion of the time is consumed in preparing the joints, moving the machine, setting up the welder, &c. The machine has been completing 30 to 50 joints per day of ten hours.

At the present writing no great trouble has been experienced from expansion and contraction. The temperature of the air has varied exceedingly. Several of the joints broke soon after welding, but these were probably imperfect welds. These joints were re-welded as soon as the break was discovered. No buckling has thus far been noticeable on the warmest days. The track is filled in as soon as possible after welding, but on several occasions, 300 to 500 feet of welded track have been left open for several days without bad results.

LEGAL INTELLIGENCE.

Grosvenor Hotel Company v. Hamilton.

This was an action before Lords Justices Lindley, Lopes and Davey, in the Court of Appeal, by the Grosvenor Hotel Company, for a quarter's rent in respect of certain premises in Buckingham Palace-road, London, of which the defendant was tenant under a lease. The defendant's case was that the plaintiff Company had placed certain pumping and electric light engines on land adjacent to the defendant's premises, and that the vibration caused by the working of the engines had so damaged his premises that they had been condemned by a magistrate as dangerous structures and ordered to be renovated and repaired. By preference the defendant removed his business, and accordingly counter-claimed for damages for the loss which he had sustained by the removal. It was proved at the trial that the premises in question were at the date of the lease (March 25, 1887) in an unstable condition, and were, in fact, 12in. out of the perpendicular. The original action was tried before Mr. Justice Grantham and a jury in April, and resulted in a verdict for the plaintiffs on the claim for £62 (the amount of the rent), and a verdict for the defendant on the counter-claim for £308. 5s., and judgment was entered accordingly. The plaintiffs now applied for a new trial as to the counter-claim, on the ground that the learned judge ought to have directed the jury that the plaintiffs would only be liable if the vibration was such as would have affected houses of ordinary stability, and also on the ground of excessive damages.

Lord Justice LINDLEY said that this was an action by a landlord against a tenant for rent. That was met by the defendant by a counter-claim to the effect that the plaintiff Company had, by working certain engines in connection with their hotel, shaken down his house. The vibration was so great that the tenant was obliged to leave, and his case was that he had thereby been put to unnecessary expense. It was said that the vibration would not amount to a nuisance unless it was sufficient to affect a house of ordinary stability. That might be so, as between strangers, but here the Court had to deal with the case of land,

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lord and tenant, and the proposition of law which had been contended for assumed a different shape. The house when it was let was an old house and more or less delicate, as it was put by one of the witnesses, and it was several inches out of the perpendicular. That house had been shaken down by the landlord. How could it be said that there was no cause of action? The cause of action was nuisance, arising from the vibration which shook the house down, and one consequence of the relation existing between landlord and tenant was that the landlord was estopped from setting up, as against the tenant, that the house which he had let was a weak house. The true cause of action was nuisance. Then, as to the damages. The true principle to be applied was the principle which governed damages in an action of tort; and in such cases the injured party was entitled to recover damages for what were the natural consequences of the wrong. Their lordships were all of opinion that the damages awarded by the jury were too large, and that they ought to be reduced to £200.

With this modification, the application for a new trial was refused.

Alabaster and Others v. Harness.

This case came before Mr. Justice Hawkins and a Special Jury for trial in April last, and there was now further consideration of it in reference to the questions of law.

The plaintiffs had taken part in the discussion as to the Harness electrical belts, and in connection with this matter there had been litigation between them and Harness. In the plaintiffs' journal there also appeared a review of a pamphlet published by Dr. Tibbits, who had some connection with the defendant. Tibbits thereupon brought an action against the plaintiffs for libel in reference to some passages in that review, but the verdict and judgment in that case were for the present plaintiffs, with costs. The costs which these plaintiffs incurred were as between solicitor and client £596, and as between party and party £435. What plaintiffs now complained of was that the defendant had instigated Tibbits to bring that unfounded action of libel against them, and had thus put them to great expense in respect of costs, they being unable to get payment of their costs from Tibbits. On the other side it was contended that the plaintiffs had made out no case, that it had not even been shown that there was a common interest between Harness and Tibbits involved in the action of libel which the latter had brought against the plaintiffs. Without this being shown it was submitted that the plaintiffs could not maintain the present action for "maintenance."

Mr. DODD, for the defendant, submitted that there were two substantial questions, whether the defendant had a common interest with Tibbits in the libel suit against the present plaintiffs, and, if not, whether he believed that he had such interest. The facts were that Tibbits was retained by Harness as Managing Director of the Battery Company to make a report as to the electrical belt, and that report Harness published at his own expense or the expense of the Company, and distributed it broadcast. Then the writer of the pamphlet was attacked by the plaintiffs, and it was important to Harness to show that this report was unjustifiable and untrue. Under these circumstances it was submitted that the defendant clearly had a common interest with Tibbits in establishing against the present plaintiffs the action for libel upon the review of Tibbit's pamphlet.

On Wednesday Mr. Justice Hawkins heard further arguments, and, after pointing out that the question involved was one of general importance, and that his decision might be appealed against, reserved judgment.

Elmore's Wire Manufacturing Company (Limited).

As though the Elmore Companies had not been sufficiently unfortunate, the Wire Company has found it necessary to ask the Court of Queen's Bench to assist them in directing that a Bill presented by a Mr. A. T. Ashwell, formerly solicitor to the Company, should be taxed. The Company's application had been refused by the Judge in Chambers on the ground that the bill had been paid; but, notwithstanding this, Mr. Justice Cave, in the present action, said that, "looking at all the circumstances, the proper conclusion appeared to be that the payment of £500 made by the Company was not a settlement of the bill for which the Company now asked the Court to direct taxation, but a payment generally on account. The Company had complained of a number of irregular charges, it being stated by counsel that, as solicitor to the Company, Mr. Ashwell had attended a Board meeting, and had taken instructions to write to 20 shareholders for payment of calls, and the bill sent in, which the Company now wished to have taxed, contained 20 items of 6s. 8d. for taking these instructions, 20 items of 6s. 8d. for receiving the writ, and 20 items of 6s. 8d. for receiving instructions for appearance! No doubt some of these allegations of undue charges had been fairly explained away in the affidavits, but there were some items which it was reasonably to be supposed would be reduced by the taxing master; and further, there were admittedly several items wrongly inserted. Under the circumstances it would be best to send the bill for taxation, the costs in the application to abide the result.

Motors in Factories.—We hear that the Western Electric Company are fitting up their Chicago factory with separate electric motors to drive the various machine shops, thus obviating the necessity of having large belts and long shafting. The generating station in the Company's factory consists of two large Western Electric generators, connected to a high-speed engine.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *May* 25, 1894.

The Annual Meeting of the American Institute of Electrical Engineers.—The annual and general meeting of the American Institute of Electrical Engineers at Philadelphia, last week, was the most successful in its history, both in attendance and sustained interest in its proceedings. About 250 members were in attendance, a large portion remaining during all four of the days that the meeting lasted. The address of the President, Prof. Houston (who was re-elected), was devoted to an historical view of the Institute which, with this meeting, entered into its second decade; to a consideration of the grounds upon which its usefulness depends; and to further extensions of its work. The desirability of co-operation with similar national bodies in Europe was dwelt upon, and the success of the experiment of local meetings as exemplified by that of Chicago was referred to as one of the notable events of the year. Of the papers, those on lightning arresters, toothed *versus* smooth core armatures, and test of closed coil arc light dynamo armatures, brought forth valuable practical discussions. There was an unanimity of opinion that arc light dynamo armatures should not be designed for an induction higher than about 16,000 lines per square centimetre, and that for street railway generators and motors and wherever fluctuations in load are sudden and great, toothed armatures are a necessity to avoid sparking. Prof. Crocker submitted a new type of unipolar dynamo, and spoke strongly in favour of the practical advantages of the unipolar principle. Prof. Anthony showed that the arc light only possessed an advantage of 50 per cent. over incandescent lamps in some cases when a certain minimum of light at any point in the surface illuminated is required. The Paper of Mr. Griscom treated of a number of obscure points connected with storage batteries. He showed that the rates of discharge of the different plates of a cell varied constantly in relation to each other, and referred to the curious buckling of plates when one side was illuminated more strongly than the other. Several problems were left for solution, one of which is the cause of the spontaneous and violent discharge of positives which sometimes occurs. Prof. Jackson's Paper related to experiments which contradicted the common belief that alternate currents deteriorate commercial fuses. The Paper of Dr. Bell was a defence of induction motors, and claimed that the efficiency of such motors at other than normal speeds did not differ from that of series motors under the same conditions. He also referred to the remarkable regulation of these motors, and to the fact that their power factor varied but slightly, even with wide variations of load. Dr. Duncan read a Paper on two-phased motors, containing the result of the application of his simultaneous method of alternate current analysis to both the primary and secondary, or the field and armature. Mr. Steinmetz read a continuation of his Paper on hysteresis, in which it is shown that hysteresis and molecular magnetic friction are not identical, and that at present commercial iron can be procured in this country better from a hysteretic standpoint than any tested by Prof. Ewing. The Paper of Dr. Pupin was on the application of his method of resonance analysis to the form of alternating current waves, and contained the result of researches into the origin of harmonics, which was found to lie in the alternator. One result of his analysis was to prove what has sometimes been disputed—that the rotary field in two- and three-phased motors does not vary in intensity. What promised to be the most valuable and lively discussion of the session—on the last papers named above—with Drs. Duncan and Pupin, and Messrs. Kennelly, Steinmetz, and several other able disputants present as participants, was, unfortunately, nipped in the bud by the final adjournment—a result of placing the most important papers at the tail of the programme.

"Inductance" and "Reactance."—One of the most important actions of the Institute at its annual meeting was the adoption of definitions of "inductance" and "reactance," two terms that originated with Mr. Oliver Heaviside, whose definitions of them are those accepted. The former has been adopted

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as a substitute for the inconvenient expression "co-efficient of induction," the co-efficients of self- and mutual-induction being thus expressed as self- and mutual-inductance. "Reactance" is defined as that quantity in a circuit traversed by a periodic current "whose square added to the square of the ohmic resistance gives the square of the apparent resistance or impedance," though the final definition of the term was deferred owing to the lack of time to enter thoroughly into the subject at Philadelphia. The term "inductance" was recommended for adoption by the Institute Committee of Units and Standards, of which Mr. A. E. Kennelly is chairman, and "reactance" was proposed by Mr. C. P. Steinmetz during the discussion on the former at the annual meeting.

CORRESPONDENCE.

ELECTRIC WAVES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of February 16th last you printed a letter of mine on Electric Waves, and in a short note you made a few remarks in reference to it. You say, "It is possible for steady states of electric or magnetic force to exist independently of each other, but it is not possible for an electric field, varying with time, to exist without giving rise to a magnetic field, and *vice versâ*." Now this was the most important point raised, and I wished to have the proof given. I presume that theory does not show us that electric and magnetic fields can exist independently. That they can has been proved experimentally. Indeed, theory would appear to be rather against the idea. What it does assert is, "that changes of dielectric polarisation in non-conductors produce the same electromagnetic forces as do the currents which are equivalents to them." The only experiment which, as far as I can ascertain, has been considered decisive, was made by Hertz.* His Paper is entitled, "On Electromagnetic Effects Produced by Electrical Disturbances in Insulators." In this Paper he describes a number of experiments made with his well-known electric vibrator and resonator. His object was to ascertain whether any effect was produced upon an oscillating field by the approach of solid or liquid dielectrics. For this purpose he used masses of asphalt, artificial pitch, paper, sandstone, sulphur, paraffin, and petroleum. All produced a decided effect upon the field. Two possible explanations of the results obtained, besides the one adopted, occurred to Hertz, but he dismissed them upon consideration. Now, it must be remembered that when this Paper was written, Hertz had not discovered that electric and magnetic waves are propagated with finite velocity through dielectrics, and that they may be polarised, refracted, and reflected. It did not, therefore, occur to him that the phenomena he was observing might possibly be due to the reflection of the waves by the dielectric masses. At any rate, if his conclusions are sound, it is strange that such an important Paper should not be quoted in support of Maxwell's theory. I do not remember to have seen the experiment mentioned in Thomson's "Recent Researches." He states the theory, but does not give proof. No doubt the theory may prove to be the true one. At any rate, it is a very beautiful conception of Maxwell's, and appeals powerfully to the mathematical mind; but we must not forget, as Kelvin points out, that Descartes's doctrine of *vortices* died hard among the old mathematicians, and that although in the past they have done great things for electric science, they must not be allowed to weave the theoretical net so closely that new ideas cannot penetrate it.—Yours, &c.,

R. M. DEELEY.

Pressure on a Lamp Globe.—Those who have not made the calculations for themselves, says the *Electrical World*, may be surprised to know that the pressure of the air on the outside of the bulb of a 2,000 c.p. incandescent lamp having a surface of 300 square inches, is about $1\frac{3}{4}$ tons. No wonder they pop when they break.

* "Electric Waves," p. 95.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

TENDERS INVITED.—The Caledonian Railway Company invite tenders for the supply of a quantity of various stores for twelve months from August 1st next. A complete list of the Company's requirements will be found set out in our advertisement columns. Specifications and forms of tender may be obtained from Mr. Jas. Lorimer, superintendent of stores; and patterns may be inspected at the Company's stores, St. Rollox. Tenders must be lodged with Mr. J. Blackburn, Secretary, at the Company's offices, 302, Buchanan-street, Glasgow, not later than Monday, June 18th.

———— The President and Governors of Robert Gordon's College, Aberdeen, are prepared to receive tenders for materials, motors, wiring, &c., for Robert Gordon's College and Gray's School of Art, Aberdeen. Further particulars are given in our advertisement columns, and tenders must be sent in, addressed to Mr. Thomas Fotheringham, Clerk of the College, by 12 noon on the 19th instant.

———— The Oswestry Electric Light and Power Company (Limited) invite tenders for engines, boilers, dynamos, cables, &c., for a central station at Oswestry. Tenders have to be in by June 16th.

———— The Guardians of the parish of Newcastle-upon-Tyne invite tenders for telephonic apparatus for communication with the workhouse. Tenders must be in by noon on the 22nd inst.

———— The Waterworks Committee of the Mansfield (Notts.) Corporation invite tenders for the erection of a line of poles and overhead wires for the automatic indicating apparatus and telephones between their Rainworth pumping station and the waterworks manager's office at the gas works, Mansfield. Tenders must be in by the 12th inst.

———— Messrs. Humphreys (Limited) require tenders for a private telephone installation to be fixed between their offices at Knightsbridge and the wharves at Ebury Bridge, W., and also between the offices and their iron building works, Hill-street, Knightsbridge.

———— The Urban Sanitary Authority of Bedford invite tenders for the building and chimney in connection with the proposed electricity works. Specifications, plans, &c., may be inspected at the offices of Mr. F. H. Medhurst, B.Sc., 13, Victoria-street, Westminster, London, S.W., or at the clerk's office, Town Hall, Bedford. Tenders have to be in by June 16th.

TENDERS ACCEPTED.—The tender of Messrs. Siemens Bros. and Co. for the supplying and laying of the cables necessary for the extension of the electric lighting area at Bolton, has been accepted.

———— The Electric Light Committee of the Dewsbury Board of Guardians have accepted the tender of their contractors to supply additional engines at a cost of £50 over the sum previously specified.

———— The Belfast Corporation have accepted the tender of Messrs. M'Laughlin and Harvey for the erection of the central electric lighting station in Chapel-lane, Belfast.

LIQUIDATIONS.—With reference to the Medical Battery Company (Limited), Mr. Justice Vaughan Williams has directed separate meetings of (1) the holders of debentures issued by the Company and the secured creditors of the Company, (2) the unsecured creditors of the Company, and (3) the contributories of the Company, to be held on June 15, 1894, at the Inns of Court Hotel, Lincoln's Inn, London.

———— Claims against the Electrical Engineering Company of Ireland (Limited) (in voluntary liquidation) must be sent in to Mr. J. M. Kean, 46 and 47, Dame-street, Dublin, by July 4th.

DISSOLUTION OF PARTNERSHIP.—The partnership existing between Mr. L. G. Tate and Mr. J. L. Fuller, trading under the name of Fuller and Tate, 20, Bucklersbury, E.C., will terminate on the 24th inst., after which date Mr. Fuller will carry on the business at the same address under the title of Fuller and Co.

PERSONAL.—Mr. Ernest Scott, A.I.E.E., who until recently was on the staff of the Brush Electrical Engineering Company, has been appointed chief of the drawing office department of the Electric Construction Company at Wolverhampton.

REMOVAL.—Messrs. A. Hurst and Co. have removed to Fenchurch-street-chambers, Church-row, Fenchurch-street, E.C.

AGENCY.—Mr. W. T. Barnett, of 53, Victoria-street, S.W., has recently been appointed agent for the Southern District for Messrs. Mather and Coulson's manufactures.

MESSRS. BINKO AND CO.—This firm have purchased the goodwill and stock of the old established business of Messrs. Ridsdale and Co., of the Minories, lamp and lantern manufacturers, brass founders, fittings makers, &c., and have combined their new busi-

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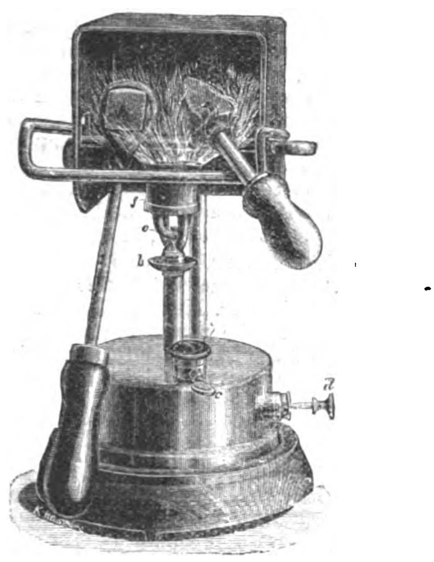
ness with that of the manufacture of electrical supplies carried on at Leadenhall-street. The name of Ridsdale and Co. is to be preserved and used in connection with supplies of nautical lamps, brass castings and specialities as hitherto. The two addresses of 34, Leadenhall-street and 54, Minories, E.C., will be retained.

Paraffin-Gas Apparatus.—A number of useful heating appliances, capable of burning ordinary paraffin oil without a wick, are supplied by Messrs. Moeller and Condrup, who are the London agents of the Swedish manufacturers. The accompanying illustration shows a heater for soldering irons; and another pattern



of heater, called the "Aetna" paraffin blow-lamp, ought to be serviceable to jointers, and for small welding and forging work. It is claimed that an intensely hot flame can be obtained by this apparatus, by means of which thick copper wire will melt in less than a minute; and that this result is attained at trifling cost, and without the use of pipes or chimneys.

The Universal Bell.—The International Electric Company, of Redcross-street, E.C., are issuing an illustrated circular giving particulars of the patent universal bell, which it is claimed can be used either as a slow-striking bell, as a single-stroke bell, or as an ordinary trembling bell. The bells are made with either 4, 5, or 6in. gongs.

Lamps for Tramcars.—Messrs. Ramsay and Co., of Glasgow, are engaged in making about 500 lamps of an improved pattern for use in the City Corporation's tramcars. The lamps are to be adapted for use either with the electric light, gas or oil, and are to be fitted with slides in various colours for use as head lights.

Pipe Tongs.—Mr. T. A. W. Clarke sends us a circular illustrating the patent pipe tongs manufactured at his Leicester works. These tongs are claimed to be an improvement upon the old parrot-nose tongs, while retaining all the merits of the old favourite. The tongs are so constructed that one pair will fit several sizes of pipes or sockets. There are six stock sizes of the tongs, and larger sizes are made to order.

Battersea (London).—A "looking-forward" motion that electric motors be substituted for horses in the vehicles belonging to the Battersea Vestry was discussed at the last meeting, and it was decided to refer the matter to the Electric Lighting Committee.

Baslow (Derbyshire).—The Local Board at their last meeting discussed a communication from Mr. E. Scott, Anderson, of Sheffield, informing the Board that the water-power available at Baslow was sufficient to provide motive-power for a public installation of electric light. The subject was adjourned for discussion by the incoming Local Board.

Batley Carr (Yorks.).—The extensive mill and works occupied by Messrs. Alfred Hill and Sons are being lighted throughout by electricity by Mr. A. Richmond Turner, of Dewsbury.

Belfast.—The Electric Lighting Committee's report states that it has been decided to charge 7d. per unit for electric current, with a meter rent varying from 2s. 6d. to 15s. per quarter, according to capacity, the rebates to be agreed to in conference with Prof. Kennedy. Enquiries have been received from intending consumers outside the area at present arranged for, and the Committee have decided to comply with the requirements, on condition that a "written undertaking is entered into for a minimum supply, for two years, of such an amount that the payment to be made shall not be less than 20 per cent. on the outlay of the Corporation in providing the necessary electric lines beyond 60ft. from the proposed distributing main."

Birkenhead.—On Wednesday the Finance Committee of the Corporation recommended that application be made to the Local Government Board for sanction to borrow £18,424 for the purpose of constructing a central electric lighting station at Bentinck-street.

Blackburn.—In connection with the lighting of the Free Library, concerning which two or three notes have appeared in our recent issues, we are asked to state that Mr. McLellan's contract is to supply and fix the lamps, pendants, and brackets.

Blackpool.—In answer to numerous complaints of the taking up of the thoroughfares, it has been pointed out that the calculations made under the original scheme have been so considerably upset by the increased demand, that it has been necessary to extend the original scheme, and to make provision for a much increased output to what had been originally estimated.

Bolton.—It has been decided to extend the electric lighting area to Newport-street, and an estimate presented by the Corporation's electrical engineer for carrying into effect a system of supplying electric fittings on the hire-purchase system has been adopted.

Bradford.—Messrs. Ullathorne and Hartley, have secured the contract for lighting the Theatre Royal and Opera House, Bradford, for which about 500 incandescents will be required. Another contract recently secured by this firm is for lighting the Self-Help Co-operative Society with 20 arcs and about 150 incandescents, the plant including a 12-h.p. Tangye gas engine.——The laying of the three-wire mains, is now being actively carried out here, and in connection with the extensions for which applications have been made to the Electric Supply Committee of the Corporation, a circular has been issued explaining the advantages of the electric light, and inquiring as to the amount of support likely to be given if the extensions are carried out.

Bristol.—The contract for lighting Bristol University College by electricity, has been given to Messrs. F. W. Ball and Co. About 200 incandescents will be required.

Chelmsford.—The Essex Standing Joint Committee has decided to light the County Room at the Shire Hall by electricity. Messrs. Crompton and Co. have obtained the order, the inclusive sum being £98. 10s.

Church and Chapel Lighting.—The Elm Grove Chapel, Portsmouth, is now lighted electrically.——The authorities at St. Jude's Church, Portsmouth, are considering the question of adopting the electric light.——The parish church, Leeds, is to be lighted with the electric light, the contract being in the hands of Messrs. Laing, Wharton, and Down, who are carrying out the work under the supervision of Messrs. Shepherd and Watney. The total cost will be about £500.——The church of St. Bride's, Kelvinside (Glasgow), has just been lighted electrically by the Kelvinside Electricity Company. The fittings are of ecclesiastical pattern in wrought iron and copper, and have a very harmonious effect with the surroundings. Several other churches in the Kelvinside district are considering the question of adopting the electric light.——Holy Trinity Church, Hull, is to be lighted by electricity, the authorities being at present in negotiation with several local electric light contractors in regard to the work.——Rudstone Church, a few miles from Bridlington Quay, is now lighted by electricity, the same motive power being used to blow the organ.

City of London.—It has been decided by the Library Committee of the Corporation to light a portion of the Records Chamber by electricity.

The Derby.—The Direct United Cable Company were successful in cabling and delivering to the news agencies in New York the result of the Derby, run on Wednesday last, at 10h. 22min. 15sec., or almost simultaneously with the time the news was received in London.

Dundee.—The Dundee Gas Commissioners will shortly be face to face with the necessity of considerably extending their electric lighting system. The capabilities of the present station are exhausted, and, while during the summer season there is sufficient capacity in the existing station, future requirements will necessitate considerable extensions, to which immediate attention must be given.

Electric Current for Organ Blowing.—A correspondent to the *Musical News* calls attention to the facilities offered by the London electric supply companies to supply current for organ blowing, and points out numerous advantages to be gained both by private and public organ owners.

Electric Light Arrears.—At the Mansion House, London, last week, the first summons for the non-payment of an account for the supply of electric current and rental of meter was heard. It was a summons against the United States Land and Investment Company for the sum of £5. 9s. 7d. Mr. G. Kebble, who appeared for the City of London Electric Lighting Company, asked that the Judge's Order be made to cover solicitor's costs, as there would be considerable difficulties in the event of non-payment by persons to whom the electric current had been supplied. The Magistrate agreed with this view, and made an order for the amount claimed and £1. 1s. costs.

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Electric Organs.—The inauguration of an electric organ at Balruddery, near Dundee, is announced for to-morrow (Saturday), and it is said that Mr. J. More Smieton, the composer, has stated that the combination of the Thynne orchestral voicing with the Hope-Jones electric system has made this organ one of the finest instruments in the country.

Glasgow.—In reference to the proposed extension of the electric lighting system to the western district of the City, the subject has been postponed until the Electric Lighting Committee have ascertained from the annual financial statement the average cost to the Corporation of supplying each of the arc lamps at present in use for street lighting.

Greenock.—On Tuesday an ineffectual attempt was made to substitute electricity for the gas lighting of the Town Hall, and it was ultimately decided to introduce special gas fittings and reflectors. It was pointed out that the Gas Trust was already £5,000 in debt, and that, therefore, it would be unwise to introduce the electric light. Fears were entertained by several of the members that if the electric light were introduced, the revenues of the Gas Trust would be seriously weakened. Gas lighting was successful by ten votes to eight.

Hotel Lighting.—Messrs. Rashleigh Phipps and Co. have secured the contract for lighting the Norfolk Hotel, Surrey-street, London, W.C., with 425 16-c.p. lamps. The contract is to be completed in four weeks.

Huntly.—Mr. Stephen, of Bogieside, has under consideration a scheme for supplying the electric light to this district, for which, it is stated, he has plenty of spare power.

Ipswich.—The Electric Lighting Committee of the Town Council have selected Prof. A. B. W. Kennedy as consulting engineer for their electric lighting scheme, for which a Provisional Order is to be applied for in the coming session.

Londonderry.—At the last meeting of the Electric Lighting Committee of the Corporation the members were asked to take over the plant at the generating station. Mr. Blake, the Corporation's electrical engineer, submitted a final report, in which he stated that the tests he had made of the work done under the specifications by Messrs. Siemens Bros. and Co., Messrs. Alex. Brown and Sons, and Mr. M. M'Clelland had proved to his entire satisfaction; and he therefore asked them to take over the plant and buildings. A lengthy discussion ensued, and ultimately the report was adopted and the machinery taken over.

Mill Lighting.—Messrs. Berry and Pope have received instructions for installing the electric light at the mills of Messrs. R. Thompson and Sons, Padiham. About 270 incandescents are required. The firm have several other large installations in hand in the Burnley district.——The extensive corn mills occupied by Messrs. Fletcher, at Milford and Pentrich, near Belper, are now being installed with the electric light. These mills have been running night and day for a considerable time, and the electric light has become a necessity.

Miners' Lamps.—At the Woodyett Pit, Denny, where a fatal explosion took place last year, the miners now use electric lamps, which are stated to give every satisfaction.

Montrose.—The Kinnaber Waterworks have been successfully lighted throughout by electricity. The current was turned on on Thursday last week by the Provost, in the presence of the leading citizens. The Provost, in the course of his remarks, stated that though the present installation was small, they need not despair of seeing the whole of the town, including the private dwellings, lighted by electricity at no distant date. The motive power is obtained from a 12in. Pelton wheel attached to the supply main from the pumps to the reservoir, this providing a 125ft. head, so that only a small quantity of water is required.

Newcastle-on-Tyne.—It appears that the cost of lighting the city by gas is between £13,000 and £14,000 per annum, and, as stated in our last issue, a Committee has reported to the Corporation that it is advisable to take into consideration the question of lighting the city by electricity under the Corporation's control. The Corporation already possess a considerable amount of waste steam power at the refuse destructor works, Byker, where it is estimated power sufficient light to nearly the whole of the east end of the town is already at the Corporation's disposal.

Provisional Orders.—Notwithstanding that the application of the Wakefield Corporation for a Provisional Order under the Electrical Lighting Acts was presented later than the time allowed by the Standing Orders, a Committee of the House of Lords, after hearing the explanation of the agents for the promotors, decided to dispense with the Standing Orders.——The Monmouth Electric Lighting Provisional Order on Tuesday passed the House of Commons Committee on Unopposed Bills, and was reported for hird reading.——The Bill confirming the Provisional Order applied for authorising the Leyton Local Board to light their district by electricity, has passed the Standing Orders Committee of the House of Commons.——The Guildford Provisional Order has passed a Committee of the House of Lords, and has been read a second time.

Restaurant Lighting.—Many of the principal restaurants and cafés in the City of London have now adopted the electric light, to the very considerable benefit of employés and customers. The advantage of the light is particularly noticeable in the many underground and semi-underground coffee-rooms springing up in all parts of the city. The old gas-lighting arrangements rendered these coffee-rooms altogether unbearable, and must have militated considerably against their success from a commercial point of view. Many of these rooms, now that the electric light is introduced, are well patronised, and what must have proved a very up-hill work seems likely to result in considerable profit to the proprietors. There is scarcely a thoroughfare of any importance in the E.C. district without one or more of these basement cafés, which are likely to become, now that the electric light is an assured success, more than ever numerous and profitable. The money saved in redecorations alone must represent, in each case, a large sum.

Shirley and Freemantle.—In this district the provisions of the recently-passed Parish Councils Act were discussed at a recent public meeting, at which Mr. Killby, Chairman of the Local Board of Health, explained to the ratepayers present the nature of the powers and duties of the Parish and District Councils under the Act. He said that amongst the chief matters for discussion by the new Parish and District Councils would be the question of public lighting by electricity or other means. At Okehampton the introduction of electric lighting had, he said, led practically to the closing of the gas works. He did not think that the district he represented would be so cruel as this, but, doubtless, a considerable change in the method of lighting would shortly be brought about.

Shoreditch (London).—It would appear that the question of electric lighting in this district has not yet succeeded in overcoming the opposition of a considerable section of the members of the Vestry. A long discussion took place at the last meeting, but nothing definite was decided upon. An alternative plan to the Pitfield-street scheme has been brought forward, several of the members preferring a site adjoining the Vestry's wharf at Kingsland-road, N.

Stafford.—At the meeting of the Town Council on Tuesday the report of the Electric Lighting Committee was presented, and Mr. W. H. Peach called attention to some remarks made at the meeting of the Birmingham City Council in connection with the gas works. Mr. Peach noticed that there had been in Birmingham a large decrease in the manufacture of gas, which the Chairman of the Gas Committee there said was mainly due to the use of electricity. The Corporation of Birmingham had not the supply of electricity in their own hands, and were beginning to feel the competition of the electric light by the depreciation of their gas property. He mentioned this in order to show the wisdom of the Stafford Council in retaining in their own hands the monopoly of the lighting of the borough.

St. Annes-on-Sea.—A proposal for applying for a Provisional Order to light by electricity this district is under the consideration of the Local Board.

The Welsh National Eisteddfod.—Mr. W. H. Preece, who will deliver the inaugural address to the Cymmrodorion section, has selected for his subject "The Development of Welsh Industrial Resources."

Trade Conferences.—The series of trade conferences recently announced in connection with the Technical Education Board of the London County Council will commence on June 7th, when the building and furniture particulars will be read; on June 20th the engineering, shipbuilding, and metal trades.

Ventilation of Underground Railways.—In the House of Commons, on Monday, Mr. Weir asked the newly appointed President of the Board of Trade whether the subject of the ventilation of the Metropolitan Railway between certain specified stations had come under the consideration of the Board of Trade, and, if so, what steps had been taken in the matter. The reply of Mr. Bryce not being considered satisfactory, Mr. Weir wished to know whether electric traction might not be introduced, with the result that the stifling atmosphere now complained of would be abolished. Mr. Bryce: "Everybody knows that if electric traction were introduced the nuisance would be avoided."

Worthing.—In connection with the Electric Lighting Provisional Order which has passed a Committee of the House of Commons, a discussion took place at the last meeting of the Town Council, and it was decided not to circularise the district for support to the scheme; but the Chairman of the Electric Lighting Committee has been instructed to obtain expert opinion as to the cost of works and machinery.

Cricket.—The employés of the Westminster Electric Supply Corporation (Limited), have formed a cricket club, and will for the season play on the Raynes Park ground, Surrey.

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WREXHAM.—The Wrexham Electric Lighting Company have authorised their solicitors to accept £350 from the Town Council for their rights in the electric lighting undertaking. This offer has been accepted by the Council on the understanding that if any insuperable difficulty should be found to prevent the carrying through of the arrangement, owing to the action of the Board of Trade, or otherwise, the Council reserve the privilege of withdrawing or cancelling the offer.

BOOKS RECEIVED.

"Leitfaden zur Konstruktion von Dynamomaschinen und zur Berechnung von Elektrischen Leitungen." By Dr. Max Corsepius. 2nd Edition. (Berlin: Julius Springer; and Munich: R. Oldenbourg.)

"Reports on Yof-Dakar Underground Cables." 1893. By Charles Bright, Assoc.M.Inst.C.E., M.I.E.E.

"The Junior Engineering Society." Record of Transactions. Edited by W. T. Dunn. Vol. III. 1892-93.

"Elementi di Fisica." By Prof. Antonio Roili. Vol. II. Price 5s. (6 lire). Firenze Successori Le Monnier.)

COMPANIES' MEETINGS AND REPORTS.

Gulcher (New) Electric Light and Power Company (Limited).

The sixth ordinary general meeting of this Company was held at Winchester House, E.C., on Monday last, Mr. D. de Castro presiding.

The SECRETARY (Mr. T. C. Morgan) read the notice convening the meeting, and the minutes of the two previous meetings, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN said that the present meeting was preliminary to an extraordinary general meeting for winding-up the Company, and as they had only to criticise and pass the accounts, he thought that these could readily be disposed of. He would say a very few words on them, but at the same time he would be happy to explain to them the meaning of the net loss of £15,822, which he thought at first sight must have startled them all. He would refer immediately to the profit and loss account, because it would explain better than anything else the way in which this large apparent loss had been made up. The accounts came to hand at a very late date, but he would submit as concisely as he could the position of the affairs of the Company up to May 31st last, and he would ask them at the next meeting, if they decided to wind up voluntarily, to do so under a scheme which he would then have the pleasure of submitting. He did not know that he had any remarks to make on the balance-sheet, because he had no doubt they had all carefully studied it. Taking the manufacturing account, the stock on July 1, 1892, was entered in their books at £17,102. The plant that same year was valued at £6,732, so that really in the balance-sheet of 1892 the stock and plant together represented £23,835. They would see that the present valuation of these was set down at £12,500, or an apparent depreciation of £11,335. In other words, their late manager wrote off 50 per cent. from the stock and plant last year. The bad debts amounted to £1,421, of which £1,368 was contracted in 1891. There was also a small loss of about £70 over the general business. The preliminary expenses were put down at £1,200. They had been in the habit of writing off £400 a year from this item, but when they made up their minds that the Company ought to be liquidated, they thought it was only sensible to write off the whole of the preliminary expenses at once. All this amounted to £14,000, out of the net loss of £15,800, for the year that had passed, which, he hoped, would disabuse their minds of any idea that their business had not been properly conducted during that period. When they found, even after writing down these items in the way described, that there was the very considerable loss of £1,800, he thought it his duty to ascertain what would have been the loss in the ordinary course of business. They had written off between £3,000 and £4,000 a year from plant and stock, and £400 from preliminary expenses, allowing £100 at least for bad debts, so that they thought that their working loss would be £4,500—a constant quantity until the preliminary expenses had been abolished. Adding to this, £2,000, the difference between the figures he had given, it showed a loss on the year's trading of £6,408. Now, that was a loss made under almost every possible advantage of working except that of having plenty of capital. They had a very large and profitable order from New Zealand, and they thought at the last meeting that that order would pull the Company round. It had not done so, and he was now perfectly satisfied that with the present works, rent, and capital, the Gülcher Company could not possibly succeed, and therefore they had decided to move a resolution at the subsequent meeting for voluntarily winding it up. Having set out in detail the various sums making up the £15,832, he said that on the other side of the account he saw that the item by sales and hire of dynamos amounted to £24,368. He was sorry to say that of this amount very nearly £20,000, was due to the New Zealand contract. It was a very good contract and paid them well, but, as stated in the report, their sales in this country dwindled down to £5,000. This was the most serious matter which they had had to face, because it was quite clear that in electrical matters Providence was on the side of big armies. It was of no good for small companies to compete for central station work, and other work had practically fallen away. This was the most discouraging thing in the whole of their transactions. The consignment to the New Zealand branch was £1,814 for plant and stuff which they had sent out there for sale, there being no profit until it was sold there, and therefore it would come into the New Zealand account, and could not now be put down as sales. Stock in hand was written down very largely, namely, to £12,500. But their manager considered that a great deal of it was getting obsolete, and he would not certify that £12,500 was its value, and insisted on writing off 30 per cent. from it. He did exactly the same thing with the plant, on what principle he (the speaker) did not pretend to know, not being an engineer. At all events, the stock and plant were written down by one-third, which accounted for the apparent calamitous trading during last year. As was stated in the report, they had been contracting the business of the Company for the last four or five months. As soon as they saw and made up their minds that it should be wound up, they limited their undertakings. They borrowed £10,000 last August, they borrowed £5,000 on the debentures which were authorised to be issued, and £5,000 from their bankers, charging the second debenture-holders with it. The Directors—or some of them—had advanced to the Company since he saw them, to pay off the civil contract debts of the Company, £5,800, and the arrears of rent and taxes, amounting up to the end of June to £400. There were only 13 unsecured creditors remaining, the debts amounting to £100 each, or £1,300. The total debts of the Company were £20,825, exclusive of its shares. The assets were put down at £12,500; they had cash debts amounting to £4,900, and they had uncalled capital and calls in arrear £5,600, so that what he might call the assets treated as cash amounted to £23,000, as against £21,500 debts, showing an apparent surplus of £1,500. They had rather over 21,000 shares in the New Zealand Electrical Syndicate. As Directors they had tried to pay off everybody, and to distribute among the shareholders as many as possible of those 21,000 odd shares in the syndicate alluded to. If the scheme which he proposed were carried out, he hoped that there would be a substantial distribution of their property. Remembering the interest which they had in the New Zealand Syndicate he ought to tell them that he had made arrangements for the sale of the stock and plant—the assets of the Company—for £12,500, to be taken as follows:—£5,700 in cash, and £6,800 in shares of one of the large companies out there. He had all the contracts arranged with the assistance of Major Cotton, Mr. Grewing, and Mr. Meyerstein, so that they would be able to treat the £8,000 First Debentures as absolutely discharged. Then nothing remained to be dealt with but the bank loan of £5,000 and the £6,000 or thereabouts due to themselves. They thought, rightly or wrongly, that the Directors of a limited company ought to pay its creditors up to the hilt, just as much as if they were engaged in private trading, and they had decided to pay everyone in full. He hoped that their proposals would meet with the approval of the shareholders. He had seen almost every one of them, and they seemed not only to be willing but glad to consent to this arrangement. He concluded by moving the adoption of the report and accounts

Mr. LAMONT seconded the motion.

Major COTTON said that the report and balance-sheet fully proved what he had said for the last few years, that it would have been very much better for the shareholders if they had wound up instead of carrying on the business of the Company at such a heavy loss. He objected to the election of Mr. Rooper and of Captain Levett to seats at the Board, with which their connection had not been an advantage to the shareholders. He protested at the time against their taking those 20,000 shares in the New Zealand Syndicate, which he regarded as merely so much paper for their valuable stock, because he would be very much surprised if ever they got anything out of them.

The CHAIRMAN replied that both the Directors referred to by Major Cotton had been of great service to him personally, particularly the former on account of his technical knowledge; and he must remind Major Cotton that no man more persistently urged the desirability of having technical ability on the Board than Major Cotton himself. For the moment he would say nothing about the accounts, and would put the motion to the meeting, which he declared carried with three dissentients.

An extraordinary general meeting was afterwards held for the purpose of passing a special resolution requiring the Company to be wound up voluntarily, and for the appointment of a liquidator.

The SECRETARY having read the notice calling it,

The CHAIRMAN said that he proposed that the winding-up of the Company should be voluntary, but personally he would like it to be carried out under the supervision of the Court, notwithstanding that several shareholders and unsecured creditors seemed to hold the opinion that it would be a waste of the assets to go into Court. He was quite willing to waive his desire for a liquidation under the Court in deference to the wishes of those gentlemen, but at any rate, it was, he thought, desirable, having regard to the state of the accounts and the impossibility of carrying on the business that the Company should be wound up voluntarily, and that a liquidator should be appointed. He supposed that he ought, as the conduct of the business had been very much impugned by Major Cotton, especially in reference to the New Zealand contract, to refer to the position of affairs out there. It had been discussed *ad nauseam* for the last four or five years. Ever since 1888, when the contract was entered into, the history of the Company had been nothing more nor less than a struggle to get over the disastrous state of affairs brought about in that year. They were committed to a contract which they had estimated would cost £2,500 or £3,500, but which before its completion had run them in for £16,000. This fact accounted for the whole of their difficulties for that period.

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He might, however, say that the Company was in a good financial position at the end of December, 1890, and but for what occurred in 1891 they ought to be in a good position now. He went away in 1890 to remedy the confusion into which their New Zealand affairs had fallen, and during his absence their manager, through his over-abundant energy or his desire to surprise him (the speaker) on his return with the work accomplished, incurred heavy losses. In all about £20,000 was considered to be sunk in that way, otherwise their accounts did not show badly for the rest of the time, even if they were not quite satisfactory. He then went on to explain the circumstances under which succeeding managers were appointed, to whom he said no one could attach any blame for the hapless plight into which the Company had got, pointing out that the fault was due to the position, size, and origination of the Company. The origin of the concern he characterised as the biggest swindle perpetrated in 1882, an allegation which he had never hesitated to repeat over and over again. No one knew better than Major Cotton that for the five years during which that gentleman had sat on the Board they were struggling to get rid of that original fraud. They had five bills to file in Chancery at once, and the result was that they succeeded in reconstructing the Company. Owing to the incompletion of a large contract, it was impossible to wind up the Company four years ago, as Major Cotton said they should have done. As to the New Zealand Syndicate shares, there was now no market for them; but, in his opinion, they would become a valuable property if they were able to maintain their position in the Colony in the way he thought they would be able to do. The stock which they possessed in New Zealand was practically unsaleable, and they thought that the best thing they could do was to exchange it for the said paper in a going concern, which might yet be very valuable. Having quoted a number of figures to show the progressive development of the property, he concluded by saying that it was merely a question of sitting tight on the saddle and riding well, and they would find that their shares would pay in the long run.

Major COTTON said that they had received a loan of £20,000 from the Gas and Water Trust, which might demand the money back at a certain date, when they would have to hand over everything—lock, stock, and barrel—at a great sacrifice in satisfaction of the claim of that Trust. He represented a large number of debentures, and he was not prepared to take shares in another company—he wanted cash.

The CHAIRMAN said that when he borrowed that £20,000 there was an income from it of £1,600 a year. It now yielded a return, he believed of nearly £5,000. Having regard to the circumstances under which the money was borrowed, he had no doubt that in the end of the year 1895 he would be able to make even better terms in the open market if the Gas and Water Trust were not disposed to renew the loan. He wished to rectify a mistake which he had made. He had stated that the debenture-holders would be paid off: £3,000 of the First Debentures would still remain. He was not prepared for Major Cotton's coming there to say that he was not prepared to take anything but cash for his interest. He thought that the arrangement was a binding one on everybody. That was the opinion of Mr. Grewing, from whom he had a letter stating that not only Major Cotton, but Mr. Meyerstein, and one or two other debenture holders, were prepared to take £5,000 in cash, and the rest in Second Debentures in another company.

Mr. LAMONT asked whether the liquidator would make a call.

The CHAIRMAN presumed that he would, and added, that after meeting the liabilities of the Company there might be some few pounds over for distribution among the shareholders. Very much would depend upon whether they would be forced into compulsory or voluntary liquidation. In further reply to Mr. Lamont, he said that arrangements had been made by himself for the proper control of their property in New Zealand. He understood that the First Debenture holders had agreed to take five-eighths of their holding in cash and three-eighths in Second Debentures of the large company out there. If that were not the case let them say so, and the concern must fall into immediate liquidation.

Mr. MEYERSTEIN said that at the meeting of the committee of debenture-holders various suggestions were made verbally, but as no decision had been come to in writing, he thought that that proposal had fallen through.

The CHAIRMAN, who said he had been ill since April, demurred, and said that it could have only fallen through during his illness. He did not know of it. He had a letter from Mr. Grewing saying that it was accepted, and he (the Chairman) had got the money to pay them off if the proposed resolution was passed at the confirmatory meeting to be held not later than a fortnight from that time. He quite agreed that there never was anything in black and white, but the matter was clearly understood. It went so far as this, that he had a circular printed and sent to the debenture holders on the subject, and he received from them proxies authorising him to act on their behalf, which he did. Of course, he could not enter into any binding contract without their consent; but all the preliminaries for a binding contract subject to their approval were completed, and he was asking their consent that day to let it be entered into, and five minutes after the next meeting confirming the resolution he would be able to hand them £3,000 in debentures and £5,000 in cash. He moved:—

"*That as from the accounts of the Company it appears that the Company cannot continue to carry on its business by reason of its liabilities, the Company be wound up voluntarily.*"

They thought it better to put the resolution in the form in which he moved it to give the shareholders an opportunity to consider the question, and to disapprove of it if they liked at the confirmatory meeting.

Mr. ADDISON seconded the motion, which was declared carried.

The CHAIRMAN next moved the appointment of Mr. C. F. Kemp, of Messrs. Kemp, Ford and Co., the auditor, as liquidator, which, after some opposition from Major Cotton and Mr. Meyerstein, was agreed to.

A vote of thanks to the Chairman, proposed by Mr. Lamont, terminated the proceedings.

Compagnie Française du Telegraphe de Paris à New York.

The following is an abstract of the report presented by the Directors to the general meeting held on the 31st ult:—

The Board of Directors appointed by the shareholders at the general meeting on May 25, 1893, in presenting their report and the balance-sheets A, B, C, D and E attached thereto, would point out that the first of these (A) was prepared from the books on February 28, 1893, by M. Lougarre, when he took charge of the Company as provisional administrator. The second statement (B) is the balance-sheet prepared from the books without alteration except the addition to the preceding balance-sheet (A) of the result of the working for the seven months during which the present Board of Directors had charge of the Company after M. Lougarre was relieved of his duties. The third statement (C) shows the position of the Company's affairs on December 31, 1893, and is the balance-sheet we now submit for your adoption. This balance-sheet shows no alteration in the amount of the capital of the Company, which remains at 42,000,000fr. Passing over several of the intermediate items, we come to, on the debtor side, the "Legal reserve" of 863,257fr. 14c., which we have been unable to find either securities or cash to meet, the securities which were supposed to represent this item having been appropriated for the necessities of the Company in 1887, 1888, and 1889. Another item in statement B, "Indemnity Submarine Company, 131,768fr. 75c.," does not represent an indemnity proper, but the repurchase of the cable connecting our Brest station with Penzance, which was laid by your Company at its own cost in 1880 under the condition that, although its use was reserved for this Company's benefit, it should become the property of the Submarine Telegraph Company, which at that time had the exclusive privilege of submarine telegraphic communication between France and England. This monopoly cased in 1889, and your Company repurchased the cable for £11,883, borrowed by annuities which have since been paid off. The necessary funds for this purpose were borrowed at 6 per cent. The item in statement B, "Redemption" 195,079fr. 65c., is also not covered by any cash or securities, and does not appear to be in conformity with No. 54 of our Articles of Association. We propose, therefore, to omit from the debit the items "Legal Reserve" and "Redemption," and from the credit the "Maintenance of Cables" and "Indemnity Submarine Company." The items "Cash at Paris and the stations," and "Cash at bankers," representing a total of 428,184fr., has been duly verified.

During the year we sold our property at Brest, for which we had no further use. It was valued on October 24, 1893, at 125,500fr., a figure which has not yet been realised. The item of 638,021fr. for "Cable in store" is cable valued at its purchase price. The large sum of 355,263fr. for material on board our cable ship, and at the stations has borne a depreciation of 5 per cent. off the figure given for December, 1892. "Cables and ship" stand in the balance-sheet at 33,907,973fr., and represent the same figure as in the accounts for 1892. Capital charges amounting to 6,358,077fr. also remain unchanged. We think it unnecessary to call attention at the moment to these latter amounts, which we think, however, will one day have to be considerably written down.

The "working" account for 1893 (during which we have had the management of the Company from June 1st to December 31st) shows a total gross traffic receipt of 2,348,639fr., out of which we have had to pay for "outpayments" and service 958,549fr., leaving net receipts 1,390,089fr., to which must be added the amount received from the chartering of the "Pouyer-Quertier" by the Société Française des Câbles sous-marins of 66,208fr., making a total gross receipt of 1,456,298fr. Deducting from this sum for general expenses 958,836fr., there remains a profit balance of 497,462fr., deducting which from the profit and loss account of 935,159fr., caused by the omission of the two items of "Legal reserve" and "Redemption," reduces this sum to 437,697fr. Other expenses of the year represent a total of 98,954fr., made up by "Repairs to land lines," "Damages paid for injury," "Fees and expenses paid to the provisional administrator," and "Compensation."

The report presented by the Provisional Administrator of the Company informs you of the breaking of the St. Pierre-Canso cable. This, however, was speedily repaired, and represents the only accident which occurred to our cables during 1893. On the return of the "Pouyer-Quertier" after her loan to the Société Française des Câbles sous-marins she was thoroughly overhauled; necessary repairs are now nearly completed, and we hope the vessel will be ready for service by the middle of June.

The five years' treaty entered into by this Company and the Commercial Cable Company in 1889 comes to an end on September 1st next.

Your Company acquired in February 5, 1892, a right to land cables on the Coast of Virginia, granted by the Senate of that State. Mr. Blaine, Under-Secretary of State of the Federal Government at that time, denied, however, the right of the Confederated States to grant concessions of that kind, and the question, although brought before Congress, has not been settled. The endeavour of M. Hector de Castro to settle this matter to the satisfaction of your Directors has not, up to the present, been successful, and an attempt by that gentleman to claim satisfaction from the Company before an American tribunal has been decided in our favour.

The action brought against this Company by the Anglo-American Telegraph Company, on account of the rupture of the common-purse agreements of 1880 and 1882, was called before the Court of Appeal in Paris at the beginning of May.

In November we entered into an agreement with M. Willot for a trial upon our cables of his relay, which had been already successfully applied on the lines and cables of the French Administration between Paris and Algiers. By this agreement we obtain, should success attend these experiments, all M. Willot's patents concerning submarine telegraph working, with the exception of the rights of the French Administration, and M. Willot enters our service for three years.

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We have shown, gentlemen, that we have been able to arrive at a credit balance on the profit and loss account of 497,462fr. If we compare this result with that of 1892, which showed a loss of 22,829fr. 94c., or with that of 1891, which showed a balance of 46,053fr. 32c., it will be seen that our efforts have commenced to bear fruit.

In July, 1893, M. Noël Pardon, formerly Governor of New Caledonia, joined the Board, but vacated his seat in December on being reappointed to his old post by the French Government. The retiring Directors are MM. Boullaire, de Carrère, Chauvassaignes, and Laffargue, who are eligible for re-election.

At the general meeting the Directors' report, which was not sent out previously to the shareholders, but was handed to each person as he entered the room, was approved. Resolutions embodying the various suggestions of the Directors were carried unanimously; and the retiring Directors were re-elected.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1894, pages 274-300, *&c., &c.*]

BAIRD, THOMPSON AND CO. (LIMITED).—This Company was registered, on June 5th, with a capital of £60,000, in £5 shares, to enter into an agreement made between John D. G. Thompson and Aubrey Richardson, for the sale to the Company of the business now carried on under the style of "Baird, Thompson and Co.," and to carry on the business of founders and workers of iron, brass and other metals, contractors for the ventilation and heating of buildings, &c., pneumatic and hydraulic engineers, electricians, electrical engineers, &c.

WILLIAM BARRACLOUGH (LIMITED).—This Company has been registered with a capital of £12,608, in £10 shares, to acquire the business of ironfounders, &c., now carried on by W. Barraclough at Stanningley, near Leeds.

CRUTO INCANDESCENT LAMP AGENCY (LIMITED).—This Company was registered on June 5th with a capital of £5,000 in £1 shares, to carry on, in the United Kingdom and elsewhere, the business of electric lighting in all its branches, and in particular to construct and fix all necessary cables, wires, lines, accumulators, lamps, and works, to generate, accumulate, distribute, and supply electricity to light cities, towns, streets, buildings, &c., and to carry on the business of electricians, electrical and mechanical engineers, &c.

ELECTROPHONE (LIMITED).—This Company was registered, on June 5th, with a capital of £20,000, in £5 shares, to acquire the undertaking of the Electrophone Syndicate, and all or any of the patent rights held by that Syndicate, and to manufacture and deal in telephones and all apparatus and appliances connected with the establishment or maintenance of telephonic communication.

TELPHER CABLE AND CLIFF RAILWAY SYNDICATE (LIMITED).—This Company has been registered with a capital of £6,000, in £10 shares, to acquire the concession granted to W. J. Brewer, C.E., authorising the construction of a cableway across the Dyke at Brighton and a cliff railway to Punch Bowl.

ROGER DAWSON (LIMITED).—The annual return of this Company, made up to May 14th, has been filed. The whole capital of £15,000 in £1 shares has been taken up, and of these 14,993 have been issued as fully paid, while the full amount has been called and paid on the seven signatories' shares.

T. L. HEMMING AND CO. (LIMITED).—The annual return of this Company, made up to April 2nd, was recently filed. Out of the nominal capital of £5,000 in £10 shares, all of which has been taken up, 130 have been issued as fully paid, while the full amounts have been called and paid on the remaining 370 shares.

HOOPER'S TELEGRAPH AND INDIA-RUBBER WORKS (LIMITED).—An agreement dated May 2nd, states that it is agreed that the business lately carried on at Millwall by William Hooper shall be sold to the Company (not, however, including the cash at the bankers or at the works or book debts), for £10,000, payable by the allotment as fully paid of 1,000 Preference shares, Nos. 1 to 1,000 inclusive, to William E. L. Hooper, Alice L. R. Hooper, John P. Hooper, Emily J. Moran, Mary E. A. Hooper, Samuel F. Hooper, Annie C. Marsh, Claude A. Hooper, and Anne M. Hooper. The contracts handed over to the Company include one for the custody and maintenance in sound electrical condition of 13 miles of 4½-ton cable belonging to the Great Northern Telegraph Company, for the custody of 20 miles of deep sea cable belonging to the Cuba Submarine Company (Limited), and running contracts with the General Electric Company. Messrs. John P. Hooper and Basil Gee become Directors and joint managers of the Company for seven years at a remuneration of £500 each per annum, and one-half of the profits remaining, after the payment of 5 per cent. per annum on the Ordinary shares, after making provision for a reserve fund.

JOHANNESBURG LIGHTING COMPANY (LIMITED).—The annual return of this Company made up to May 21st has been filed. The nominal capital is £150,000, divided into 50,000 Preference and 100,000 Ordinary shares of £1 each. All the Preference and 77,132 Ordinary shares have been taken up, and with the exception of seven Ordinary shares, have all been issued as fully paid. Upon these seven shares the full amount has been called and paid.

THOMPSON, RITCHIE AND CO. (LIMITED).—The annual return of this Company made up to May 21st has been filed. Out of a nominal capital of £5,000, divided into 200 Preference and 300 Ordinary shares of £10 each, 200 Preference and 140 Ordinary have been taken up and all issued as fully paid.

CITY NOTES.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended June 3rd were £869, as against £914 in the corresponding period of 1893, being a decrease of £45. The total receipts for the half-year amount to £20,012, as against £19,493 for the corresponding period of 1893, an increase of £519. The shares of this Company continue to show an upward tendency, the 4 per cent. debenture stock having had a sharp rise during the week.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the month of May are £3,550, as compared with £3,712 in the corresponding month of last year.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—This Company's estimated traffic receipts for the month of May amounted to £1,594, as against £1,866 in the corresponding period of last year.

EASTERN TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of May amounted to £54,846, against £57,946 in the corresponding period of last year.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of May amounted to £43,960, and to £45,395 in the corresponding period of 1893.

ELECTRIC AND GENERAL INVESTMENT COMPANY (LIMITED).—The Directors of this Company have decided to recommend the payment of a further dividend upon the Ordinary shares at the rate of 40 per cent. per annum. for the six months ended May 31st last (making with the interim dividend of 10 per cent. already paid, 25 per cent. for the year), and a dividend on the Founders' shares of £30 per share for the year. The transfer books of the Company will be closed from the 12th to the 26th inst. inclusive.

GEORGE ANGUS AND COMPANY (LIMITED).—The Directors of this Company have declared an interim dividend on the Ordinary shares at the rate of 5 per cent. per annum, payable July 1st.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic returns of this Company for May, 1894, amount to £22,800, and from January 1st to May 31, 1894, £105,800. In the corresponding months of 1892 and 1893 the amounts were £104,800 and £108,000 respectively.

THE GULCHER COMPANY.—It will be seen from a report of the meeting of the shareholders of the Gulcher Electric Light and Power Company, appearing in this issue, that the Chairman intimated that a scheme had been prepared by the Board of Directors, under which the Debenture holders (for £8,000) would receive £5,000 in cash, and £3,000 in second Debentures of one of the leading electric manufacturing companies. The Chairman likewise said that it would be unlikely that the holders of Deferred shares would receive anything in the distribution of the assets of the Company which is shortly to take place.

SHEFFIELD ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The report of the Directors on the accounts for the year 1893 states that the balance of profit for the year is £585. 5s. 6½d., which the Directors propose to carry forward to the current year. In order to provide capital for the extension of mains into new districts and to defray the cost of new buildings, works, and machinery, which the development of the business and the increasing demand for current renders necessary, the Board recently resolved upon an issue of £25,000 Four and a-Half per Cent. Debentures and 6,000 Ordinary shares, and they are glad to report that this issue has been favourably received. Owing to the growth of the Company's business, and its probable development in the future, the Directors propose to submit to the shareholders at a meeting which will be called within the next few weeks an alteration in the Company's Memorandum and Articles of Association, with a view to making them more convenient and better adapted to the present status and requirements of the Company.

SWAN UNITED ELECTRIC LIGHT COMPANY (LIMITED).—An extraordinary general meeting of the Swan United Electric Light Company (Limited) will be held at the Cannon-street Hotel, E.C., on Thursday, the 14th inst., at 12 o'clock, to consider and, if approved, to pass the following resolution, which, if passed by the required majority, will be submitted to a second meeting to be hereafter convened for confirmation as a special resolution, viz.:—"That the Swan United Electric Light Company (Limited) be wound up voluntarily, and that Henry Charles Gover, of No. 100, Victoria Street, in the City of Westminster, be, and he is hereby appointed, liquidator for the purpose of such winding up, and that the liquidator be, and he is hereby authorised to carry into effect upon the terms of a Provisional Agreement between the two Companies dated June 5th (subject to any modification), a sale of the Company's undertaking to the Edison and Swan United Electric Light Company (Limited) for debenture stock of that Company to be distributed among the members of this Company."

TELEGRAPH MANUFACTURING COMPANY (LIMITED).—The annual ordinary meeting of the shareholders of this Company was held at Helsby on Monday last, when a dividend of 5 per cent. and a bonus of 2½ per cent. were declared, being the same distribution as for last year.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended June 1st (after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited), were £2,637.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, May 30.		Price Wednesday, June 6.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending June 6.	
			TELEGRAPHS.					£ s. d.		Highest	Lowest
£1,012,880	Stock	9 0	Anglo-American	41	43	43	45	5 4 4	Jan., Apr., July, Oct.	..	..
£2,933,560	Stock	18 0	Do. Preferred	79	80	82	83	5 14 5	" "	81½	79¾
£2,933,560	Stock	5/0	Do. Deferred	7½	7¾	7½	8¼	..	..	8	7¾
£184,500	100	4%	African Direct Telegraph 4% Deb. (Reg. & Bearer)	102	105	102	105	3 16 2	January and July .	..	..
130,000	£10	3/0	Brazilian Submarine	12	12½	12	12½	5 4 0	Mar., June, Oct., Dec.	12⅜	12 1/16
£18,700	£100	5%	Do. 5 per Cent. Bonds	100	103	100	103	4 17 1	January and July .	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	108	112	108	112	4 4 10	June and December	.	..
10,000,000	$100	$1¾	Commercial Cable Capital Stock	140	145	140	145	4 16 7	Jan., Apr., July, Oct.	144	143¼
16,000	10	8/0	Cuba Submarine	12	13	12	13	6 3 1	February and August	..	
6,000	10	10%	Do. Preference 10 per Cent.	18	19	18	19	5 5 3	" "	18 11/16	18½
12,931	5	1/7½	Direct Spanish (fully paid)	2¾	3¼	3¾	4¼	4 14 2	April and October	..	..
6,000	5	10%	Do. Preference 10 per Cent.	9	9½	9	9½	5 5 3	" "	..	.
60,710	20	2 0	Direct United States Cable, 1877	9¼	10	9¾	10¼	5 17 1	Jan., Apr., July, Oct.	10	9¾
400,000	10	2/6	Eastern	14¾	15	14¾	15¼	4 5 11	" "	15 1/16	15
70,000	10	6%	Do. 6 per Cent. Preference	15¾	16¼	15¾	16¼	3 13 10	" "	16¼	16 1/16
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	113	116	113	116	3 9 0	May and November	115	113½
£102,100	100	5%	Do. 5 per Cent. Debentures, 1899	107	110	107	110	4 10 11	February & August		..
250,000	10	6/6	Eastern Extension	15½	15¾	15½	15¾	4 8 11	Jan., Apr., July, Oct.	15⅝	15½
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	114	117	114	117	3 8 5	February & August	116	..
£62,700	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	104	107	104	107	4 13 6	January and July	..	..
£95,100	100	5%	Eastern and S. African 5 per Cent. Mor. Deb., 1900	104	107	104	107	4 13 6	" "	106¾	–
£300,000	100	4%	Do. 4% Mortgage Debentures, 1909 (regd.)	104	107	104	107	3 14 9	February & August	..	..
£200,000	£25	4%	Do. 4% Mauritius Sub. Debs.	106%	109%	106%	109%	3 13 5	May and November	..	..
180,227	10	2/6	Globe Telegraph and Trust	8¾	9	8¾	9¼	4 7 8	Jan., Apr., July, Oct.	9¼	8¾
180,042	10	6%	Do. 6 per Cent. Preference	15½	15¾	15½	15¾	3 17 5	" "	15⅝	15⅝
150,000	10	7/2	Great Northern	21	21½	21	21½	3 19 1	Jan., April, and July	..	..
£190,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	104	107	104	107	4 13 6	March & September	..	–
17,000	25	37/6	Indo-European xd & bonus	43	45	43	45	5 11 1	May and November	44¾	44½
37,548	10	5/0	London Platino-Brazilian	4	6	4	6		" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106	109	106	109	5 10 1	March & September	..	..
£100,000	£100	4%	Pacific European Tel. 4% Guar. Debs. "Red" 1942	102	105	102	105	3 16 2	..	..	..
11,839	8	4/0	Reuter's	5½	6½	5	6	.	April and October	..	..
3,381	£100 Cert.	37/0	Submarine Cables Trust 6 per Cent.	112	116	113	118	5 1 8	" "	..	..
15,609	10	5/0	West African Telegraph	3	5	3	5	..	January and July ..	..	..
£249,900	100	5%	Do. 5 per Cent. Debentures	101	104	101	104	4 16 2	March & September	..	..
30,000	10	2/0	West Coast of America	2½	3	2½	3		January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	100	105	100	105	7 12 5	June and December	..	..
88,321	10	9d.	West India and Panama	1½	1¾	1½	1¾	..		1½	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10½	10⅞	10½	10⅞	5 11 7	May and November	10⅝	10⅝
4,669	10	6%	Do. 6 per Cent. 2nd Preference	9	10	9	10	6 0 0	" "	..	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	109	112	109	112	4 9 3	June and December	..	–
64,242	15	7/6	Western and Brazilian xd	7½	7¾	7½	7¾	..	May and November	7½	..
33,129	7½	7/6	Do. 5 per Cent. Cumulative Preferred .. xd	6½	6¾	6½	6¾	..	..	..	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	2	2½	2	2½		..	2½	..
£171,900	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	106	109	106	109	5 10 1	February & August	..	..
£214,800	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	106	109	106	109	5 10 1	" "	..	..
$1,211,000	$1,000	7%	Western Union 7% 1st Mort. (Building) Bonds	111	115	111	115	6 1 9	May and November	..	–
£166,900	£100	6%	Do. 6 per Cent. Sterling Bonds	100	104	100	104	5 15 5	March & September	..	–
			TELEPHONES.								
44,000	5	10/0	Chili Telephone (fully paid)	1½	2½	1½	2½	..	..	..	–
224,850	10/0	3½d.	Consolidated Telephone Const. & Maintenance	1/16	3/16	1/16	3/16	..	May and November	..	..
171,504	£1	6d.	Oriental Telephone and Electric (fully paid)	⅛	⅜	⅛	⅜	..	Yearly	..	..
484,597	5	2/6	National	4¾	5¼	4¾	5¼	4 17 7	June and December	5 1/16	4 15/16
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	15	16	15	16	3 15 0	" "	5 1/16	15
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	14½	15½	14½	15½	3 17 5	" "	..	..
119,234	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	5½	5¾	5½	5¾	4 6 11	..	5¾	5 11/16
1,000,000	Stock	4½%	Do. Debenture Stock, 4½%	114	116	115	117	3 16 11	January and July	115½	–
58,000	5	1/0	United River Plate	1½	2	1½	2		" "	..	..
£146,733	Stock	5%	Do. 5 per Cent. Debenture Stock	90	100	90	100	5 0 0	" "	..	–
			ELECTRICITY SUPPLY COMPANIES.								
40,000	£10		City of London Electric Lighting (fully paid)	12	13	12	13	..	..	12½	12
40,000	10	6 0	Do. 6% Cumulative Pref. (fully paid)	13½	14	13½	14	4 5 9	..	13 11/16	13¾
19,900	£5		Electricity Supply Co. for Spain	..		..		..	..	..	..
£30,000	£5	2 0	Charing Cross and Strand Electricity Supply Corp.	4½	5½	4½	5½	..	..	..	..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	..		..		..	..	..	..
8,322	£5		House-to-House Electric	..		..		..	..	..	–
15,000	£5		Kensington & Knightsbridge El. Light (fully paid)	..		..		.	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..		.		..	January and July	..	–
5,523	£5	1/9	Liverpool Electric Supply (£4. 10s. paid)	..		..		..		..	–
39,477	£5	2/6	Do (fully paid)	6⅜	6⅞	6⅜	6⅞	..	..	..	..
111,000	5	..	London Electric Supply	½	1	½	1	..	..	..	..
£49,900	£10	5/0	Metropolitan Electric Supply (fully paid)	7½	8	8	8½	2 18 10	..	8¼	8
£100,000	Stock	5%	Do. 5% Debs. (Bonds of £10, £20, and £40) xd	108	111	107	110	4 10 11	June and December	..	..
6,452	£10		Notting Hill Electric	4½	5½	4½	5½		..	–	..
19,960	£5	4 6	St. James and Pall Mall	6¾	7¼	6¾	7½	..	..	..	..
20,000	£5	7%	Do. 7 per Cent. Preference	8	8½	8	8½	4 2 4	..	8⅜	..
59,900	5	2/6	Westminster Electric Supply (fully paid)	6½	6¾	6½	6¾	2 19 3	..	6⅝	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
90,000		1 6	Brush Electrical Engineering	2¾	3	2¾	3	6 0 0	..	3	2 15/16
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	2½	2¾	2½	2¾	5 1 1		2 9/16	2¾
£125,000	Stock	4½%	Do. 4½ per Cent Debentures	103	111	108	111	4 1 1	March & September	110¼	–
20,000	5	2/6	Crompton and Co., 7 per Cent. Cumulative Pref.	3	3½	3	3½	..	January and July ..	..	–
12,139	5	..	Edison and Swan United	–		.		..	..	–	–
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	..		..		..	..	–	..
120,000	2	..	Electric Construction	¾	1	¾	1	..	..	–	–
12,845	2	..	Do. 7 per Cent. Cumulative Pref.	1½	1¾	1½	1¾	..	..	..	–
91,195	2	10/0	Elmore's Patent Copper Depositing	1½	1¾	1½	1¾	..	..	1⅝	1½
20,000	5		Fowler-Waring Cables (fully paid)	¾	1¼	¾	1¼	–	..	..	–
50,000	10	15/0	India Rubber, Gutta Percha, &c., Works	23	24	23	24	5 4 2	February & August	23¾	23
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103	105	103	105	4 5 9	March & September	103¾	–
15,995	£10	6/4	International Okonite Ordinary	..		..		..		–	–
16,000	£10	..	Do. 8 per Cent. Preference	..		..		..	December and June	–	–
20,000	9		Manchester Edison-Swan "A" (£1 paid)	—	½	—	½	.	..	–	..
78,949	5	3/6	Swan United (£3 10s. paid)	1¾	2½	2	2½	7 0 0	May and November	2⅛	2¼
37,350	12	36/0	Telegraph Construction and Maintenance	39	41	39	41	5 17 1	March and July .	40½	39¾
£150,000	100	5%	Do. 5 per Cent. Bonds	104	107	104	107	4 18 6	January and July	..	–
37,514	£5	–	Woodhouse and Rawson Ordinary (£3 15s. paid)	..						–	–
41,098	£5	–	Do. Preference (fully paid)	–		..		..	..	–	–
			RAILWAYS AND TRAMWAYS.								
£630,000	Stock	1%	City and South London Railway	33	35	36	38	1 16 2	May and November	37½	35
£67,130	Stock	4%	Do. 4% Perpetual Debenture	..		119	121	3 6 2	May and November	119½	119
7,000	10	..	Do. 5% Perpetual Preference	..		12	12½	4 0 0	..	..	–
37,500	£10	1%	Liverpool Overhead Railway	8¼	8¾	8¼	8¾	..	..	..	–
6,295	10	5%	Do. 5% Preference	..		12¾	13¼	3 15 6	..	..	–
£125,000	Stock	4%	Do. 4% Debenture	–		110	112	3 11 5	January and July ..	..	–

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THE ELECTRICIAN:

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NOTES.

The exhibits at the Royal Society Conversazione on Wednesday were, as a rule, repetitions of those shown in May. Perhaps the most interesting novelty was the Postmaster-General's exhibit, consisting of a Hughes' telegraph and a Wheatstone transmitter, each driven by a little Willmot air-motor. In the case of the Hughes instrument, the use of this motor enables a 132lb. weight and winding gear, and nearly all the train of wheel-work to be dispensed with. In the case of the Wheatstone, a 42lb. weight, which required rewinding every few seconds, is got rid of with its attendant complicated train of wheel-work. The speed of the motor is regulated by expanding or contracting the blast nozzle. The power required is so minute that a fair speed is attained by merely blowing into the motor supply tube with the mouth.

Dr. Oliver Lodge showed several forms of sensitive Hertzian wave detectors, the delicate susceptibilities of which were not a little upset by Prof. Thompson's three-phase experiments in the adjoining room. Mr. J. W. Swan exhibited several specimens of electro-deposited gold leaf four-millionths of an inch thick. The gold is deposited on a thin highly polished electro-deposited copper sheet, which is then dissolved off by perchloride of iron.

An attempt was made by Prof. Vernon Boys on Friday evening last to supply some of that impressiveness of style, which, though of small moment compared with a good popular exposition, may, as we observed last week, be used with advantage in conveying to a Royal Institution audience the importance of some of the subjects of the Friday evening discourses. Few other lecturers would have so scornfully rejected the title, "How to Weigh the Earth," and would have contented themselves with the colourless phrase, "The Newtonian Constant of Gravitation." The catch-penny title would, in a superficial way, have been the more impressive, gaining, indeed, by contrast with the delicate quartz-fibre refinements with which Prof. Boys has revolutionised many physical measurements. He contented himself with the difficult task of explaining what is meant by the constant of gravitation, and of showing its fundamental importance, while he repudiated any concern with the weight of the earth, as an accidental property of an insignificant planet, which might be dealt with by County Councils. The difficulty of the actual research was so great that the only chance of explaining it to the audience lay in the use of comparative figures. A model of Cavendish's apparatus was shown in which a force equal to the weight of $\frac{1}{3000}$th of a grain was measured. Prof. Boys, by deliberately choosing smaller dimensions, knowing that in his hands, at all events, greater accuracy would be obtained, limited himself to $\frac{1}{3000000}$th of a grain, and a torsion $\frac{1}{100000}$th of that of Cavendish. When his 16lb. lead balls were moved round his little golden pills they set up a whirlwind in his apparatus, at the raging speed of one inch in a fortnight, and making one revolution in six weeks.

Fearing a bad year, the Lockerbie Gas Commissioners recently sought to impose a gas contingent guarantee rate in order to pay therewith interest on capital and to meet the various liabilities of their undertaking. A local Hampden has, however, taken the matter into the Law Courts, and Lord Low in the Court of Session has decided against the Commissioners, and forbidden the imposition of the rate. If this decision were to be upheld, and if the law of electric were the same as the law of gas lighting, there would be joy amongst those who happen to have opposed the modern *penchant* for municipal electricity supply, and who foresee nothing but bad debts and corruption; at any rate, they, as innocent ratepayers, could not be made to suffer. Unfortunately all municipal Electric Lighting Provisional Orders contain the proviso that "any deficiency of income in any year shall be charged upon and payable out of the local rate."

The elaborate speculations which American electricians have been making during the past few weeks as to "the distance to which Niagara water-power can be economically transmitted by electricity"—when they have got it—strike one as being not a little premature. There is a ludicrous resemblance to betting on the future jumping performances of an unhatched frog. This is all the more the case, because it is by no means certain that, even in the event of the hatching being successful, there will be anyone anxious to have the creature jump very far, or to jump at all in their direction. One pair of mathematical speculators, arguing on certain convenient assumptions, arrived at the conclusion "that the power of Niagara Falls can be transmitted to a radius of 200 miles, cheaper than it can be produced at any point within that range by steam engines." Next comes a learned doctor who disputes the others' assumptions, invents his own, and concludes that the economical distance depends on several coefficients, but is never so great as 200 miles. Several other

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writers take up the theme, arriving at various conclusions. Looking at the matter from a common-sense point of view, it would appear that to expect to arrive at any general formula for the radius of economical transmission, is simply ridiculous. The special requirements of the consumer, the character of the route, the ever-changing question of prices, all these affect the details of the problem in a way which must hopelessly baffle any useful general investigation.

The satirist who once declared that the American method of rating arc lamps consisted in taking photometer readings from each of the cardinal points of the compass, adding the quantities together, and calling the sum the candle-power, could scarcely have supposed that in the fulness of time a real American "electrical expert" would adopt this self-same method of specifying the candle-power of a lamp. Yet, it is the unexpected which happens. According to one of our American electrical contemporaries, the Board of Public Works of a city not so very distant from New York recently applied for expert advice relative to a clause in a street lighting contract with a local electric light company, and the following is the manner in which it was enlightened:—"The arc lights are hung at the street intersections, and each one throws its light in four directions; 2,000 c.p. of lights on each of the four streets cannot, therefore, be expected. An arc light which throws 500 c.p. of light along each of four streets is a 2,000-c.p. lamp, as called for in the contract."

Alloys.—Prof. Roberts-Austen has been awarded a prize of £80 by the Société d'Encouragement, for his researches on alloys.

Telephonic Communication in Sweden.—During last year the Swedish Government spent a sum of £55,500 in improving the telephone system of the country.

Académie des Sciences.—M. d'Arsonval has been elected to fill the vacancy in the ranks of the Académie des Sciences caused by the death of M. Brown-Séquard. The nomination requires the approbation of the President of the Republic.

Copper.—The copper output of the United States for the year 1893, amounted to 144,000 English tons, or only 1 per cent. less than in 1892, the average value of the copper at the place of production being £48 per ton, against £50 for 1892.

Cable Interruptions and Repairs:—

	Date of Interruption.	Date of Repair.
Accra-Kotonou	Apr. 1, 1894	June 14, 1894.
Bissao-Bolama	Nov. 24, 1893	—
Brest-St. Pierre (P.Q. Co.)	Mar. 29, 1894	—
Tarifa-Tangier	June 12, 1894	—

A New Arc-Lamp Carbon-Producing Process.—The firm of Krupp, of Essen, Germany, is reported to have introduced a new process for the production of carbons for arc lamps, by which it is claimed carbons having a life of from 17 to 28 per cent. longer than ordinary carbons are produced.

Aluminium.—The Société Electro-Metallurgique Française recently held its annual meeting, when it was stated that 500 kilogrammes of aluminium per day were being produced at the Proz Works, near Modane. It is intended to increase the production shortly so as to utilise the whole of the water-power available, estimated at 3,000 H.P.

Multiple-Filament Lamps.—Experiments with multiple-filament lamps having proved that there is practically no after-glow when the current is switched off, as in the case of single filament lamps, the Admiralty have directed that the multiple-filament lamp is to be adopted for mast-head flashing lanterns in all ships from second-class cruisers upwards.

International Congress of Hygiene and Demography.—A British Committee, of which Sir Douglas Galton is the Chairman, has been formed to further the interests in this country of the Eighth International Congress of Hygiene and Demography, which is to be held in Budapest, from September 1st to 8th this year. Any information may be obtained about the Congress from the Hon. Secretary, Dr. Paul F. Moline, 42, Walton-street, Chelsea, S.W.

Telegraphic Communication in Australia.—Some dissatisfaction exists in South Australia with the charges made for intercolonial telegrams, which are said to be higher in that colony than in the other colonies of the Australian continent. The Adelaide Chamber of Commerce is, therefore, taking steps to endeavour to bring about a uniform rate between the colonies of 1s. per ten words, and is inviting the assistance of other Chambers of Commerce.

Kew Observatory.—The Kew Observatory affords an excellent example of what may be done towards making a purely scientific institution more or less self-supporting, if only it is permitted to alloy the purity of its science with the baser metal of a little work of immediate practical utility. The outgoings at Kew amounted last year to £3,000, in round figures; grants from the Royal and Meteorological Societies amounted to nearly £900; but no less than £1,865. 3s. 3d. was derived from fees for various tests.

Exports of Telegraphic Wire and Apparatus.—The returns regarding the value of the telegraphic wire and apparatus connected therewith exported from this country during last month, although not showing the same activity as existed in 1892, must still be considered satisfactory, amounting as they do to £90,077 for the month, as against only £15,487 in May, 1893. During the past five months of this year the value of such exports is put down at £542,095, those for the corresponding periods of 1893 and 1892 being £450,921 and £651,658 respectively.

An International Institute of Engineers.—Since the inauguration and successful establishment and conduct of the World's Fair, the country, says the *Engineering Magazine*, instinctively looks to Chicago for the inception of grand ideas. It is therefore, perhaps, not surprising that from the Western Society of Engineers should come a suggestion for the formation of an International Institute of Engineers. It is eminently fitting, says our contemporary, that such a proposition should have originated with a man of international reputation like Mr. E. L. Corthell.

Non-Magnetic Watches.—In the report of the Kew Committee for 1893 it is stated that twelve watches, designated as "non-magnetic," were examined during the year, both as to their ordinary time-keeping and also as to their non-magnetic properties, and although the trial to which they were submitted was severe—the movement being tested in an intense magnetic field, both in vertical and horizontal positions, and gradually approached to and removed from the poles, whilst its behaviour was critically watched—in the majority of cases the watches were found to perform very satisfactorily.

Fareham.—Matters do not appear to be in a very prosperous state with the Fareham Electric Lighting Company. The concern has had a brief career of about four years, and now seems likely to collapse. The immediate cause of the trouble is the compulsion the Company is under to put its mains underground, together with the fact that the scant public support and recognition it is receiving will not justify the expenditure of capital necessary for this change. A short time ago the Company threatened the Local Board that it would abandon its Provisional Order. As the Local Board does not seem to be distressed at the threat, it is pretty certain the Company will have to abandon the Order.

Board of Trade Rules and Regulations.—The daily press has been circulating a paragraph to the effect that Mr. Francis Hopwood, Assistant-Secretary to the Board of Trade, has issued a circular letter notifying that the electric light regulations, dated July 6, 1891, are revoked, and promulgating new regulations and conditions for the safety of the public, and for ensuring a proper and sufficient supply of energy. Our readers

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will be relieved to hear that the only foundation for this alarming rumour of the issue of yet another batch of rules, regulations, and restrictions is the application of the old rules to the undertakers of a certain Provisional Order.

Royal Society Government Grant.—In the account of the appropriation of the sum of £4,000 annually voted by Parliament to the Royal Society, to be employed in aiding the advancement of science, the following amounts were allotted to electrical researches from April 1, 1893, to March 31, 1894:—W. G. Rhodes, for a Minute Study of the Electrical Temperature Coefficient of some Pure Metals, with the view of obtaining an Electrical Thermometer more reliable than the Platinum Thermometer, £35; Dr. Schuster, for Assistance in certain Numerical Calculations concerning Terrestrial Magnetism, £50; W. A. Shenstone, for Continuing the Investigation of the Influence of Silent Discharge of Electricity on Oxygen and other Gases, £30.

Blackburn.—On Friday last Mr. Arnold Taylor, an inspector of the Local Government Board, held an inquiry with reference to the application of the Corporation for power to borrow money for the purposes of electric lighting. The Town Clerk traced the history of the electric lighting scheme, and said that in the early part of last year the Corporation made application to the Local Government Board for sanction to borrow £50,000 for the purpose of electric lighting, and in April sanction was granted. Owing, however, to a change in the site of the proposed electric light works, the sanction for £50,000 was cancelled. They now proposed to borrow £34,000 to cover the expenditure on plant. The inspector pointed out that the Corporation had allowed too large a sum for contingencies, whereupon the Town Clerk asked for sanction to borrow £32,000. The inquiry then terminated.

Electrical Communication with Lighthouses and Lightships.—In answer to a question in the House of Commons last week, Mr. Bryce said that in the last financial year £10,000 was placed at the disposal of the Board of Trade for the purpose of effecting electrical communication with light vessels, &c. That money was expended in connecting the Kentish Knock and Goodwin (N. Sand Head) light vessels and the Gunfleet Pile lighthouse with the shore. In the present financial year £11,000 had been similarly placed at the disposal of the Board of Trade, and it was intended to expend that amount in connecting the Haisborough and the Shipwash light vessels with the shore, and in laying a cable to the Tuskar Rock lighthouse. He was afraid that the other works recommended by the Royal Commission must wait until the Treasury could place more money at his disposal.

Search Lights and Torpedo Boats.—A test of the value of search lights for naval purposes was lately made at the naval station, Newport, R.I. It was arranged that during the evening of May 15th the torpedo boats "Cushing" and "Stiletto" should endeavour to enter the harbour while search lights should be employed in detecting them. The "Cushing" was painted nearly a black, while the "Stiletto" was left a dark green. The test took place at 9:30 in the evening. The boats entered the range of the search light and passed to their anchorage while the officers were still looking for them at the entrance to the bay. For ten minutes the boats were in the open channel, but the deep colour of the vessels blended with the colour of the rocky shores, so they were not detected. The German Government have decided to paint their torpedo-boats bluish-grey, this colour being, they consider, that least visible under the electric light.

Science and Engineering at Cambridge.—The University is at the present time crippled for want of funds. The wants of the University which are at the present time much pressing are—(1) The extension of the Cavendish Laboratory of Experimental Physics; (2) The commencement of the Geological Museum in honour of the late Prof. Sedgwick, towards which object a large sum has been already raised by subscription, but more is needed before the erection of the building can be proceeded with; (3) The Engineering School lately built with funds raised by the efforts of Prof. Ewing is still in need of much apparatus to give it requisite efficiency. The borrowing powers of the University are well-nigh exhausted, and it would not be prudent, in view of the falling off in the annual income of the common University fund, further to increase existing loans. In these circumstances it is hoped that, as in the past, some benefactors may be found to enable the University without delay to supply the three urgent works above specified.

Technical Training Conference.—There was a large attendance on Thursday night last at the offices of the London County Council, upon the occasion of the first of a series of trade conferences which have been arranged to discuss technical education in its relation to the various London industries. The meeting on Thursday night was confined to those interested in the building and furniture trades, and the chair was taken by Mr. Sidney Webb, Chairman of the Technical Education Board. Sir John Hutton offered the delegates a cordial welcome, and remarked that the members of the Board found that a mass of extremely useful teaching was given, but it was not made full use of because its existence was not largely known and there was a lack of funds. Several of the delegates then expressed their opinions with reference to different branches of the trade which they represented, and the subjects discussed included a suggested return to the old system of apprenticeship, with State protection for the men who had fulfilled its conditions; the modification of the practice by which apprentices were confined to one particular branch of their trade; the management of classes by men possessing practical knowledge; and the provision of additional half-holidays on which apprentices could receive instruction in technical matters and other subjects. The conference unanimously adopted a resolution in favour of greater facilities being extended to apprentices for attending technical classes by means of at least one half-holiday a week. Matters of detail were then discussed.

Electric Phenomena during Thunderstorms.—Mr. C. S. Du Riche Preller has contributed a letter to the *Standard*, in which he gives a graphic description of some electric phenomena during thunderstorms which have come under his personal notice. The following extract may interest our readers:—

"The large 'village' of Gossau, about seven miles from the town of St. Gall, derives its electric supply for lighting and motive power for industrial purposes from a hydro-electrical central station, situated at a distance of eight miles, by a high-tension transmission, with transformer stations in the village. The thunderstorm, accompanied by violent lightning discharges, passed over the place at five p.m., and then, driven back by a change of wind, returned and lasted for several hours. Soon after five p.m. all the electric lights went out spontaneously, but the place was illuminated by violent sparks and flashes, which were emitted by the overhead wire system, and ran along the conductors. These phenomena reached their height at the principal transformer station, close to an hotel; for here the high-pressure current escaped from the conductors to the earth, viz., the ground saturated with rain, the effect being a succession of flashes or continuous blaze, which so endangered the building that the Fire Brigade had to be called out to protect it. These phenomena continued for several hours, till the electric supply was cut off at the central station, a special messenger on horseback having been despatched thither, for, wonderful to relate, the installation was as yet without telephonic communication. Only last summer I witnessed a similar occurrence on the Mont Salève electric railway, near Geneva, where the lightning struck the feed-conductor of the line, and thence found its way along the transmission cables to the central station, fully two miles distant, where it passed through the lightning arrester and burnt out one of the huge 1,000-H.P. dynamos. In this case, too, the lightning discharge was only the indirect cause, the direct cause being that the dynamo was running at the time—viz., that the current followed the discharge through the not quite perfect lightning arrester, and 'short-circuited' the dynamo."

The Restoration of the Apparently Electrocuted.—The formula for restoring the vitality of the apparently drowned is nowadays well known. Briefly, its main object is to induce the lungs to recommence their normal respiratory functions. According to M. d'Arsonval, precisely similar treatment should be tried on the apparently electrocuted. A few weeks ago MM. Picou and Maurice Leblanc were afforded an opportunity of putting M. d'Arsonval's prescription to the test at the St. Denis generating station. At the time of the accident an electrometer showed that a difference of potential of 4,500 volts existed between two of the three wires of the transmission line, the frequency being 55. The three wires are carried by insulators supported by a bracket fixed into the wall of the station some 20ft. above the floor. A man engaged in putting up a telephone wire was seated astride a bracket below, holding on to one wire with his hand. At that moment the telephone wire, one end of which was in contact with the bracket on which the man was seated, came in contact with

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another of the three wires. How long the man was actually short circuiting the 4,500 volts it is impossible to say. Some minutes, however, certainly elapsed before the current was cut off, and a quarter of an hour after the man was still sitting senseless on the bracket, and it was another half hour before he could be got down. Artificial respiration was immediately tried, and in two hours time the man could talk, and is now none the worse for his experience, with the exception of a few burns.

Obituary.—The death is announced of Prof. August Kundt, who died at Israelsdorf, near Übeck, on the 21st ult. Prof. Kundt was born in Mecklenburg on November 18, 1839. He received his scientific education in Berlin, and from 1866 onwards filled in rapid succession the chair of Professor of Physics at Zürich, Würzburg, and Strasburg. In 1888 Prof. Kundt succeeded von Helmholtz in the management of the Physikalisches Institut, in Berlin. Prof. Kundt was one of the old school of natural philosophers, who took an active and productive interest in everything connected with physics. In every branch of physical science he has published valuable memoirs; optics, acoustics, electricity, and magnetism have all been enriched by his labours. In acoustics he devoted himself to the study of the motion of solid and gaseous bodies, and to him is due the discovery of dust figures in closed pipes, by which simple means it is possible to measure the velocity of sound in gases, and to compare it with the velocity in solids. He investigated the behaviour of those bodies which, like rosaniline, produce an anomalous spectrum in which the red and orange rays are more refracted than the green and blue, thus changing the usual order of succession of the colours. In the course of his investigations on anomalous dispersion, he found that it was peculiar to those substances which exhibited a strong absorption for certain colours, a fact which theoretical considerations subsequently confirmed. Prof. Kundt also busied himself respecting the optical properties of thin films of the metals, and even succeeded in measuring the refractive index of some of them. In conjunction with Warburg, he did valuable work on the conduction of heat and the friction of gases; and, in conjunction with Röntgen, on the rotation of the plane of polarisation in gases.

The Manufacture of Engineers.—To the correspondence on this subject in the columns of the *Engineer*, to which we referred on p. 121 of our last issue, "A Young Engineer" from Glasgow contributes the following:—

SIR: Your correspondent "Pater" deserves the gratitude of all the young members of the profession for his praiseworthy attempt to dissuade young men from entering a profession which is already crowded to overflowing. His position as a practical engineer and the father of a family will no doubt give weight to his argument in the opinions of many of your non-technical readers, to whom, I take it, the warning is specially directed. While cordially endorsing all that he says as a practical engineer, I wish to point out that, by his own statements, he has gone beyond the sphere of his experience in attacking technical colleges as the source of the evil above referred to. It is a common occurrence in our day to see men build up fantastic theories for the purpose of demolishing them, and I venture to suggest that your worthy correspondent lays himself open to this charge. He clearly has no knowledge of technical colleges, or he would not make the ludicrous mistake of assuming that professors of engineering go touting for pupils, and lead inexperienced parents to believe that when their sons have studied under them for three years they become qualified engineers. I am personally acquainted with most of the said professors in Great Britain, but I must confess that I know of none to whom your correspondent's argument applies. My experience of them is that they are honourable men in the highest sense of the word, and this is fully borne out by the kindly relations which generally exist between professors of engineering and their pupils in after life. Now, Sir, can anyone with an atom of common sense believe that this would be the case if your correspondent's theory was a true one! Your correspondent evidently forgets that a man may be a successful business man, and even possess an engineering works, without being an engineer in the true sense of the word. In conclusion, I may mention that I am one of the "bye products" of a technical college; but as I have earned a living as a journeyman mechanic, and as a draughtsman, I beg leave to subscribe myself—A YOUNG ENGINEER."

University College of South Wales.—An influential deputation representing the educational interests of South Wales and Monmouthshire waited, on Thursday last week, on the Master Wardens and Court of the Drapers' Company at Drapers' Hall, Throgmorton-street, for the purpose of explaining the present financial position of the University College of South Wales, to whose funds the Drapers' Company have liberally contributed, with the view of enlisting further assistance. Prof. V. Jones, Principal of the College, explained the object of the deputation, stating that it was to solicit a continuance of the kindness which the Drapers' Company had already from time to time extended to the South Wales University College. Five years ago the Company were good enough, in response to a petition, in the first place, to give the college £1,000 for the establishment of a scholarship. The second gift of the Company had assumed the form of a donation of £1,000 towards capital expenditure in respect of higher technical education in the college. Further, the Company had granted the college £300 per annum for five years towards the establishment of a professorship of mechanical engineering. The deputation desired to thank the Drapers' Company for the assistance it had rendered the college in the past, to ask for the continued support of the Company towards the maintenance of the professorship that bore the Company's name, and to point out that the large increase in the number of the departments in the college, as well as in the number of the students, had produced the result that the present buildings were inadequate to the amount of work required to be done. The Master (Sir. J. H. Johnson) expressed the pleasure it had given himself and and his colleagues to receive so influential a deputation, and said that the statements which had been presented would receive very favourable consideration.

Graphic Methods of Calculation.—The increasing popularity of graphical methods of calculation, as compared with the more precise (but not necessarily more accurate) analytical methods, suggests some thoughts which may not, says Mr. H. H. Suplee in the *Engineering Magazine*, be out of place, bearing as they do, upon problems directly relating to the daily work of the mechanical engineer. The great attraction of graphical methods, remarks Mr. Suplee, lies in the directness with which the result is attained and the fact that the whole work is before the observer in a shape to be grasped as a unit, instead of a succession of statements. Every one who has used tables and curve-diagrams to express the same set of relations—such, for instance, as a set of Regnault's steam tables compared with a curve of steam-pressures and volumes—will appreciate this fact. Even the simple exercise of graphical addition, marking off the successive items on a strip of paper and then measuring the total length, is in fact doing what is considered quite a feat by the expert arithmetician, as it permits items of several columns in width, as well as fractional quantities of all denominations, to be added simultaneously, without previous reduction. The clumsy notation of the ancient Greeks and Romans compelled them to direct their mathematical ingenuity almost entirely to the solution of geometrical problems, and any one who has seen even a simple example in elementary arithmetic worked out in the Roman system of numerals can imagine how the veriest schoolboy of to-day would appear as a mathematical prodigy, merely because of the fact that he possessed the infinitely superior notation possible with the Indian (miscalled Arabic) numerals. When we consider, however, how many unnecessary details of reduction and similar manipulation are avoided by the most elementary graphical processes, the reflection that we are entirely too well satisfied with our present system forces itself upon us. May it not be possible that as great an improvement upon the Indian system as that was over the Roman is possible, and that, while the solution by graphical methods is only an indication of what may be attainable, yet the indication may be clear and the solution not far off? There are some analogies in our present system which point in the same direction—notably the curious properties of the figures nine and seven; and the manner in which such arithmetical prodigies as Mondeux, Colburn, Bidder, and Inaudi operated, makes one regret that the processes by which they performed calculations mentally which required much longer time for "experts" to accomplish with pencil and paper, were not investigated, at least to an extent which would give a clue to the conscious or unconscious process employed. The direct methods of nature go immediately to the results which they must produce, just as a freely-suspended chain forms a catenary without requiring any guidance, and it may not be too much to hope that some day we shall be able to think and calculate by methods as direct as the action of the forces which we are endeavouring to grasp.

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MOTIVE POWER AND GEARING.*

BY E. TREMLETT CARTER.

(Continued from page 100.)

Furnaces and Boilers.

Water Room.—Not only the rapidity of circulation, but several other important actions in a boiler are affected by the amount of water room provided, or rather by the ratio which this space bears to the heating surface and grate area. Where the amount of water in the boiler is large as compared with the surface which is provided for heating that water, it is evident that a longer time will be spent in raising steam than where there is a larger allowance of heating surface. There are indeed two reasons for this. The first is the obvious reason that where a given rate of heat supply has to heat a large mass of water it will take longer than where it has only to heat a small mass. The second reason is, that if attempts are made to rapidly heat a bulky boiler the stresses which will arise on account of unequal expansions will seriously injure the boiler and involve serious risks; while with a less bulky boiler the circulation being much more rapid, there is a greater tendency to equalisation of temperatures, and steam can be raised much more rapidly without risk of serious consequences. On the other hand the large mass of hot water in a boiler under steam serves a very useful purpose, as will presently be seen, in regulating the pressure of the steam. The following Table (XIII.) shows approximately the relation between the water room and heating surface in some important boilers:—

Table XIII.

Type of Boiler.	Ratio of Water Room in cubic ft. to Heating Surface in sq. ft.
Cornish	0·90 to 1·00
Lancashire	0·60 to 0·80
Galloway	0·50 to 0·60
Return Tube	0·40 to 0·45
Locomotive	0·12 to 0·20
Babcock-Wilcox Water Tube	0·14 to 0·15

Regulating Effect of Water Room.—Hot water in a boiler is a store of heat energy, which, by a perfectly automatic action, tends to minimise the fall of pressure whenever steam is drawn off through the steam pipe. To make the action clear, let us suppose that we have a Lancashire boiler, containing 25,000lb. of water at the temperature of the steam, the pressure of the steam being 100lb. on the gauge. We will, in the first place, assume that no heat is being supplied from the fire, and we will afterwards consider what will happen if heat is so supplied. Let us suppose that we wish to draw off steam without allowing the pressure to fall more than 5lb. How much steam can be drawn off? Neglecting the steam in the steam space, the whole of the steam drawn off will be produced by evaporation at the surface of the water. Directly any steam is drawn off, the pressure and temperature of the steam above the water will fall, but before it can fall perceptibly the water will commence to evaporate, and thus to make new steam, thereby tending to keep the pressure up. Steam at 100lb. pressure on the gauge has a temperature of 338°F., while steam at 5lb. lower pressure has a temperature of 334·6°F. The difference in temperature is 3·4°F. Consequently the 25,000lb. of hot water may go on making steam, by virtue of its stored heat, until it has fallen 3·4°F., without fear of the pressure dropping more than 5lb. This fall of temperature corresponds to a loss of 85,000 B.T.U. Now, the average latent heat of 1lb. of steam between 115lb. and 110lb. absolute pressure is equal to 794·7, which, if divided into 85,000, will give about 107lb. as the weight of steam which may be generated by this amount of heat. Here, then, the heat stored in the water compensates the draught of steam to the extent of 107lb. We will next suppose that the furnace is supplying heat and generating steam at a certain rate, say, W pounds per minute. Then, if a sudden increase in the demand for steam arises, the furnace may not be in a condition to meet it instantaneously. Suppose the demand rises to W + 10lb. of steam per minute, it is evident that the hot water will keep the steam pressure above 95lb. on the gauge for over ten minutes, and in this time it would be easy to get the fires into a more active state, or the extra demand for steam may have passed away.

Mr. Druitt Halpin has devised a system of thermal storage for the purpose of meeting the fluctuating demands for steam at an electric power station. In this system it is proposed to have a very large mass of hot water, contained under pressure in steel cylinders, available for evaporating in the manner already described; the steam thus generated by the hot water being used for helping the boilers over the heaviest loads. We may here observe that this proposed remedy for fluctuating loads is to be placed, not as near as possible to, but as far as possible away from the source of fluctuation, thereby causing the fluctuations to be imposed on a long series of intermediate parts, including the steam mains, engines, and gearing.

Evaporating Surface.—The allowance of surface of water from which to permit steam to be given off varies considerably with different types of boilers. Some makers have considered that a boiler should not be forced to give more steam than at the rate of about 25lb. or 30lb. per square foot of water surface per hour, while others have designed boilers to give steam at nearly five times this rate. With electric power boilers the limits of allowance may be represented, on the one hand, by the Lancashire boiler, and, on the other hand, by the boiler of Messrs. Babcock and Wilcox. In the Lancashire boiler, under ordinary rates of steaming, the evaporation is at the rate of from 25lb. to 35lb. of steam per square foot of water per hour; and with 50 per cent. forcing of the steaming rate this is not brought to more than from 38lb. to 53lb. per square foot per hour. The Babcock and Wilcox boiler, however, has an allowance of as much as 52lb. of steam per square foot of water per hour under normal steaming rate, with as much as 78lb. when the boiler is forced to steam 50 per cent. faster. Moreover, in the former boiler it is comparatively easy to maintain the full amount of evaporative surface, for the large water space will not permit the water level to fall very rapidly, while, if it does fall, there will not be any reduction but an increase of the width of the water surface. Whereas, in the latter boiler, the bulk of water is much smaller, and the curvature of the drum is much more rapid, so that it is more difficult to maintain the water line and to keep up the maximum evaporative surface.

The object in view in designing that a boiler shall not develop steam at too high a rate per square foot of water surface, is based upon the fact that excessively rapid evolution of steam from a water surface is liable to carry unevaporated masses of water over into the steam space, and possibly into the steam mains with the steam. This is known as *priming*; and the wetness of steam which follows upon priming in the boiler is, of course, injurious to the efficiency and proper working of the steam plant. This, among other reasons, is why it is impossible to get satisfactory results with a heavily forced boiler. Mr. Crompton claims* for the Babcock and Wilcox boiler, that it will stand 50 per cent. of forcing without producing wet steam; but it is evident that this could only be done under the most careful management, with a perfectly steady rate of steaming. A Lancashire boiler will stand, so far as the priming goes, far more forcing than this; but not with a high furnace efficiency, owing to the loss of heat up the chimney.

Steam Space.—In every boiler a certain amount of space is left for the accumulation of steam, between the evaporating surface and the top of the shell. The object in making this space large is to allow of the return of most of the primed water, before it can reach the steam pipe. In some types of boilers, mostly of older date, the distance traversed by the steam before it can reach the steam pipe is increased by the use of a steam dome, or small separate chamber fitted on to the top of the shell. As this dome weakened the shell it has largely

* From a forthcoming work to be published by *The Electrician* Printing and Publishing Company, All rights are reserved.

* Proc. Inst.E.E., April 26, 1894.

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been abandoned. The regulating effect of steam space being very much lower than that of an equal volume of water space, makers of boilers have latterly sought to minimise the amount of steam space while preventing the priming of water into the steam pipes. This has been done by using baffle plates and perforated pipes for the collection of steam, as well as by the use of more direct forms of steam separators. Steam space, where the shell is a horizontal cylinder, becomes a necessity also on account of the necessity for a certain area of water surface; for if the water level is raised this surface becomes reduced. Table XIV. gives the usual allowances of steam space in some typical boilers.

Table XIV.

Type of Boiler.	Percentage of Boiler Capacity used as Steam Space.
Cornish	40
Lancashire	30
Marine and Locomotive	30
Water Tube	35

Feed Water.—The performance of a boiler is greatly affected by the quality of the feed water, and with the manner of feeding it. The sources of boiler water in electric-power stations are town mains, wells, and artesian borings, adjacent rivers, and in some rare cases canals. The nature of the source affects the character and amount of saline and mineral matter dissolved in the feed water, and as these are largely deposited in a solid form wherever the water is heated, it is very desirable to obtain a water as free as possible from either permanent or temporary hardness. The deposition of these solids on the useful heating surface will reduce the efficiency of the surface, and will expose the plates or tubes to risk of burning, owing to the much higher temperature to which they will be raised by the furnace gases. The frequent cleaning, often attended with considerable manual labour, which these deposits make it necessary for the boiler to have, will increase the cost of maintenance. If the water is fed cold into the boiler all the deposition and incrustation will occur in the boiler, while, if the water is raised nearly to the steaming temperature in a separate feed-heater, a considerable amount of the mineral matter will be deposited before the water enters the boiler, and it may be collected in suitable mud-drums.

Cold Feed.—It is only rarely that one hears of boilers being fed with water at its natural temperature in connection with electric-power stations, for the practice is almost intolerable. Cold feed, besides having the objectionable feature just named, causes the boiler-shell and internal flues to become locally cooled, resulting in unequal expansions and injurious strains. Further, by chilling the plates locally it tends to the deposition of a hard incrustation on the furnace side of the plates. Thus, both the life and the efficiency of the boiler are diminished. Besides these features, a boiler fed with cold water will not evaporate as great a weight of water per hour as one fed nearly at the steaming temperature, because the boiler has in the former case the additional duty of warming up the water. Now, it can be shown, as the result of experience in hundreds of factories, that a greater evaporation can be obtained, with a given amount of heating surface, if some of the heating surface only is placed in the boiler, the rest being placed in a separate feed-heater, called an economiser.

Hot Feed.—The reason for this is that it is difficult to build a boiler, on any of the usual lines, which will reduce the furnace gases down to about 300°F., without having a most bulky and inefficient boiler, while it is quite practicable to reduce the furnace gases to from 400° to 500°F. by a good boiler, and afterwards to take the surplus heat out of them by means of an economiser. It is, therefore, in the joint interest of the life, efficiency, and steaming capacity of a boiler, to feed it with hot water rather than with cold. The following are the methods of warming feed-water before injecting it into the boiler:—

(1). By means of an exhaust steam heater, *i.e.*, by passing the heat of the steam exhausted from the engines through metal partitions into the feed water.

(2). By taking the feed water from the condenser hot well, *i.e.*, utilising the condensed steam drawn from a surface condenser. This is simply an extension of (1).

(3). By taking the warm water, part of which is condensed exhaust steam, from a jet condenser.

(4). By admixture of live steam with the feed water.

(5). By taking some of the heat from the furnace gases after they leave the boiler flues, and passing this heat through metal partitions into the feed water.

"Compactum" Feed Water Heater.—It is obvious that the maximum temperature to which the feed water can be raised by exhaust steam is very much lower than the evaporating temperature in the boiler, being necessarily lower than the temperature of the exhaust steam. An exhaust steam feed-heater is a form of surface condenser, but with insufficient surface to condense more than a small proportion of the steam. It is therefore unprovided with special pumps, the condensed steam being trapped out of the steam space and the feed water being kept in circulation by the feed pump. A form of exhaust steam feed heater met with in some electric power stations is the "Compactum" heater, manufactured by Messrs. Kirkaldy, Limited, a vertical section of which is shown in Fig. 16. The exhaust connection with the engines is made

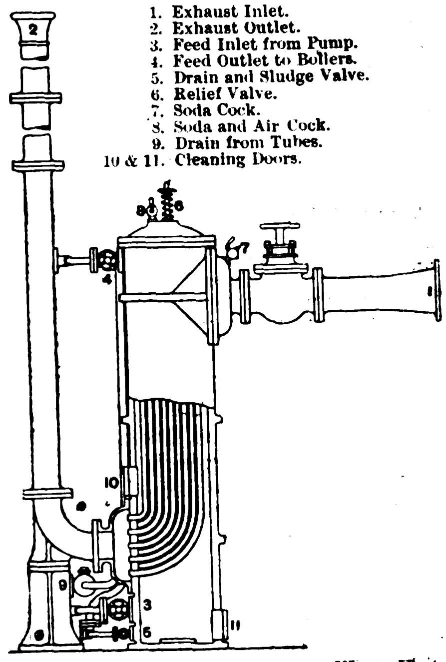

FIG. 16.—"Compactum" Exhaust Feed-Water Heater.

at 1, and the admission of the steam is regulated by the adjacent stop valve. The steam passes through this valve into a large number of parallel pipes of thin sheet brass, which terminate at each end in a small chamber; and from the chamber at the lower end, the cooled steam passes away to the exhaust up-take, 2, and the condensed water is drained through 9. The system of pipes is contained within a vertical cylinder, into the bottom of which, at 8, the feed water enters, and from the top of which, at 4, this water passes on to the boilers, being propelled through the apparatus by the ordinary pumps. It will be seen that the feed water has free circulation between the parallel steam pipes, enabling it to become considerably raised in temperature between the inlet and outlet points. The allowance of pipe surface in these feed-heaters varies from one to two square feet per 30lb. of feed water per hour. It is an economical practice to choose a feed-heater sufficiently large to enable the whole of the feed water to pass through it at a slow speed, as this enables the feed water to deposit its mineral matter in the heater, while, if the water passes rapidly through the heater, the mineral matter will largely be carried into the boiler. Anti-incrustation fluids should be injected into the feed-heater; never directly into the boiler.

(To be continued.)

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NOTES ON ELECTROLYSIS.

BY JOHN WADDELL, D.SC. (EDIN.)

Introductory.

Before entering upon the particular subject of electrolysis, it will be well to consider the analogy between an electrical machine or galvanic battery and an air fan, an analogy which is becoming familiar in the consideration of motors, though not so widely applied as it might be.

Suppose an air-tight box, made similar to a ventilating shaft, but with its ends closed, and a fan revolving in it in the usual manner. In one end of the box air will be compressed, while in the other it will be rarefied. There is evidently a limit to the amount of compression and rarefaction for any fan, for it is impossible for all the air to be exhausted from one end, and, moreover, the compressed air tends to slip back past the fan. The difference of air pressure on the two sides of the fan depends upon its construction and upon the method of setting-up in the box, as well as upon its speed of rotation. The *size* of the box has little effect, except in influencing the time which is required for reaching the limit of difference of pressure. A small fan may be capable of producing greater difference of pressure than a large fan, and the difference of pressure does not depend upon the total quantity of air; for in a small box the difference of pressure between the two ends may be greater than in a large box, if the fan in the small box is more effective.

So far we have an analogy with a frictional electric machine or a Holtz machine (or, indeed, with a galvanic cell, with circuit unclosed), the difference of pressure of air representing difference of potential of the two terminals which is not affected by the size of the conductors, except that as the conductors have larger capacity longer time is necessary for the machine to reach the limit of its power to create difference of potential.

Electrical capacity is analagous to size of the box containing air just as difference of potential is analagous to difference of pressure.

Returing to the original illustration. If a small opening be made in each end of the box containing air, the fan will not be able to create such a difference of pressure as before, because air will flow in on one side and prevent so great rarefaction, and flow out on the other side and prevent so great compression. If the openings are enlarged there will be still less difference of pressure on the two sides of the fan. This represents the case of a Holtz machine connected with conductors having a smaller or larger number of points.

Suppose the two ends of the box to be joined up by pipe external to the fan chamber, so that air which is compressed on one side of the fan returns to the other side through the pipe there is a continual circulation of air, a continual current.

Suppose friction absent, then, if the fan has been moving long enough to make the current of air constant, since there is no acceleration of the mass of the air, there will be no work done by the fan; but, under such circumstances, the pressure on the two sides of the fan will be equalised, and the action would be precisely the same as if the fan after communicating the motion to the air were suddenly to vanish.

Owing to the friction of air, however, the pressure does, in practice, differ on the two sides of the fan, and the quantity of air which flows round the circuit in a minute depends upon the difference of pressure and upon the friction. So long as the quantity of air, passing per minute through the pipe is constant, all the work done by the fan is against friction and develops heat. The work done by the fan is exactly equivalent to the heat produced. Moreover, all other conditions remaining the same, the fan, by working harder would increase the difference of pressure, and, therefore, the quantity of air passing per minute, and therefore the friction, and therefore the heat. If, on the other hand, the passage of the air is made more difficult than to keep the same current going, the difference of pressure must be increased, and the heat produced by the friction is also increased. The work done by the passage of air, therefore, would in a given time be proportional to the difference of pressure and proportional to the quantity of air passing, except that the friction of air passing rapidly is greater in proportion than of air passing slowly.

In the case of an electrical circuit, there is no limitation such as has been just mentioned. The work done by a galvanic battery or a dynamo being proportional to the difference of potential created by it, and proportional to that factor ordinarily called *current of electricity*, a factor which is analogous to current of air. The unit of difference of potential being the *volt*, and the unit of current the *ampere*, the product gives the electrical unit of power which is called the *watt*, and is $\frac{1}{746}$ of a horse-power. (Power is work done in unit time.)

Electrolytic Phenomena and Analysis.

If a current passes through a metallic conductor, it produces a heating effect, and no other change. If it passes through such substances as fused salts or aqueous solutions of salts, acids or bases, the conductor is decomposed. This decomposition is called *electrolysis*, and the conductor which is decomposed is called an *electrolyte*. The products of decomposition are set free at the places where the current enters, and leaves the electrolyte at what are called the *electrodes*, which usually consist of metal or carbon plates or rods.

The electrodes are necessarily of different potential, else there would be no flow of electricity from one to the other; the electrode of higher potential is the *anode*, the other the *cathode*. The products of decomposition are usually denominated *ions*. Since bodies of high potential repell other bodies of high potential, and attract those of low potential, the ions separating at the anode are of lower potential than those separating at the cathode, or, as commonly stated, are *electro-negative*, the ions separating at the cathode being *electro-positive*.

If water is decomposed by a current, oxygen separates at the anode and hydrogen at the cathode, in equivalent amounts, eight parts by weight of oxygen to one of hydrogen, or one volume of oxygen to two of hydrogen. Not only is this so, but if a current be passed through a series of electrolytes, equivalent weights of the ions will separate at the electrodes in each electrolyte. This law of equivalents was stated by Faraday in 1833.

If, for example, a current be passed through the series of electrolytes, acidulated water, and aqueous solutions of silver nitrate, lead acetate and antimony trichloride, it will be found that at the cathodes hydrogen, silver, lead and antimony will be separated in the proportions by weight of $1:108:\frac{208}{2}:\frac{120}{3}$, equivalent ions being separated at the anodes. In all parts of an electric circuit the current is the same, therefore the amount of any of the ions separated corresponds to the quantity of electricity passing. The fact that, however the conditions may be varied, a current is always accompanied by an amount of decomposition proportional to the strength of current, seems to prove that there is no conductivity apart from the transport of the ions nothing which corresponds to metallic conductivity, but that the conductivity of an electrolyte is similar to the power of a fluid to carry heat by convection.

As, then, electricity is conveyed by the ions, it is not strange that equivalent weights carry equal quantities. Since one atom of silver or potassium is equivalent to one atom of hydrogen, it is evident that all three carry the same charge of electricity. The capacity of the three atoms is equal. On the other hand, one atom of lead being equivalent to two atoms of hydrogen, it must carry twice the electric charge, and in the same way the atom of antimony three times the charge carried by hydrogen. Copper, in the decomposition of *cupric* salts, carries twice the charge of copper in the *cuprous* salts, because, in the former case, it acts as a divalent element, in the latter as monovalent. In the case of potassium ferrocyanide, $K_4F_2Cy_6$, the ions are potassium and the radical F_2Cy_6, and the radical F_2Cy_6 carries four units of negative electricity (if the quantity of electricity carried by one atom of hydrogen be taken as the unit of positive electricity) because it is equivalent to four atoms of potassium. But in potassium ferricyanide, $K_3F_2Cy_6$, the radical F_2Cy_6 carries three units only of negative electricity.

The question may be asked, how is it that substances whose heat of combination vary so much should be decomposed by a current in exactly equivalent quantities? A little considera-

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tion will elucidate the matter. Heat of combination is a form of energy, and quantity of electricity, which alone has been so far discussed, is not energy. It was stated above that the work done by a galvanic battery or a dynamo depends upon *the difference of potential* created by it, as well as upon the current which passes in the circuit. In the same way, the work done in the electrolyte depends, *not only upon the current, but also upon the difference of potential between the electrodes due to the separation of the different ions upon them.*

The analogy of the fan causing a current of air gives a useful illustration. The work of the fan need not all be expended against friction, but the air set in motion may be employed to drive machinery. A number of machines might be driven by the same current of air, each machine doing a different amount of work. The current of air could be produced by a powerful fan, and might be used for causing the rotation of a series of less powerful fans, employed to drive machinery of various kinds. When work is done by any of the fans there is a difference of pressure of air on each side of it, and if one fan does twice as much work as another, the difference of pressure in the former case is twice that in the latter, the quantity of air passing each fan in a given time being the same. This difference of pressure is quite independent of the friction of the air; in the circuit it is merely due to the difficulty of rotating the fan, which is the greater the greater the work it has to do.

In an electric circuit, the case is the same when motors are placed in series. Each motor employs the same current, but the different motors may do different amounts of work, owing to a varying difference of the potential of their terminals. To take a numerical example, if a dynamo is working with a difference of potential between its terminals of 1,000 volts, and if there are in the circuit three motors in series, and if there is a fall of potential, at the first motor of 100 volts, at the second of 200 volts, and at the third of 500 volts, the second and third motors do, respectively, two and five times as much work as the first, all necessarily using the same current because in the same circuit. Moreover, all the motors combined use $\frac{800}{1000}$ of the total work done in the circuit, the remainder heating the resistance.

In the same manner precisely, a current passing through three electrolytes may do different amounts of work in each, though the current is the same, owing to the varying difference of potential between the electrodes. The difference of potential between the terminals both in the case of motors and of electrolytes is called *counter electromotive* force.

The origin of the term is easily seen, for if the cycle of work were reversed, and the machinery instead of being *driven by* the armature were to *drive* the armature in a reverse direction, there would be a difference of potential between the terminals such as to cause a current of electricity opposite to that of the dynamo, hence the term *counter* electromotive force.

The case of the electrolyte is similar. In the above examples the fall of potential due to the resistance of the conductivity wires in the motor, or of the liquid in the electrolyte, has been left out of account just as in the case of the fans any difference of pressure of air owing to friction in passing the blades of the fan has been neglected. In practice this may not be negligible, and heat is produced in the conductors. The matter, so far as necessary for the present purpose, will be spoken of later.

If the armature of a motor be rotating very slowly it will produce very little counter electromotive force, but if it be allowed to rotate more rapidly the counter electromotive force will increase until, theoretically, it may equal that of the dynamo, the rotation being sufficiently rapid. In this case, there would be no current in the circuit, and therefore no work done by either dynamo or motor. In practice, it is, of course, impossible to completely attain the conditions just mentioned; but if there be very little load on the motor, its armature may rotate so fast as to permit very little current in the circuit.

A dynamo, or galvanic battery of very low electromotive force, could cause rotation of the armature of a motor, provided the work done by such rotation is less than that of the dynamo, and there is not too great loss of energy in the form of heat or otherwise. The counter electromotive force may have any value from zero to that of the generator. With a dynamo of large electromotive force the maximum limit of the counter electromotive force is raised, the minimum limit still being zero.

An electrolyte is different from a motor in this respect, that its counter electromotive force varies within narrow limits having a certain minimum as well as maximum value. A galvanic cell may not have a sufficiently high electromotive force to decompose the electrolyte at all, and therefore no current passes; not because the resistance of the electrolyte is so great, but because decomposition would produce a counter electromotive force greater than the electromotive force of the galvanic cell. In an actual experiment, roughly carried out in order to illustrate the principle, it was found that a Daniell cell joined with a resistance and a tangent galvanometer in circuit, caused a deflection of the needle in the latter of 7deg. A Grove cell under the same conditions gave a deflection of nearly 14deg. This latter cell in circuit with a water voltameter and the same galvanometer gave a reading on the latter of 6deg., while the Daniell cell under the same conditions produced no deflection of the needle. The reason was that the Grove cell has an electromotive force nearly double that of the Daniell, and the counter electromotive force of water decomposed between platinum electrodes is greater than that of the Daniell cell and less than that of the Grove. Two Daniell cells, in series, would have caused a current through the electrolyte. If there were a number of cells in series with the electrolyte they would cause more rapid decomposition; but there would be very little, if any, change in the counter electromotive force.

If the electrodes are plates of large size, and very close together, the resistance of the electrolyte is small; but if the electrodes are small, the resistance may be considerable. The resistance of the electrolyte causes a difference of potential between the electrodes, and in this respect is similar to counter electromotive force. On this account the ordinary Wheatstone bridge is not convenient for measuring the resistance of an electrolyte, but if the battery in the usual arrangement is replaced by a Ruhmkorff coil, the effect of the counter electromotive force is got rid of, because the current is alternating, and the electrode, which at one instant is anode, is at the next instant cathode, and there is no setting free of ions on the plates. Since the current is alternating, a galvanometer cannot be employed in the bridge, its place is taken by a telephone, which speaks if the resistances are not balanced, but is silent if they are. (Further details upon this matter are given in Oswald's "Outlines of General Chemistry," translated by Walker, page 279.)

The relationship between counter electromotive force, and the fall of potential in the electrolyte, due to its resistance, can be clearly seen by a numerical example. Suppose a battery to supply a current, at a pressure of eight volts, the resistance in the total circuit being 800 ohms, and the counter electromotive force of the electrolyte two volts; there will be an effective electromotive force of six volts, causing a current of $\frac{6}{800}$ amperes, through the resistance of 800 ohms.

Suppose the resistance of the electrolyte to be practically zero, then the difference of potential between the electrodes will be two volts. There will be decomposition of the electrolyte, corresponding to the current, and all the work done in the electrolyte will go to its decomposition. The current in the rest of the circuit, whose resistance is 800 ohms, will produce heat, the quantity of heat being by Joule's law proportional to $C^2 R$. If the conditions be now changed so that the electrolyte has 100 ohms resistance, the remaining 700 ohms being in other parts of the circuit; the difference of potential between the electrode will be increased. The counter electromotive force will be two volts as before, but there will be an additional $\frac{6}{8}$ volt, due to the resistance of the electrolyte, which is $\frac{1}{8}$ the total resistance. The effective electromotive force in the whole circuit being still six volts. The strength of current will not be changed, and therefore the rate of decomposition of the electrolyte will remain as before, but the electrolyte will become heated, the amount of heat developed in the electrolyte will be $\frac{1}{8}$ the total heat developed, because its resistance is $\frac{1}{8}$ the total resistance, but the total heat will be precisely what it was in the first instance.

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If the battery should be changed, so as to give a pressure of 10 volts, the current would be increased, the effective electromotive force being now eight volts. The resistance remaining still 800 ohms, the current would be $\frac{8}{800}$ amperes, therefore a decomposition of the electrolyte would take place at a rate more rapid than before in the ratio of 8:6. With the resistance in electrolyte 100 ohms, heat would be developed, but this heat would not be $\frac{8}{6}$ of what it was before, but according to Joule's law above cited $(\frac{8}{6})^2$ its former value. It would remain still $\frac{1}{8}$ of the total heat developed in the circuit, the total being increased in the same ratio, a little consideration will show that the difference of potential between the electrode would be three volts, of which two are owing to the counter electromotive force.

Application of Principles to Battery.

The law of equivalents in electrolytes applies to the battery itself. For every 63·5 grammes of copper deposited from a solution of sulphate of copper electrolysed 65 grammes of zinc must be consumed in the battery; if a single cell only is employed, and if there is no local action in the cell. It is not an uncommon idea that this statement will hold only if no other work is done in the circuit, such as heating the circuit, that is, if there is no resistance, or, at all events, no resistance except in the electrolyte itself. The resistance in the circuit makes no difference in the ratio between the quantity of zinc used up in the single cell and the amount of the electrolyte decomposed.

This follows from the fact that electricity is conveyed only by the ions; hence the ions must travel in the galvanic cell just as in the electrolyte, and the travelling of the ions in the cell is possible only when zinc is consumed.

The resistance merely diminishes the quantity of electricty which will flow in a given time; the electrolyte will be decomposed more slowly; but, on the other hand, the zinc will be used up more slowly in the same proportion. It is entirely a matter of indifference, so far as the rate of decomposition of the electrolyte or the rate of consumption of zinc in the cell is concerned, *where* the resistance is, whether in the cell or in the connecting wires, or in the electrolyte. The *position* of greatest resistance determines merely the *position* of greatest development of heat. The energy which shows itself as heat is merely the difference between the energy developed by the galvanic cell in the chemical action going on there, and the energy used up by the electrolyte in its decomposition. The latter in some cases may be zero, as, for instance, when copper sulphate is electrolysed between copper electrodes. The energy used up by the decomposition of the copper sulphate is given out again by the re-formation of that salt; as the copper is deposited on the cathode it is taken from the anode. In such a case all the energy goes to heating the circuit. By lessening the resistance the action will go on faster, the current will be greater, and the heat develop more *rapidly*; but otherwise there will be no difference. The energy of the chemical action going on in the cell will produce its equivalent heat somewhere.

In the statement above, the galvanic battery has been assumed to consist of a single cell. If there are two or more cells in series in the battery, more zinc will on the whole be used than is equivalent to the electrolyte decomposed. In fact, each cell of the series will consume the equivalent zinc, since in each cell the current is carried by the ions.

Suppose, in illustration, that copper sulphate is the electrolyte and the electrodes copper, one Daniell cell will produce a certain current, C, depending on the resistance. There will be 65 grammes of zinc used up for 63·5 grammes of copper deposited on the cathode.

Now, suppose two Daniell cells placed in series, the resistance remaining the same as before, the electromotive force will be doubled, therefore the current will now be 2 C. This being so, twice the quantity of zinc will be used up in *each* Daniell as was consumed before; in all, therefore, four times as much zinc as before. But since the current is twice what it was, twice as much copper will be deposited on the cathode as before; so that, while the zinc consumed is increased four-fold, the copper deposited is increased only two-fold. There is therefore a loss of energy, the two extra equivalents of zinc being wasted as heat.

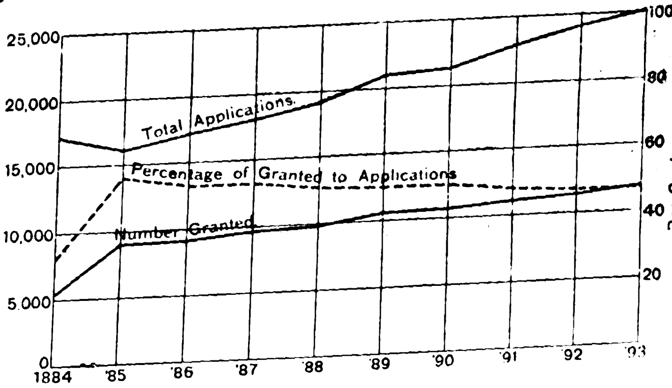
For electrolytic purposes, therefore, it is not economical to increase the electromotive force of a battery by putting on more cells in series; if rapid decomposition is required, the best way is to diminish the resistance in the circuit as much as possible. This statement raises no question except that of economical use of zinc in the battery, it has nothing to do with the matter of convenience of manipulation or excellence of the work performed.

That the two cells in series must consume four times as much zinc as a single cell with the resistance unchanged, is evident from another consideration; the electromotive force is doubled and the current doubled, therefore the power of the battery which is the product of the two, must be increased four-fold. The consumption of the zinc is the source of the power, and, therefore, it must also be increased four-fold.

By a similar argument, it can be shown that two similar dynamos in series will require four times as much power to drive them as either of them alone would require in order to keep up its electromotive force. It is left to the reader to follow out this point, and to trace, if he chooses, the analogy in the working of a series of fans.

PATENTS IN 1893.

During last year 25,120 patents were applied for, as against 24,169 in 1892, an increase of 4 per cent. The Comptroller-General in his report states that the practice of filing a complete specification at the time of application is growing in favour, and that every year the number of applications accompanied by provisional specifications which are allowed to lapse



through omission to file complete specifications becomes relatively larger. The names of eight gentlemen were added to the register of Patent Agents during the year, the total number upon the register upon December 31, 1893, amounting to 237.

The total income of the Patent Office in 1893 amounted to close on £175,000, against nearly £200,000 for 1892. The outgoings amounted to £95,000, leaving a handsome surplus of £80,000, or £23,000 less than last year.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

WEDNESDAY, June 20th.

ROYAL MICROSCOPICAL SOCIETY.

8 p.m. Meeting at 20, Hanover-square.

ROYAL METEOROLOGICAL SOCIETY.

8 p.m. Ordinary Meeting at 25, Great George-street.

FRIDAY, June 22nd.

PHYSICAL SOCIETY.

5 p.m. (1) An Exhibition of Photographs of Flames, by Capt. Abney; (2) "An Elementary Theory of Planimeters," by Prof. Henrici; (3) "The Hatchet Planimeter," by F. W. Hill; (4) "A New Integrating Apparatus," by A. Sharp. Other Papers if time allows.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

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The Electrician.

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MUNICIPAL ELECTRICAL APPOINTMENTS.

Advertisements inviting applications for the position of "Electrician," "Resident Engineer," or "Manager" are now so frequently appearing that it may be of interest to give some attention to the probable position of a successful candidate. The large number of applications sent in for all vacant posts has caused an uneasy impression that the supply of competent engineers far exceeds the demand, and we fear this must always remain true until some standard qualifications in both mechanical engineering and electrical knowledge are generally recognised and defined; the unfortunate result at the present time being that the few qualified men suffer from the glut of embryo engineers who fire off applications regardless, and probably ignorant of, the deficiency of their training. The task of examining testimonials when solely committed to the care of a professional adviser is probably lightened by his skilful winnowing of talk from deeds; but if these applications, with their accompanying testimonials, are placed before the members of an average Corporation or Town Council the bewildering array of talent seeking their patronage must have a tendency to increase their pride in their importance and to depreciate the value of the services of the chosen man; in fact, they may justly say to him, "Engineers are cheap to-day, and if we don't like you there are plenty more." An obvious remedy for this plethora of inexperienced aspirants would be the publication of the minimum requisite qualifications, but this would practically mean a definition of the much-abused title, assumed at discretion by the plumber, bell-hanger, upholsterer, and others, who call themselves electrical engineers by virtue of handling wire and nails; and as such a definition has never yet been attempted, it is not surprising that statements or advertisements of municipal staff requirements are published in somewhat general terms, though occasionally one reads that the applicant must have had experience in a "central station" with, perhaps a modicum of "theoretical training," whatever that may mean. If, as we hope, the time has now arrived

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when all agree that the work involved in reducing the potential energy in coal to the maximum amount of electrical energy, and utilising and supplying the same with the least waste, is simply and solely a mechanical operation, and therefore entirely within the province of a mechanical engineer conversant with electrical science, then the term "electrician" may revert to its original meaning, and to those experts in the cable-testing rooms who originally assumed it.

A mechanical engineer may have theoretical or practical, or perhaps both qualifications, but as his duty in an electricity supply works is to manage men and handle material, it follows that to be worthy of this position he must have had practical employment in the workshops, and if this has been accompanied by sound theoretical training, he is all the more likely to have realised the importance of his work. We confess it would be a relief to see future inquiries for electrical engineers accompanied by a proviso that the applicant must have had at least three years' shop practice and some experience in electricity supply works, any further qualifications being enumerated or implied in the statement of duties; these conditions would tend to stem the tide with its ever-increasing flow of unqualified applicants, and while many would retire from the field rather than face the difficulties before them, those who had the pluck and determination to place their ambition on firm ground would not only facilitate all their future labours, but would also improve their prospects and the position of their profession. This desirable result might be attained if consulting engineers would mutually draw up specifications for the most perfect resident engineer, &c., and agree amongst themselves that they will recommend only those applicants who fulfil the requirements. In many cases the consulting engineer is placed in a delicate position as regards the final selection, for though the municipal authority may consult him, it sometimes happens that they have a decided preference for a local aspirant who has neither sympathy with the consulting engineer, nor the necessary experience and knowledge to appreciate his labours; every hitch in the working of the plant or mains somehow becomes magnified into a great blunder which the municipal authority are led to believe can only be rectified by the local aspirant—in fact, the reputation of consulting engineer and contractors is at the mercy of the successful candidate who has slipped in through the wide meshes of a general statement of qualifications, which the consulting engineer has not elaborated into an acknowledged form of close specification. The remuneration now offered for appointments involving serious responsibility cannot be considered very generous, and consulting engineers might reasonably be expected to suggest a more liberal and adequate return for labours upon the success of which so much depends. A perusal of the statements of duties recently issued by various corporations and boroughs will give an impression that the candidate will find it all very easy if he only carries out the orders and instructions to be given him by others, and a feeling of curiosity may be pardoned if we wonder what these instructions are likely to be, for we find in one document of this kind some evidence that the selected "electrician," also referred to in the advertisement as an electrical engineer, is to be considered as a tame and helpless subordinate in the department of the borough surveyor. We read that the electrical engineer must attend to his duties at such hours as the borough engineer may direct, all reports being made to the latter, who is evidently the only authority to whom the successful electrician has access.

Many electrical engineers are at present so enamoured of municipalisation of electric supply, for the obvious reason that corporations and vestries have ready-money orders to give, that no general observations on the subject are likely to receive much attention, nor is the present occasion a suitable one. We must, however, refer to the extremely interesting article by Mr. JOSEPH CHAMBERLAIN in the current number of the *New Review*. Municipalisation was not so popular among electrical engineers when Mr. CHAMBERLAIN proposed to give power to local authorities to buy up electric supply undertakings at the end of seven years, a term afterwards altered in Committee to fifteen years, and by the House of Lords to twenty-one years; but times have altered, local authorities, once detested, are now courted and flattered, and Mr. CHAMBERLAIN has moderated and matured his views. The ruinous effect of municipal workshops is clearly pointed out in this article, and serious objection made to the action of the London County Council in becoming their own builders and contractors; but what concerns us at present are his observations on municipal technical appointments, and these we quote in full. "A workman with 30s. a week, or a small shopkeeper with £100 or £200 a year, cannot understand the necessity or propriety of paying a town clerk or a chief engineer £2,000 or £3,000 a year. He is very ready to be liberal, and even generous, in dealing with the wages of manual or unskilled labour, but he does not appreciate the exceptional value of special technical gifts and professional experience. In his position as a councillor appointing his subordinates, he finds it difficult to believe that the man can be worth so much more than the master. He is aware that hundreds are ready to take the post for a tenth part of the remuneration, and he forgets that a single mistake or act of carelessness on the part of a high official may cost the community many times as much as the whole of his salary."

The positions of borough surveyors or engineers have long been recognised as honourable distinctions in an important branch of the wide field of engineering, the work necessitating a special training and experience in architecture, building, road making, and occasionally the design, construction, and use of dust destructors; but it seems impossible to believe that a correct appreciation and sound knowledge of high-pressure steam plants and electrical machinery can have been attained, together with the necessary experience in the working, to warrant exclusive authority being held over an electrical engineer able to show proofs of his abilities. Our only object in stating these views is to uphold the dignity of a profession which can no longer be considered as an unimportant or secondary branch of engineering. The training of an electrical engineer is so essentially one long struggle with difficulties, that after emerging from the ordeal the student has a more retentive mind and a greater energy of purpose than the drawing-office pupil who has only developed a pretty skill in colouring tracings. Yet we fear the young electrical engineer will have to continue to fight his way, taking comfort in the thought that municipal works such as tramways, water supplies, &c., may at no distant date become an important part of the utilisation of the energy from the electrical power works which few towns will be so ill-advised as to neglect. The "central station" now so frequently eccentric in position (and occasionally in design) will then bloom into a riper manhood and nobler name of "power house," and we hope by that time the nominal remuneration now offered for services cheerfully undertaken and ably performed will increase to a substantial salary, instead of being a mere honorarium, and thus avert the danger of the "central station" becoming a veritable "work house."

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The happy combination of the electrician with the mechanical engineer, or *vice versâ*, must result in rapidly developing many improvements in industrial applications of power, and while the field of employment for electrical engineers may, we hope, accommodate a large army of qualified men, work will always be found for those whose tastes or opportunities have led them to seek the calmer life of an electrician. This reminds us that the Commissioners of Sewers of the City of London are now inviting applications for the post of electrical inspector, and as the duties attached to this position are essentially those of a highly qualified electrician—if they are to be properly and perfectly carried out—we have studied with much interest the circular of duties issued to all applicants. These duties are clearly stated, and considerable care has evidently been given to their compilation. The best man will, doubtless, be selected, but we feel some sympathy for the unsuccessful candidates, as it is probable a large number will apply, buoyed up by the easy wording of the list of duties. For example, under the heading of "Machinery," we read, "He must have sufficient knowledge of the practical working of electric plant of all kinds to enable him to understand the uses of the various portions of the generating and distributing apparatus." This condition would, doubtlessly, be easiyl fulfilled in the case of an ordinary continuous-current supply, but no warning is given of the necessity of the candidate having had experience of periodic currents or alternating-current machinery. The testing of meters within this district will also, we fear, require higher qualifications than those enumerated in the list, for no mention is made of the employment of two different types of alternators by the Company supplying the area, and we cannot recommend the task of certifying meters, or of "devising the best means of satisfactorily testing any electrical meter," as an easy matter, except to those who are on speaking terms with phase characteristics, and who have some acquaintance with power factors and other distinguishing features of the harmonic progress of alternate currents. It is, therefore, with some reason that we urge the importance of insisting upon an ascending scale of qualifications for all appointments.

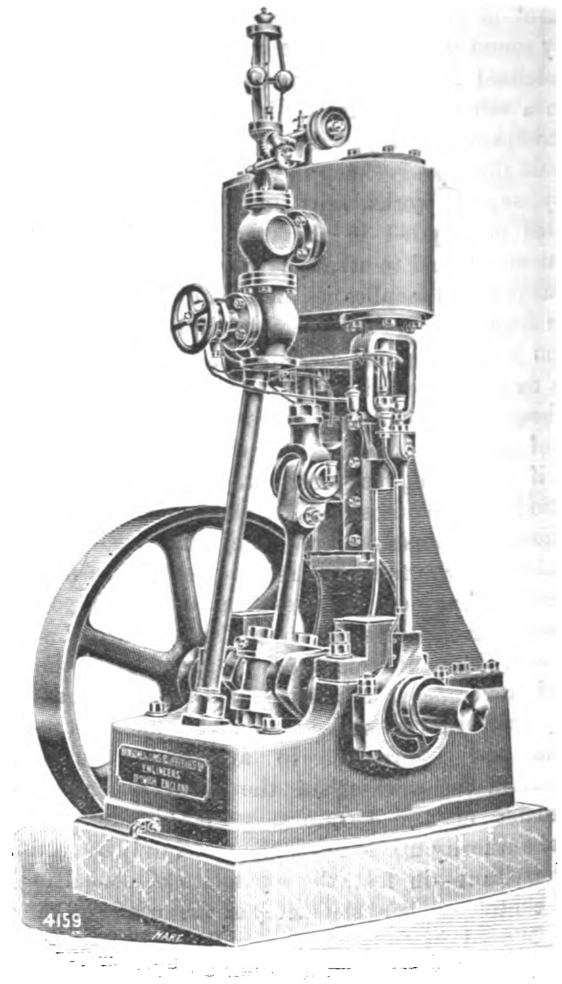
REVIEWS.

Taschenbuch für Monteure elektrischer Beleuchtungsanlagen. By S. Freiherr v. Gaisberg. (R. Oldenbourg, Munich and Leipzig.)

The fact that this "Pocket-book for Wiremen" has reached its eighth edition predisposes the reviewer to a favourable estimate of its contents, and a nearer acquaintance with it has not caused us to form the opposite opinion. It must always be a source of difficulty in the compilation of handbooks of this sort to include only that kind of matter which suits the intelligence of the man who is to use it, but in reading over this work we have several times noticed the inclusion of facts which no ordinary wireman is ever likely to require to know; on the other hand, the total absence of theorising (we have not met a single 4π in the book) is very refreshing. If, however, the wireman requires no figures nor equations, does not want to know the specific resistance of copper, nor the value of π, then a good deal of the rest must also be above his head. The practical hints are valuable, and should be useful to any man of intelligence, though we notice in one place a curious omission. In treating of charging cells, and remarking on the care that must be taken to have the dynamo of the right polarity, the author does not allude to the universal method used for ensuring this, namely, putting the field coils in series with the cells before starting up. On the whole, however, these small defects do not much detract from the value of the book, and we regret that there is little chance of any British workman ever being able to use it.

A HIGH-SPEED VERTICAL STEAM ENGINE.

We give this week an illustration of a high-speed, vertical, inverted, open type of steam engine, specially designed for electric lighting and similar work, by Messrs. Ransomes, Sims, and Jefferies. The illustration shows a pattern constructed for a belt drive, and with throttle valve steam governing; but the engine is also manufactured for direct driving, the engine and dynamo being bolted to the same bed, and may be fitted with a special form of automatic expansion "shaft" governor. This governor acts directly on the piston slide valve. The throttle valve governor is of the well-known Pickering pattern, and is provided with the usual attachment for varying the speed. The engine being of the open type and designed to



Ransomes, Sims and Jefferies High Speed Engine.

run at a high speed, a wrought-iron splash-guard (not shown in our illustration) is provided. Ample bearing surface has been provided for working at high speeds and with considerable steam pressures, the length of each bearing being twice the diameter of the journal. We understand that no tests have yet been made which would show the steam consumption on ordinary loads, and we regret that we are unable to give our readers any information on this point. There is a great field for economical small steam motors of this class, and we hope that the engines of Messrs. Ransomes, Sims and Jefferies will shortly be put under trial with a view to determine their economy.

THE WATERHOUSE ELECTROLYTIC METER.

In view of the comparatively small measure of success which has attended the Edison electrolytic depositing meter, even in the land where it first saw light, and notwithstanding the time and trouble devoted to its perfection, it is a somewhat bold step to seek to introduce into this country such a primitive piece of apparatus as a voltameter-meter, that is to say, one in which the time integral of the current is measured by the

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volume of the mixed gases given off in a voltameter. We were, however, invited last week to inspect a meter on this principle, and it would certainly seem as if the undoubted advantages of the electrolytic type of meter, namely, cheap first cost, easy calibration, and robust mechanism had been secured at the same time that many of the usually-urged objections to this type had been met. At any rate, English electricity consumers have the satisfaction of knowing that, unless this type of meter survives the stringent examination at the Standardising Laboratory, the Board of Trade will bar its way into general use.

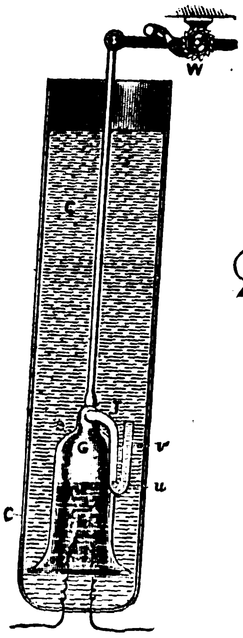


Fig. 1.

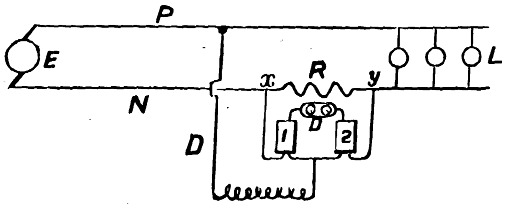


Fig. 2.

The electrolytic cell of the meter, which the Waterhouse Electrometric Syndicate are seeking to put on the market, is shown in Fig. 1. The electrodes are two coils of platinum wire, and the electrolyte is a 12 per cent. solution of sulphuric acid. The mixed gases are collected in the glass bell-jar B, which is fitted with an inverted syphon-tube T. The gases accumulate until they force the fluid down to the bend of the U-tube, when they escape, leaving the collector ready to collect another charge of gas. The rise and fall of the bell-jar in the glass cell actuate a ratchet wheel, and the motion is recorded by a series of dials and pointers in the usual way.

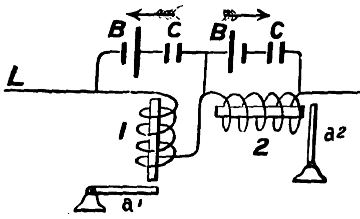


Fig. 3.

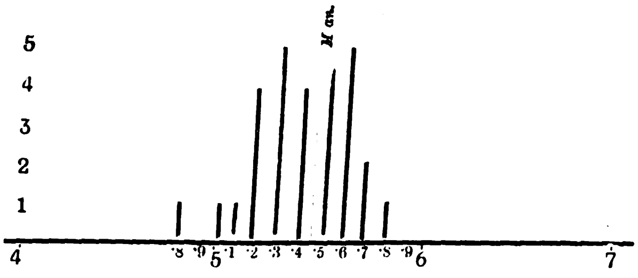
The latest arrangement of the meter circuit is shown diagrammatically in Fig. 2; where E is the source of energy, P and N the positive and negative mains respectively, D a derived circuit of some 1,200 ohms leading to the meter, L the lamps, and R the portion of the main circuit with which the meter-circuit is placed in parallel. When no lamps are alight a special device, not shown, breaks the derived circuit, completing it as soon as one lamp is turned on. If we assume the derived circuit D to be complete but no current to be flowing in the mains, the derived current will divide equally between the two electrolytic cells 1 and 2, the floats of which work the dial *d* in opposite directions, thus nothing is registered. On the other hand, when a current flows in the mains there will be a fall of potential between x and y proportional to the amount of current passing from the lamps. As the fall of pressure over R is limited by the Board of Trade to 0·5 volt, whilst the counter electromotive force offered by the two cells is over 4 volts, it is evident that none of the main current will actually pass through the meter circuit, but, according to the difference of potential between x and y, a greater or less proportion of the total derived circuit current will be diverted through cell 1. The main current is thus measured indirectly by the varying proportions of a practically constant current which is sent through cell 1. In this way the necessity for maintaining by a system of carefully-adjusted resistances the exact proportionality at all temperatures between R and the meter circuit is got over. A meter of this kind, it is obvious, can be made extremely sensitive, since if the derived circuit D is not broken, the minutest fall of pressure over R will have its due changing-over effect. The range also can be made as wide as we please by suitably reducing the value of R. The two branches of the meter circuit being of identical nature, and exposed to identical conditions, temperature effects, so far as resistance is concerned, cancel out, and the errors introduced by volumetric temperature effects are small within the ordinary limits, and easily compensated for. Ordinary changes in the voltage do not materially affect the indications, owing to the fact that, as the meter works differentially, any change in the derived current will balance itself on both sides when no lamps are burning; and when lamps are put on, any increase in the derived current will reduce the changing-over effect, on account of the increased fall of potential over the meter circuit, and *vice versâ*. Curves produced by this meter show it to be capable of considerable accuracy.

Mr. Waterhouse also proposes to apply the voltameter principle, so as to obtain non-wasteful shunts, safety shunts for series motors run on constant current circuits, &c. In Fig. 3 is shown a sort of electrolytically polarised relay arrangement. When the line current is passing from left to right the path through the shunt battery B and electrolytic cell C is taken in preference to that through the high resistance coil 1, and the armature a^1 is left at rest, whilst a^2 is actuated. Just the opposite takes place when the current is sent along the line in the reverse direction.

THE MEAN OF OBSERVATIONS.

One of the diagrams on the walls of the Royal Institution on Friday last, to which Prof. Vernon Boys had no time to allude, was taken from Prof. Poynting's book on "The Mean Density of the Earth." This diagram, which we reproduce, is an interesting mode of exhibiting the distribution of a number of results about the mean. The diagram relates to the 29 results

Mean of Observations.



of Cavendish about the mean value 5·448. The figures 1 to 5 on the left-hand side refer to the number of observations, and the figures on the horizontal scale are the value of the results. The vertical lines in the diagram show that the results, 4·8, 5, 5·1, and 5·8 were obtained on three occasions, 5·7 was obtained twice, 5·2 and 5·4 were each obtained four times, and 5·3, 5·5, and 5·6 appeared five times each. The extremities of these lines would fall very fairly on a symmetrical probability curve, were it not for the single observation 4·8, but consideration of the average deviation shows that such an observation is not highly improbable.

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The application of the theory of probabilities to the errors of observations, the calculation of the so-called probable error, and the average deviation, involve so much mathematical work that, in many cases, time would much better be spent in making a few more observations, and relying on the arithmetical mean. Some observations, such as transits of Venus, can be made only at rare intervals; others, such as the motions of double stars, consist in the record of slow changes; and others, again, as in the case of Prof. Boys' recent research, consist in weeks or months of preliminary measurements, culminating in a few observations on a single night. In these, examination of the results by the theory of errors is of great importance. One of the important lessons taught by the theory of errors is the distinction between an error and a mistake. Cavendish, with all his experimental care, and painstaking calculations, made a mistake in adding up the results of these observations, to get the mean. The plotting of results on squared paper, even when no graphical record is wanted, is a valuable safeguard against mistakes, and this simple method of showing the distribution of results about the mean, deserves to be better known, and to be frequently used. The theory of probability and a large number of its applications has been recently treated by Prof. Karl Pearson from a geometrical point of view, and when his Gresham College lectures on this extremely interesting topic are published, they will no doubt do much to popularise a subject which is generally presented in a most unattractive form.

A METHOD FOR THE TREATMENT OF ROTATING OR ALTERNATING VECTORS, WITH AN APPLICATION TO ALTERNATE CURRENT MOTORS.

BY PROF. GALILEO FERRARIS.

(*Concluded from page 153.*)

17. In that which precedes, we have considered the relation between the couple of rotation and the frequency u of the *relative motion* of the rotating field with respect to the armature. To find now the relation between the couple and the velocity of the rotation of the armature, it is enough to observe that if we represent, as usual, by n the frequency of the rotating magnetic field, and represent by m the frequency of the rotation of the armature, or the number of turns which the armature makes in 1″, we have

$$u = n - m.$$

Inserting this value into (1) we have

$$K = \pi N B^2 S^2 \frac{r(n-m)}{r^2 + 4\pi^2 L^2 (n-m)^2}, \quad . \quad . \quad . \quad . \quad . \quad (2)$$

which gives the required relation. The curve into which this formula is converted when we take as ordinate the couple K, and as abscissa the frequency m of the rotation of the armature, can be deduced at once from the curve $C_1 O C_2$ of Fig. 14; but this is the same curve only referred to other axes of co-ordinates. In fact, let there be set out on $O X'$ a length $O O_1 = n$, and let p be the foot of the ordinate of any point P of the curve $C_1 C_2$, then we have $O_1 p = O O_1 - O p = n - u = m$. Then take the point O_1 as the origin of the co-ordinates, the straight line $O_1 Y_1$ parallel to $O Y$ as axis of the ordinates, and take $O_1 O X$, directed from right to left, as positive part of the axis of the abscissæ; the line $C_1 M' O P M Q C_2$ is then without doubt such that its points which have for co-ordinates the values of m and of K.

The curve exhibits the properties appertaining to the motor. Two cases must be distinguished; the case of $n \leqq \frac{1}{2\pi} \frac{r}{L}$, and that of $n > \frac{1}{2\pi} \frac{r}{L}$.

In the first case, when $n \leqq \frac{1}{2\pi} \frac{r}{L}$; when, therefore, $2\pi n L \leqq r$, we have $O O_1 \leqq O q$. The origin O_1 falls to the left of q or at q. Then K has the maximum value for $m=0$. The motor couple is at a maximum when the armature no longer turns, and is at its maximum at the moment of starting. If when starting from rest, or from $m=0$, m is made to increase, K diminishes down to nothing for $m=n$ and to become negative for $m > n$. The running of the motor is steady. In fact, the resisting couple increases, and if meanwhile m diminishes, pP increases; moreover, the motor couple K increases also, until it becomes equal to the new value of the resisting couple. If *vice versâ* the resisting couple diminishes, and if meanwhile the velocity augments, p P diminishes, or also diminishes the motor couple K until it re-establishes the equilibrium.

In the second case, when $n > \frac{1}{2\pi} \frac{r}{L}$, or when $2 \pi n L > r$, we have $O O_1, > O q$. The origin O_1 falls to the right of q. Then for $m = 0$ the motor couple K has a value $O_1 Q$ less than the maximum q M. If m is made to increase, starting from the value zero, K commences to increase, and attains the maximum value q M when $m = O_1 q = O_1 O - O q = n - \frac{r}{2 L \pi}$. After that, if m again increases K diminishes down to nothing for $m=n$, and becomes negative for $m > n$. The working of the motor is steady, for $m > O_1 q$, or for $m > n - \frac{r}{2\pi L}$, because then, as in the preceding case, an augmentation of the resisting couple, provoking a diminution of m, gives place to a diminution of K, by which the equilibrium is re-established. But for $m \leqq n - \frac{r}{2\pi L}$ the working of the motor is unsteady. If, in fact, by an augmentation of the resisting couple a diminution of m is proved, this diminution gives place to a diminution of the motor couple K, and therefore to a further diminution of m; and this effect is reproduced and multiplied until the motor is brought to rest.

In all the cases K is reduced to zero by $m = n$, and becomes negative for $m > n$. That is to say, that in no case can an armature turn itself with a frequency greater than that of the current, unless by means of a motor couple applied from without to the shaft, or without an expenditure of work. The couple necessary for that has the maximum moment q' M′ when

$$m = O_1 O + O q' = O_1 O + O q = n + \frac{r}{2\pi L}.$$

In the second case before considered, when $2\pi n L > r$, it may happen (and it happens commonly when n is great) that the value O_1 Q of K corresponding to $m=0$ is insufficient for the starting of the motor. Then the starting may be aided by inserting a non-inductive resistance into the circuit of the armature, thus making r increase without augmenting L. In fact the value K_0 of K which formula (2) gives for $m=0$, a value which can be written

$$K_0 = \pi N B^2 S^2 \frac{n}{r + \frac{4\pi^2 n^2 L^2}{r}},$$

is greatest for $r = 2\pi n L$. And moreover, since r is less than $2\pi n L$, it increases with the increase of r. The efficacy of this artifice for increasing K_0 at the moment of starting is so much the greater, the greater the frequency n of the current used, and it is precisely in the case of great frequencies that it may be necessary. The motor may be able to start itself without special provision, and has a more steady working when the frequency n is small.

18. *Closed Armature placed in an Alternating Magnetic Field. Monophase Asynchronous Motors.*—Let us imagine, now, that the same armature already considered in Article 15 is situated no longer in a rotating magnetic field, but in an alternating magnetic field of fixed direction, that which now occurs may be easily deduced from what has been already said. The alternating magnetic field is equal to two fields rotating in opposite directions; similarly, the currents induced in the armature are equivalent to two magnets rotating in opposite directions. There acts, therefore, upon the armature a couple equal to the resultant of those exercised by the two fields upon the two rotating magnets. But by what was said in Article 12, case 3rd, the mean values of the couples produced by any of the fields on the magnet rotating in the opposite sense are equal to zero; hence the mean value of the moment of the resultant couple acting in total on the armature is simply equal to the difference between that of the couple which the field rotating to the right exercises on the magnet rotating to the right, and that of the couple which the field rotating to the left produces on the magnet rotating to the left. Given K_1 and K_2, the moment of these two couples, and given K, the moment of the resulting couple acting on the armature (taken as positive when the couple is directed towards the right), we have

$$K = K_1 - K_2. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

The couples K_1 and K_2 can be calculated by the formula (1) of Art. 16. We should remember at this point that B represents the value of the magnetic induction in each of the two rotating fields into which the given alternating field is resolved. It may also be noted that the maximum value of the magnetic induction in this last may be represented by 2 B. We should then substitute successively in the formula for the frequency u of the relative motion, the values u_1 and u_2 corresponding to the movements which the two rotating fields have *relatively to the armature*. Now if it is supposed that the armature turns *towards the right* with a frequency m, and we represent by n the frequency of the alternating magnetic field, we have

$$u_1 = n - m, \quad u_2 = n + m;$$

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thence,
$$K_1 = \pi N B^2 S^2 \frac{r(n-m)}{r^2+4\pi^2 L^2(n-m)^2}, \quad . \quad . \quad . \quad . \quad (4)$$
$$K_2 = \pi N B^2 S^2 \frac{r(n+m)}{r^2+4\pi^2 L^2(n+m)^2}, \quad . \quad . \quad . \quad . \quad (5)$$
and, finally,
$$K = \pi N B^2 S^2 r \left[\frac{n-m}{r^2+4\pi^2 L^2(n-m)^2} - \frac{n+m}{r^2+4\pi^2 L^2(n+m)^2} \right]. \quad . \quad (6)$$

The curves which represent the relations between K_1, K_2, K, and the frequency m of the rotation of the armature, can be copied at once from $C_1 O C_2$, which in Fig. 14 represents the equation (1): The $C_1 O C_2$ is reproduced and marked with the same letters as in Fig. 15, where, as in 14, the point O is the origin of u; and the point O_1, at the distance $O O_1$, which is at a distance n from O, is the origin of m.

If we take (Fig. 15) $O_1 p_1 = O_1 p_2 = m$, and draw the corresponding ordinates $p_1 P_1$ and $p_2 P_2$; we have at once: $O p_1 = O O_1 - p_1 O_1 = n - m$ and $O p_2 = O O_1 + O_1 p_2 = n + m$. Thence the ordinates $p_1 P_1$ and $p_2 P_2$ represent respectively K_1 and K_2. In order to have K alone it is enough to subtract $p_2 P_2$ from $p_1 P_1$. If we cut off from $p_1 P_1$ the segment $P_1 P = p_2 P_2$, the remaining segment $p_1 P$ represents K, and the point P is a point of the curve which gives K as a function of m, referred to the axes of co-ordinates $O_1 X$ and $O_1 Y_1$.

What the form of the curve K should be we see also more clearly if we draw the line $Q P_0 C_0$ symmetric, with respect to the axis $O_1 Y_1$, to the portion $Q P_2 C_2$ of $C_1 O C_2$. Then there results the value of K corresponding to the value $O_1 p_1$ of m, represented by the segment $P_0 P_1$, comprised between the two lines $Q P_1 C_1$ and $Q P_0 C_0$. This segment is equal to the ordinate $p_1 P$ of the curve K, corresponding to the abscissa $m = O_1 p_1$. The examination of the curve K shows clearly the principal property of the motor. The moment K of the couple acting on the armature is zero when $m=0$, or when the armature is at rest; but if this turns suddenly K assumes a value different from zero, and if the frequency m of the rotation does not exceed the value represented in the figure by $O_1 A$, it is positive, or the couple has the same direction of rotation, it is a motor couple. If, starting from rest, the armature takes an increasing velocity, the couple, zero at the beginning, goes on increasing finally to a maximum, reaching which, if m also increases, it thence diminishes rapidly and is reduced again to zero when m reaches a determinate value $O_1 A$ somewhat lower than n. For the values of m greater than $O_1 A$, the couple K becomes and remains always negative, or is opposed to the rotation, it being a resisting couple.

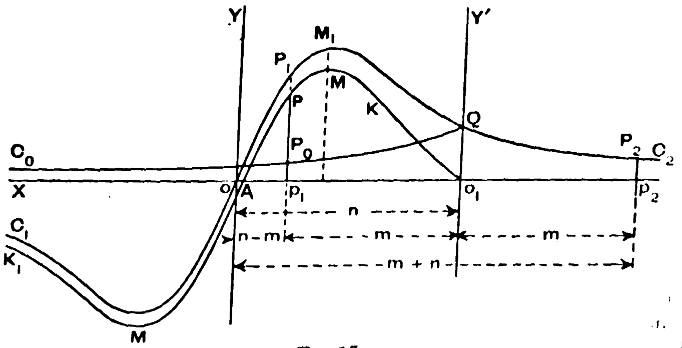

Fig. 15.

The descending portion of the curve M M′ corresponds to a steady running of the motor. In fact, if, whilst the armature turns with the frequency $m = O_1 p_1$, and with the motor couple $p_1 P$, the resisting couple begins to increase somewhat, and becomes greater than $p_1 P$, the velocity of the armature diminishes, $O_1 p_1$ diminishes, and the motor couple $p_1 P$ increases up to the re-establishment of equilibrium. If similarly the resisting couple begins to diminish, the armature is accelerated p_1, is projected towards the left, and the motor couple $p_1 P$ diminishes also.

On the other hand, the working is not steady for the ascending portion $O_1 M$ of the line, or for values of m less than that to which the maximum of the motor couple corresponds. Then, in fact, a diminution of velocity due to an excess of the resisting couple over the motor couple, provokes a diminution of this last, and, therefore, produces a further diminution of velocity, which is multiplied and continues until the armature stops completely. The descending portion of the curve K, for which the working is stable, has an inclination slightly less than that of the neighbouring curve $C_1 O C_2$, and the inclination of this at point O (Art. 16) is equal to $\frac{\pi N B^2 S^2}{r}$. Similarly, the maximum point of the curve K is but little distant from that of the curve $C_1 O C_2$, the abscissa of which is $n - \frac{1}{2\pi} \frac{r}{L}$ (Art. 16). Hence, if the resistance r is small, the useful portion of the curve K has a large slope; and, if the self-induction L is not very small, the values of m corresponding to it are comprised within limits very close to one another. This happens pretty often in practice; the motor is truly asynchronous, but the limits between which the velocity can vary compatibly with steadiness of working are frequently much restricted. The line $Q P_1 O C_1$ (Fig. 15) is that which would represent the relation between the motor couple and the velocity when the armature, instead of being situated in an alternating field where the magnetic induction has the maximum value 2 B, might be situated in a simple rotating magnetic field, where the induction would have the constant value B. Meanwhile Fig. 15 shows clearly the analogy and the difference which exist between the properties of an asynchronous motor with alternating field and those of a motor with rotating field.

If n is not very small, and if the resistance r of the armature is as is usual somewhat small, the two curves $Q P_1 O C_1$ and $O_1 K P A K_1$ run very close to one another for all the values of m superior to those for which the motors commenced to have a steady working. Thence for all the velocities compatible with a steady working the monophase motor behaves, approximately, like the motor with rotating field; only the motor couple is in it somewhat smaller, and is reduced to zero for a value of m somewhat less than n. The two curves diverge most from one another in the parts corresponding to the lesser velocity. The charcteristic difference which follows therefrom is that for $m=0$, the moment of the motor couple, which in the motor with rotating field may have a value $O_1 Q$, which is fairly high, is zero in the monophase motor. The motor with rotating field may start of itself, the monophase motor cannot do so.

The expression (6) for the motor couple of a monophase motor can also easily be found, without going back to our method of treatment of alternating vectors; it was, in fact, demonstrated by

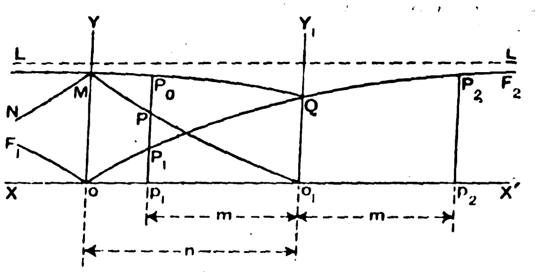

Fig. 16.

Dr. J. Sahulka directly by a purely algebraic method (1), and is noteworthy. But the essential advantage of our method is, that it appeals to a physical reasoning of facts, and shows clearly the relations which exist between a motor with alternating field and one with rotating field. A motor with alternating field presents itself as a motor with differential rotating field; its properties are derived directly from those of the motors with rotating field.

19. Various additional considerations present themselves which would be hardly obvious by the ordinary analytical treatment. One of these refers to the nature of the currents in the armature, and to the reaction of these on the inductor. The currents in the armature are equivalent, as we have shown, to two magnets rotating in opposite directions. The vectors which represent these magnets turn in space with equal angular velocity and precisely with the frequency n of the alternating magnetic field; they are, therefore (Art. 4, b), equivalent to the system of a rotating vector and of an alternating vector. That is to say, that the currents induced in the armature produce in space a flux of magnetic induction, which may be considered as resulting from the superposition of two fluxes, one of constant value and rotating in direction, the other of alternating value and in a fixed direction. Let us consider these two fluxes successively.

Rotating Flux.—The rotating flux is proportional to the difference between the *absolute values* of the vectors which represent the two rotating magnets equivalent to the currents of the armature (Art. 4, b). Therefore it is proportional to
$$y_1 - y_2,$$
where y_1 and y_2 represent the *absolute* values, coresponding to
$$u = n - m \text{ and to } u = n + m,$$
of the quantity y, which is the function of u given by the formula
$$y = \frac{u}{\sqrt{r^2 + 4\pi^2 u^2 L^2}}.$$

In order to give an idea of the mode of variation of it as a function of m, it is enough to consider the curve of y. Now y has

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absolute values for u and for $-u$, which are equal. It is equal to zero, for $u=0$, increases with the increase of u, and for $u=\pm\infty$ tends asymptotically towards the value $\frac{1}{2\pi L}$ as its limit. If, then (Fig. 16), we take as abscissæ the values of u, and as ordinates the absolute values of y, and if we take as origin the point O, and as the positive direction of the axis of u the line O X′, we find the line $F_1 O F_2$, which has for asymptote the straight line, L L, parallel to the axis of the abscissæ. In order to find $y_1 - y_2$ we take $O O_1 = n$ and $O_1 p_1 = O_1 p_2 = m$; there results $O p_1 = n - m$, $O p_2 = n + m$, whence the ordinates $p_1 P_1$ and $p_2 P_2$ represent y_1 and y_2, and we have at once $y_1 - y_2 = p_1 P_1 - p_2 P_2 = -(p_2 P_2 - p_1 P_1)$.

The mode of variation of this difference appears clear if we draw in $Q P_0 M$ the line symmetric with respect to $O_1 Y_1$ to $Q P_2 F_2$. Now we have $y_1 - y_2 = - P_1 P_0$. We can, if we wish, take this length as ordinate, and thus find, that taking as origin the point O_1, as axis of the ordinates the line $O_1 Y_1$ and as the positive direction of the axis of abscissæ $O_1 X$, $y_1 - y_2$ is represented as a function of m by the curve $O_1 P M N$.

The sign ($-$) of the value derived from the condition $p_2 P_2 > p_1 P_1$ tells that the flux under consideration rotates towards the left, or in the direction opposed to the movement of the armature. Now this flux, which turns towards the left, produces in the metal of the fixed part of the machine, induced currents on which it then exercises forces tending to draw it from its proper rotation, towards the left. Thence, *vice versâ*, the induced currents in the fixed part of the machine solicit the armature to turn towards the right, in the direction in which it already moves. Whence results that the rotating flux due to the currents in the armature provokes induced currents, which help the rotation, and give place to a couple, which joins to the principal couple of which we spoke in the preceding article. The value of the couple due to the induced currents varies with the variation of m, and increases with the increase of the ordinate $p_1 P$ of the line $O_1 M N$. It is zero for $m=0$ and greatest for $m=n$. Owing to it, the total couple acting on the armature instead of being reduced to zero for $m = O_1 A$ (Fig. 15), is not reduced to zero for any value a little larger, a little nearer to n.

Alternating Flux.—The alternating vector resulting from the composition of two vectors rotating in opposite senses, has an amplitude equal to double the smallest of the two component vectors (Art. 4). However, the alternating flux is proportional to

$$\frac{n-m}{\sqrt{r^2 + 4\pi^2 L^2 (n-m)^2}}.$$

It can be zero only for $m=n$.

THE WORK OF HERTZ.*

(Continued from page 155.)

Zinc Discharging Negative — Electricity in Light; Gold Leaf Electroscope; Glass and Quartz Panes; Quartz Prism.

Take a piece of zinc, clean it with emery paper, connect it to a gold leaf electroscope, and expose it to an arc lamp. If charged positively nothing appears to happen, the action is very slow; but a negative charge leaks away in a few seconds if the light is bright. Any source of light rich in ultra-violet rays will do; the light from a spark is perhaps most powerful of all. A pane of glass cuts off all the action; so does atmospheric air in sufficient thickness (at any rate, town air), hence sunlight is not powerful. A pane of quartz transmits the action almost undiminished, but fluor-spar may be more transparent still. Condensing the arc rays with a quartz lens and analysing them with a quartz prism or reflection grating, we find that the most effective part of the light is high up in the ultra-violet, surprisingly far beyond the limits of the visible spectrum† (Figs. 7 and 8).

This is rather a digression, but I have taken some pains to show it properly because of the interest betrayed by Lord Kelvin on this matter, and the caution which he felt about accepting the results of the Continental experimenters too hastily.

It is probably a chemical phenomenon, and I am disposed to express it as a modification of the volta contact effect* with illumination.

Return now to the Hertz vibrator, or Leyden jar with its coatings well separated, so that we can get into its electric as well as its

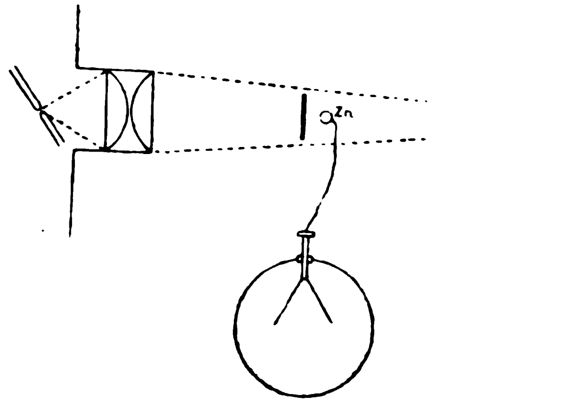

Fig. 7.—Zinc Rod with Glass Screen.

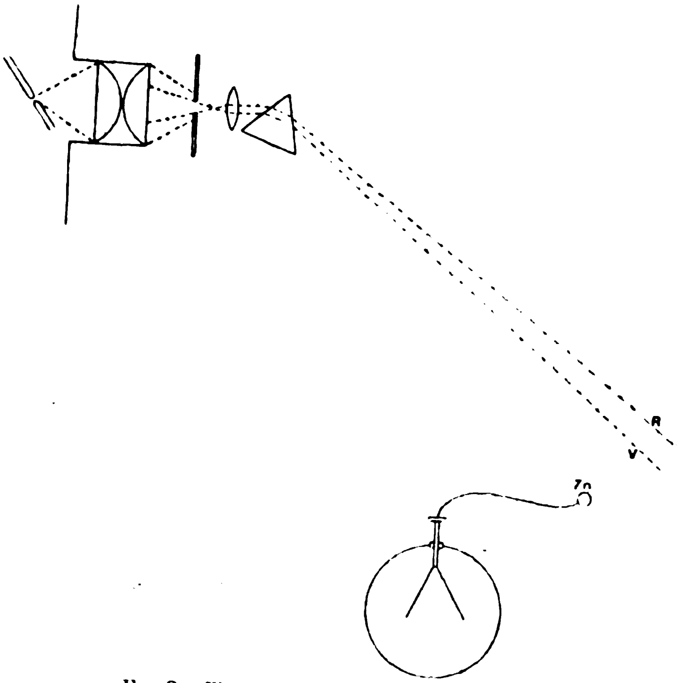

Fig. 8.—Zinc Rod with Ultra-violet Light.

magnetic field. Here is a great one giving waves 30 metres long, radiating while it lasts with an activity of 100 H.P., and making ten million complete electric vibrations per second.

Large Hertz Vibrator in action; Abel's Fuse; Vacuum Tube; Strike an Arc.

Its great radiating power damps it down very rapidly, so that it does not make above two or three swings; but nevertheless, each time it is excited, sparks can be drawn from most of the reasonably elongated conductors in this theatre.

A suitably situated gas-leak can be ignited by these induced sparks. An Abel's fuse connecting the water pipes with the gas pipes will blow off; vacuum tubes connected to nothing will glow (this fact has

* A lecture delivered at the Royal Institution on Friday, June 1st, by Prof. Oliver Lodge, F.R.S., ably assisted during both preparation and performance by Mr. Edward E. Robinson.

† While preparing for the lecture it occurred to me to try, if possible, during the lecture itself, some new experiments on the effect of light on negatively charged bits of rock and ice, because if the effect is not limited to metals it must be important in connection with atmospheric electricity. When Mr. Branly coated an aluminium plate with an insulating varnish, he found that its charge was able to soak in and out of the varnish during illumination (*Comptes Rendus*, Vol. CX., p. 898, 1890). Now, the mountain tops of a negatively charged earth are exposed to very ultra-violet rays, and the air is a dielectric in which quiet up-carrying and sudden downpour of electricity could go on in a manner not very unlike the well-known behaviour of water vapour; and this perhaps may be the reason, or one of the reasons, why it is not unusual to experience a thunderstorm after a few fine days. I have now tried these experiments on such geological fragments as were handy, and find that many of them discharge negative electricity under the action of a naked arc, especially from the side of the specimens which was somewhat dusty, but that when wet they discharge much less rapidly, and when positively charged hardly at all. Ice and garden soil discharge negative electrification, too, under ultra-violet illumination, but not so quickly as limestone, mica schist, ferruginous quartz, clay, and some other specimens. Granite barely acts; it seems to insulate too well. The ice and soil were tried in their usual moist condition, but, when thoroughly dry, soil discharges quite rapidly. No rock tested was found to discharge as quickly as does a surface of perfectly bright metal, such as iron, but many discharged much more quickly than ordinary dull iron, and rather more quickly than when the bright iron surface was thinly oiled or wetted with water. To-day (June 5) I find that the leaves of the geranium discharge positive electrification five times as quickly as negative, under the action of an arc-light, and that glass cuts the effect off while quartz transmits it.

* See Brit. Assoc. Report, 1884, pp. 502-519, or *Phil. Mag.*, Vol. XIX, pp. 267-352.

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been familiar to all who have worked with Hertz waves since 1889); electric leads, if anywhere near each other, as they are in some incandescent lamp-holders, may spark across to each other, thus striking an arc and blowing their fuses.

This blowing of fuses by electric radiation frequently happened at Liverpool till the suspensions of the theatre lamps were altered.

The striking of an arc by the little reverberating sparks between two carbon points connected with the 100 volt mains I incidentally now demonstrate.

sensitive galvanometer could indicate that a feeble spark had passed, by reason of the consequent disturbance of electrical equilibrium which settled down again through the galvanometer. This was the method he used in this theatre four years ago. Blyth used a one-sided electrometer, and young Bjerkness has greatly developed this method (Fig. 14), abolishing the need for a spark, and making the electrometer metrical, integrating, and satisfactory.† With this detector many measurements have been made at Bonn

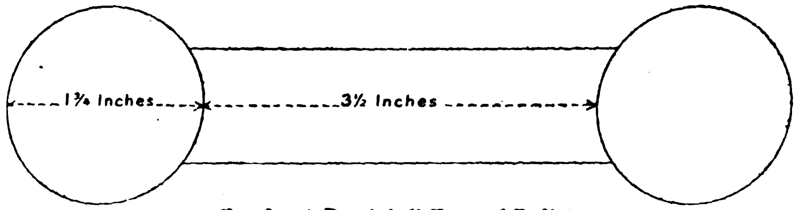

FIG. 9.—A Dumb-bell Form of Radiator.

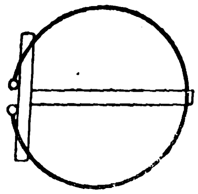

FIG. 11.—Circular Resonator.

There are some who think that lightning flashes can do none of these secondary things. They are mistaken.

On the table are specimens of various emitters and receivers such as have been used by different people (*see* Table). The orthodox Hertz radiator of dumb-bell type (Fig. 9), the orthodox Hertz receivers (Fig. 10); a circular ring (Fig. 11) for interference experiments, because it is but little damped, and a straight wire for receiving at a distance, because it is a much better absorber.

by Bjerkness, Yule, Barton, and others on waves concentrated and kept from space dissipation by guiding wires.

Mr. Boys has experimented on the mechanical force exerted by electrical surgings, and Hertz also made observations of the same kind.

Going back to older methods of detecting electrical radiation, we have, most important of all, a discovery made long before man existed, by a creature that developed a sensitive cavity on its skin ;

Detectors of Radiation.

Physiological.	Chemical.	Thermal.	Electrical.	Mechanical.	Microphonic.
					Selenium.(?)
Eye.	Photographic Plate.	Thermopile.	Spark. (Hertz.)	Electrometer. (Blyth and Bjerknes.)	Impulsion Cell. (Minchin.)
× Frog's Leg. (Hertz and Ritter.)	Explosive Gases.	Bolometer. (Rubens and Ritter.)	Telephone ; Air-gap and Arc. (Lodge.)	Suspended Wires. (Hertz and Boys)	Filings. (Branly.)
	Photoelectric Cell.	Expanding Wire. (Gregory.)	Vacuum Tube. (Dragoumis).		Coherer. (Hughes and Lodge.)
		Thermal Junction. (Klemencic.)	Galvanometer. (Fitzgerald.)		
			Air-gap and Electroscope. (Boltzmann.)		
			Trigger Tube. (Warburg and Zehnder.)		

× The cross against the frog's leg indicates that it does not appear really to respond to radiation, unless stimulated in some secondary manner. The names against the other things are unimportant, but suggest the persons who applied the detector to electric radiation. The interrogation mark against Selenium indicates that its position in the microphonic column may be doubtful.

Beside these are the spheres and ellipsoids (or elliptical plates), which I have mainly used, because they are powerful radiators and absorbers, and because their theory has been worked out by Horace Lamb and J. J. Thomson. Also dumb-bells without air-gap, and many other shapes, the most recent of mine being the inside of a hollow cylinder with sparks at ends of a diameter ; this (Fig. 12) being a feeble radiator, but a very persistent vibrator,* and, therefore, well adapted for interference and diffraction experiments. But, indeed, spheres can be made to vibrate longer than usual by putting them into copper hats or enclosures, in which an aperture of varying size can be made to let the waves out.

Many of these senders will do for receivers too, giving off sparks to other insulated bodies or to earth ; but, besides the Hertz type

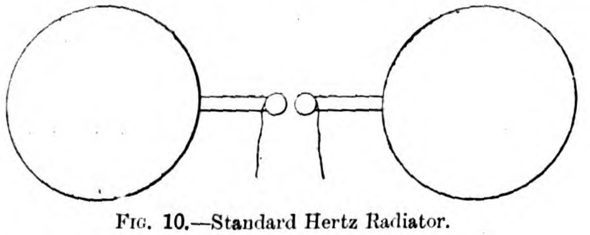

FIG. 10.—Standard Hertz Radiator.

of receiver, many other detectors of radiation have been employed. Vacuum tubes can be used, either directly or on the trigger principle, as by Zehnder (Fig. 13),† the resonator spark precipitating a discharge from some auxiliary battery or source of energy, and so making a feeble disturbance very visible. Explosives may be used for the same purpose, either in the form of mixed water-gases or in the form of an Abel's fuse. Fitzgerald found that a tremendously

* J. J. Thomson, "Recent Researches," 344. † *Wied. Ann.*, XLVII., 47, p. 77.

a creature which never so much as had a name to be remembered by (though, perhaps, we now call it trilobite). Then, in recent times we recall the photographic plate and the thermopile with its modification, the radiomicrometer ; also the so-called bolometer, or otherwise known Siemens' pyrometer, applied to astronomy by Langley ; applied to the detection of electric waves in wires by

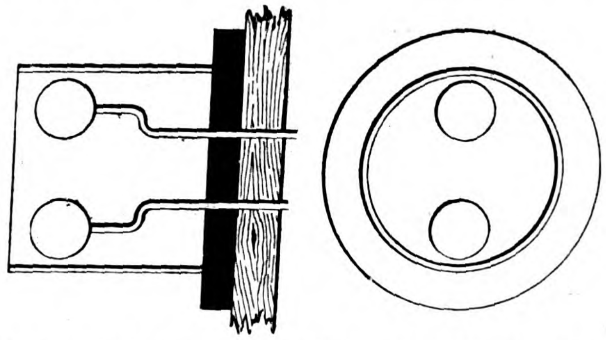

FIG. 12.—Dr. Lodge's Hollow Cylindrical Resonator, arranged horizontally against the Inside of a Wooden Box. Half natural size.

Rubens and Ritter and Paalzow and Arons. The thermal junction was applied to the same purpose by Kolacec, D. E. Jones, and others.

And, before all these, the late Mr. Gregory, of Cooper's Hill, made his singularly sensitive expansion meter, whereby waves in free space could be detected by the minute rise of temperature they

* Fitzgerald, *Nature*, Vol. XLL, p. 295, and Vol. XLII., p. 172.
† *Wied. Ann.*, XLIV., 44, p. 74.

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caused in a platinum wire, a kind of early and sensitive form of Cardew voltmeter.

Going back to the physiological method of detecting surgings, Hertz tried the frog's-leg nerve and muscle preparation, which to the steadier types of electrical stimulus is so surpassingly sensitive, and to which we owe the discovery of current electricity. But he failed to get any result. Ritter has succeeded; but, in my experience, failing in the normal and proper result. Working with my colleague Prof. Gotch, at Liverpool, I too have tried the nerve and muscle preparation of the frog (Fig. 15), and we find that an excessively violent stimulus of a rapidly alternating character, if pure and unaccompanied by secondary actions, produces no effect—no stimulating effect, that is, even though the voltage is so high that sparks are ready to jump between the needles in direct contact with the nerve.

All that such oscillations do, if continued, is to produce a temporary paralysis or fatigue of the nerve, so that it is unable to transmit the nerve impulses evoked by other stimuli, from which paralysis it recovers readily enough in course of time.

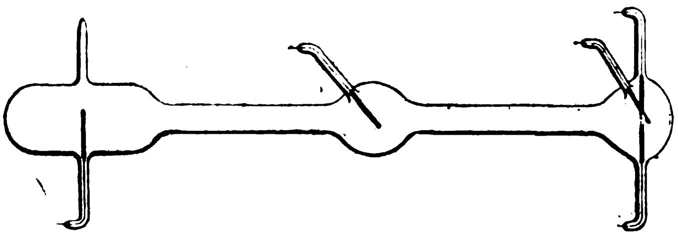

FIG. 13.—Zehnder's Trigger Tube. Half Natural Size.

This has been expected from experiments on human beings, such experiments as Tesla's and those of d'Arsonval. But an entire animal is not at all a satisfactory instrument wherewith to attack the question; its nerves are so embedded in conducting tissues that it may easily be doubted whether the alternating type of stimulus ever reaches them at all. By dissecting out a nerve and muscle from a deceased frog after the historic manner of physiologists, and applying the stimulus direct to the nerve, at the same time as some other well known $\frac{1}{100}$th of a volt stimulus is applied to another part of the same nerve further from the muscle, it can be shown that rapid electric alternations, if entirely unaccompanied by static charge or by resultant algebraic electric transmission, evoke no excitatory response until they are so violent as to give rise to secondary effects such as heat or mechanical shock. Yet, notwithstanding this inaction, they gradually and slowly exert a paralysing or obstructive action on the portion of the nerve to which they are applied, so that the nerve impulse excited by the feeble just perceptible $\frac{1}{100}$th-volt stimulus above is gradually throttled on its way down to the muscle, and remains so throttled for a time varying from a few minutes to an hour after the cessation of the violence.

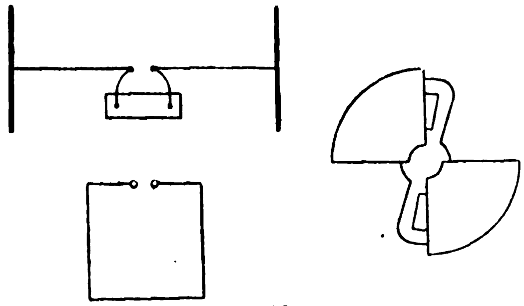

FIG. 14.

I had intended to exhibit this effect, which is very marked and definite, but it is impossible to show everything in the time at my disposal.

Air Gap and Electroscope charged by Glass Rod and discharged by moderately distant Sphere excited by Coil.

Among trigger methods of detecting electric radiation, I have spoken of the Zehnder vacuum tubes; another method is one used by Boltzmann.* A pile of several hundred volts is on the verge of charging an electroscope through an air gap just too wide to break down. Very slight electric surgings precipitate the discharge across the gap, and the leaves diverge. I show this in a modified and simple form. On the cap of an electroscope is placed a highly-polished knob or rounded end connected to the sole, and just not touching the cap (Fig. 16). Such an electroscope overflows suddenly and completely with any gentle rise of potential. Bring excited glass near it, the leaves diverge gradually and then suddenly collapse, because the air space snaps; remove the glass, and they rediverge with negative electricity; the knob above the cap being then charged positively, and to the verge of sparking. In this condition any electrical waves, collected if weak by a foot or so of wire projecting from the cap, will discharge the electroscope by exciting surgings in the wire, and so breaking down the air-gap. The chief interest about this experiment seems to me the extremely definite dielectric strength of so infinitesimal an air space. Moreover, it is a detector for Hertz waves that might have been used last century; it might have been used by Benjamin Franklin.

For to excite them no coil or anything complicated is necessary; it is sufficient to flick a metal sphere or cylinder with a silk handkerchief and then discharge it with a well-polished knob. If it is not well polished the discharge is comparatively gradual, and the vibrations are weak; the more polished are the sides of an air-gap, the more sudden is the collapse and the more vigorous the consequent radiation, especially the radiation of high frequency, the higher harmonics of the disturbance.

For delicate experiments it is sometimes well to repolish the knobs every hour or so. For metrical experiments it is often

FIG. 15.—Experiment of Gotch and Lodge on the physiological effect of rapid pure electric alternations. Nerve and muscle preparation, with four needles or else non-polarisable electrodes applied to the nerve. C and D are the terminals of a rapidly alternating electric current from a conductor at zero potential, while A and B are the terminals of an ordinary very weak galvanic or induction coil stimulus only just sufficient to make the muscle twitch.

better to let the knobs get into a less efficient but more permanent state. This is true of all senders or radiators. For the generation of the, so to speak, "infra-red" Hertz waves any knobs will do, but to generate the "ultra-violet" high polish is essential.

Microphonic Detectors.

Receivers or detectors, which for the present I temporarily call microphonic, are liable to respond best to the more rapid vibrations. Their sensitiveness is to me surprising, though of course it does not approach the sensitiveness of the eye; at the same time, I am by no means sure that the eye differs from them in kind. It is these detectors that I wish specially to bring to your notice.

Prof. Minchin, whose long and patient work in connection with photo-electricity is now becoming known, and who has devised an instrument more sensitive to radiation than even Boys' radiomicrometer, in that it responds to the radiation of a star while the radiomicrometer does not, found some years ago that some of his slight excitable cells lost their sensitiveness capriciously on tapping, and later he found that they frequently regained it again while Mr. Gregory's Hertz-wave experiments were going on in the same room.

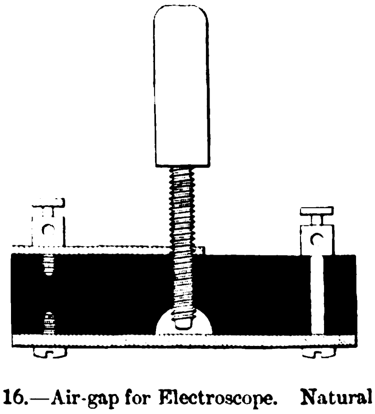

FIG. 16.—Air-gap for Electroscope. Natural Size.

These "impulsion-cells," as he terms them, are troublesome things for ordinary persons to make and work with—at least I have never presumed to try—but in Mr. Minchin's hands they are surprisingly sensitive to electric waves.*

The sensitiveness of selenium to light is known to everyone, and Mr. Shelford Bidwell has made experiments on the variations of conductivity exhibited by a mixture of sulphur and carbon.

Nearly four years ago M. Edouard Branly found that a burnished coat of porphyrised copper spread on glass diminished its resistance enormously, from some millions to some hundreds of ohms when it was exposed to the neigbourhood, even the distant neighbourhood, of Leyden jars or coil sparks. He likewise found that a tube of metallic filings behaved similarly, but that this recovered its original resistance on shaking. Mr. Croft exhibited this fact

* *Wied. Ann.*, XL., p. 399.

* *Phil. Mag.*, Vol. XXXI., p. 223.

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recently at the Physical Society. Branly also mades pastes and solid rods of filings in Canada balsam and in sulphur and found them likewise sensitive.*

With me the matter arose somewhat differently, as an outcome of the air-gap detector employed with an electroscope by Boltzmann. For I had observed in 1889 that two knobs sufficiently close together, far too close to stand any voltage such as an electroscope can show, could, when a spark passed between them, actually cohere; conducting an ordinary bell-ringing current if a single voltaic cell was in circuit; and, if there were no such cell, exhibiting an electromotive force of their own sufficient to disturb a low resistance galvanometer vigorously, and sometimes requiring a faintly perceptible amount of force to detach them. The experiment was described to the Institution of Electrical Engineers,† and Prof. Hughes said he had observed the same thing.

Coherer in open, responding to Feeble Stimuli; Small Sphere Gas-lighter; Distant Sphere Electrophorus.

Well, this arrangement, which I call a coherer, is the most astonishingly sensitive detector of Hertz waves. It differs from the actual air-gap in that the insulating film is not really insulating; the

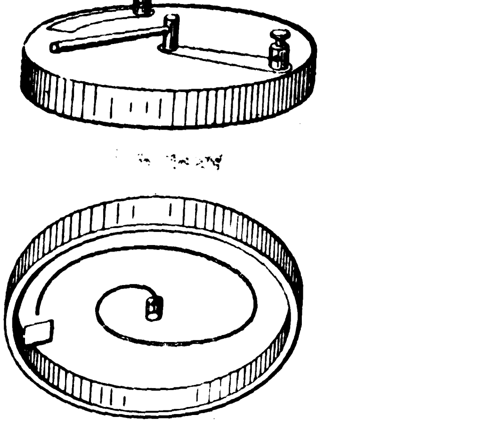

FIG. 17.—Wire Coherer, consisting of a spiral of thin iron wire mounted on an adjustable spindle and an aluminium plate. When the lever is moved clockwise, against a stop not shown in the illustration, the tip of the iron wire presses very gently against the aluminium plate.

film breaks down not only much more easily, but also in a less discontinuous and more permanent manner than an air-gap. A tube of filings, being a series of bad contacts, clearly works on the same plan; and though a tube of filings is by no means so sensitive, yet it is in many respects easier to work with, and, except for very feeble stimuli, is more metrical. If the filings used are coarse, say turnings or borings, the tube approximates to a single coherer; if they are fine, it has a larger range of sensibility. In every case what these receivers feel are sudden jerks of current; smooth

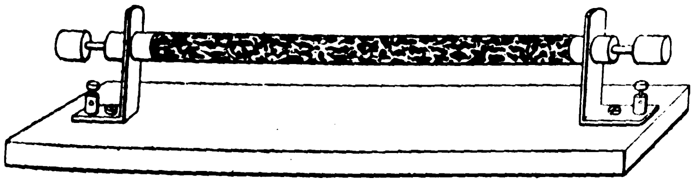

FIG. 18.—Iron Borings Coherer, one-third natural size.

sinuous vibrations are ineffective. They seem to me to respond best to waves a few inches long, but doubtless that is determined chiefly by the dimensions of some conductor with which they happen to be associated. (Figs. 17 and 18.)

Filings in open, responding to Sphere, to Electrophorus, to Spark from Gold-leaf Electroscope.

I picture to myself the action as follows: Suppose two fairly clean pieces of metal in light contact—say two pieces of iron—connected to a single voltaic cell; a film of what may be called oxide intervenes between the surfaces, so that only an insignificant current is allowed to pass, because a volt or two is insufficient to break down the insulating film except perhaps at one or two atoms. If the film is not permitted to conduct at all, it is not very sensitive; the most sensitive condition is attained when an infinitesimal current passes, strong enough just to show on a moderate galvanometer.

Now let the slightest surging occur, say by reason of a sphere being charged and discharged at a distance of forty yards, the film at once breaks down--perhaps not completely, that is a question of intensity—but permanently. As I imagine, more molecules get within each other's range, incipient cohesion sets in, and the momentary electric quiver acts as it were as a flux. It is a singular variety of electric welding. A stronger stimulus enables more molecules to hold on, the process is surprisingly metrical, and as far as I roughly know at present, the change of resistance is proportional to the energy of the electric radiation from a source of given frequency.

It is to be specially noted that the battery current is not needed to effect the cohesion, only to demonstrate it. The battery can be applied after the spark has occurred, and the resistance will be found changed as much as if the battery had been on all the time.

The incipient cohesion electrically caused can be mechanically destroyed. Sound vibrations, or any other feeble mechanical disturbances, such as scratches or taps, are well adapted to restore the contact to its original high-resistance sensitive condition. The more feeble the electrical disturbance the slighter is the corresponding mechanical stimulus needed for restoration. When working with the radiating sphere (Fig. 19) at a distance of forty yards out of window, I could not for this reason shout to my assistant, to cause him to press the key of the coil and make a spark, but I showed him a duster instead, this being a silent signal which had no disturbing effect on the coherer or tube of filings. I mention 40 yards, because that was one of the first outdoor experiments; but I should think that something more like half an mile was nearer the limit of sensitiveness. However, this is a rash statement not at present verified. At 40 yards the exciting spark could be distinctly heard, and it was interesting to watch the spot of light begin its long excursion and actually travel a distance of 2in. or 3in. before the sound arrived.

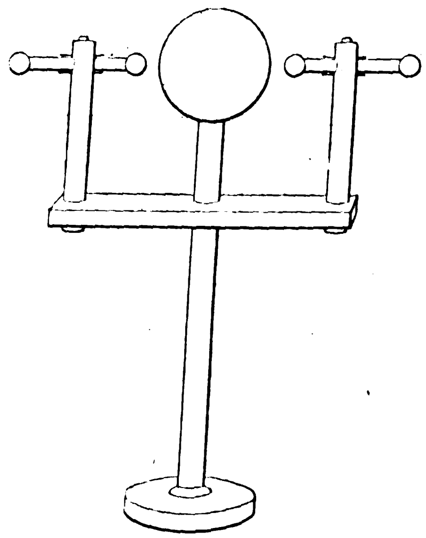

FIG. 19.—Radiator used in the library of the Royal Institution, exciting the Coherer (Fig. 18) on the lecture table in the theatre.

This experiment proved definitely enough that the efficient cause travelled quicker than sound, and disposed completely of any sceptical doubts as to the sound-waves being, perhaps, the real cause of the phenomenon.

Invariably, when the receiver is in good condition, sound or other mechanical disturbance acts one way, viz., in the direction of increasing resistance, while electrical radiation or jerks act the other way, decreasing it. While getting the receiver into condition, or when it is getting out of order, vibrations and sometimes electric discharges act irregularly, and an occasional good shaking does the filings good. . I have taken rough measurements of the resistance, by the simple process of restoring the original galvanometer deflection by adding or removing resistance coils. A half-inch tube 8in. long, of selected iron turnings, had a resistance of 2,500 ohms in the sensitive state. A feeble stimulus, caused by a distant electrophorous spark, brought it down 400 ohms. A rather stronger one reduced it by 500 and 600, while a trace of spark given to a point of the circuit itself, ran it down 1,400 ohms.

This is only to give an idea of the quantities. I have not yet done any seriously metrical experiments.

From the wall diagram which summarises the various detectors, and which were prepared a month or so ago, I see I have omitted selenium, a substance which in certain states is well known to behave to visible light as these other microphonic detectors behave to Hertz waves.

And I want to suggest that quite possibly the sensitiveness of the eye is of the same kind. As I am not a physiologist I cannot be seriously blamed for making wild and hazardous speculations in that region. I therefore wish to guess that some part of the retina is an electrical organ, say like that of some fishes, maintaining an electromotive force which is prevented from stimulating the nerves

* E. Branly, *Comptes Rendus*, Vol. CXI., p. 785; and Vol. CXII., p. 90.
† *Journal* Institution of Electrical Engineers, 1890, Vol. XIX., pp. 352-4; or "Lightning Conductors and Lightning Guards" (Whittaker), pp. 382-4.

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solely by an intervening layer of badly conducting material, or of conducting material with gaps in it; but that when light falls upon the retina these gaps become more or less conducting, and the nerves are stimulated.

I do not feel clear which part is taken by the rods and cones, and which part by the pigment cells; I must not try to make the hypothesis too definite at present.

If I had to make a demonstration model of the eye on these lines, I should arrange a little battery to excite a frog's nerve and muscle preparation through a circuit completed all except a layer of filings or a single bad contact. Such an arrangement would respond to Hertz waves. Or, if I wanted actual light to act instead of grosser waves, I would use a layer of selenium.

But the bad contact and the Hertz waves are the most instructive, because we do not at present really know what the selenium is doing, any more than what the retina is doing.

And observe that (to my surprise, I confess) the rough outline of a theory of vision thus suggested is in accordance with some of the principal views of the physiologist Hering. The sensation of light is due to the electrical stimulus; the sensation of black is due to the mechanical or tapping back stimulus. Darkness is physiologically not the mere cessation of light. Both are positive sensations, and both stimuli are necessary; for until the filings are tapped back vision is persistent. In the eye model, the period of mechanical tremor should be, say, $\frac{1}{10}$th second, so as to give the right amount of persistence of impression.

No doubt in the eye the tapping back is done automatically by the tissues, so that it is always ready for a new impression, until fatigued. And by mounting an electric bell or other vibrator on the same board as a tube of filings, it is possible to arrange so that a feeble electric stimulus shall produce a feeble steady effect, a stronger stimulus a stronger effect, and so on, the tremor asserting its predominance, and bringing the spot back whenever the electric stimulus ceases.

An electric bell thus close to the tube is, perhaps, not the best vibrator; clockwork might do better, because the bell contains in itself a jerky current, which produces one effect, and a mechanical vibration, which produces an opposite effect; hence the spot of light can hardly keep still. By lessening the vibration—say, by detaching the bell from actual contact with the board, the electric jerks of the intermittent current drive the spot violently up the scale; mechanical tremor brings it down again.

You observe that the eye on this hypothesis is, in electrometer language, heterostatic. The energy of vision is supplied by the organism; the light only pulls a trigger. Whereas the organ of hearing is idiostatic. I might draw further analogies, about the effect of blows or disorder causing irregular conduction and stimulation of the galvanometer in the one instrument, of the brain cells in the other.

A handy portable exciter of electric waves is one of the ordinary hand electric gas-lighters, containing a small revolving doubler—*i.e.*, an inductive or replenishing machine. A coherer can feel a gas-lighter across a lecture theatre. Minchin often used them for stimulating his impulsion cells. I find that when held near they act a little before the spark occurs, plainly because of the little incipient sparks at the brushes or tinfoil contacts made. A Voss machine acts similarly, giving a small deflection while working up before it sparks. And notice here that our model eye has a well-defined range of vision. It cannot see waves too long for it.

(To be concluded.)

ELECTRICAL TRADES SECTION.

The members of the Electrical Trade Section of the London Chamber of Commerce met in the afternoon of Thursday, June 7th, at the offices, Botolph House, Eastcheap, under the presidency of Major Flood Page.

After the usual preliminaries were disposed of, the Chairman said that the members would remember that when they did him the honour of appointing him to the chair he accepted the office on condition that the appointment should be for only two years. The subject was discussed pretty freely at the time, and they came to the conclusion that it would be far better that they should have a change of Chairman every two years. For that period he had presided over the Section, and he now took the opportunity of thanking them for the kindness and forbearance with which they had treated him during the time he had held that honourable position. He had been, more or less, in bad health the whole time, and had not been so active, perhaps, as he might otherwise have been. He believed that it now became his privilege to nominate his successor, and he had great pleasure in proposing that Mr. Emile Garcke should be elected to the office.

Mr. Sellon seconded the motion, which was agreed to unanimously.

Mr. Garcke, having taken the chair, said that while thanking them for the confidence which they reposed in him by placing him in that responsible position, he felt that he occupied it under the great disadvantage of its having been filled first by Mr. Crompton and then by Major Flood Page. He could but say that he would do his best to perform his duties to the satisfaction of the members. He would like to refer to the very valuable services rendered to the Section by Major Flood Page during his period of office, and to propose a vote of thanks to him for his services. Although that gentleman had not enjoyed the best of health, they must all recognise that he had devoted a great deal of time to the interests of the Section, with the result that they had been enabled to carry out some very important business matters in which they were all interested, such as the subject of overhead wires and various other questions which had to go before the Board of Trade, in connection with which Major Flood Page had rendered very valuable service.

A Member briefly seconded the motion, which was cordially passed.

Major Flood Page, in expressing his acknowledgment, said that he would be still able to be of some little use to the Section, because the Council had done him the honour of electing him to be a permanent member of that body, and, therefore, in addition to the fact that Mr. Garcke, as Chairman of the Section, would be entitled to attend the meetings of the Council, he (Major Flood Page) would always be there to act upon any suggestion which Mr. Garcke might recommend.

On the motion of the Chairman, seconded by Mr. Sydney Morse, Mr. Siemens was elected Deputy-Chairman.

After a short discussion, a committee was formed to watch the interests of the Section in connection with the rating of electrical works, and a letter was read on the subject of the Locomotive Acts from the Board of Trade, intimating that the representations of the Section on the question of their amendment had been brought to the notice of the Home Office.

The consideration of the provisions of the Electric Lighting Acts with regard to alleged nuisances was left in the hands of the same committee.

On the suggestion of the Chairman, seconded by Mr. Morse, and supported by Mr. Sellon, it was decided to circularise the various departments of the electrical industry, urging upon them the desirability of supporting the Section in promoting the interests appertaining to each.

The proceedings then ended.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

New York, *June* 2, 1894.

New Telephone Rates.—The local New York City Telephone Company on June 1st introduced a new system of charges for telephone service, based upon the number of messages sent by a subscriber. All lines will be metallic circuits, and the subscriber sending messages of not less than 1,000, nor over 2,000 annually, may elect if he will have a line for his sole use, or share one with another subscriber. The lowest annual rate, $100, is for "two-party" lines only and 700 messages, the charge for additional messages being $15 per 100. The lowest rate for a "direct" line is $150 per annum, 1,000 messages being the limit; the charge for those in excess of that number being $12 per 100. A "two-party" line for this service costs $20 less per annum. For 2,000 messages per annum the charge for a "direct" line is $220, and for a "two-party" line $200; excess messages being $8 per 100. For more than $2,000 messages "direct" lines only can be used, and the rate will be $5 per 100, with $7 per 100 for excess messages.

Central Stations in Massachusetts.—A recent report of the Board of the Gas and Electric Light Commissioners of the Commonwealth of Massachusetts for 1893, shows that, during the last year, out of 60 central electric lighting stations in that State 28 paid dividends, 26 paid no dividends, and 6 did not earn expenses. Of the $434,328 paid in dividends, two Boston stations paid $257,808, and the several larger cities paid the greater part of the remainder. Five stations, including those of Boston, paid 8 per cent., two 7 per cent., ten 6 per cent., and two 5 per cent. The assets of the various companies were returned at $14,275,363.23; 37 showing a surplus of $671,261.16, and 23 a deficit of $116,848.15. The

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assessed value of the plants for taxing purposes is $4,588,067, corresponding to a real value in the neighbourhood of $6,000,000. The dynamo capacity of the stations is 293,000 16-c.p. incandescent lamps, 9,910 2,000-c.p. and 9,121 1,200-c.p. arcs. 341 motors are supplied from incandescent circuits, 530 from power circuits, and 30 from arc circuits; the aggregate horse-power being 6,843.

CORRESPONDENCE.

WRIGHT'S DEMAND INDICATOR.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The description of Mr. Wright's Demand Indicator and the account of its effect on the load diagram of the Brighton Corporation, in your issue of June 1st, is most interesting. These instruments have, I understand, been in use at Brighton for over a year, and have been the means of procuring valuable information as to the actual distribution of the load. But it would be interesting to know how they have been appreciated from the consumer's point of view. What innumerable arguments and explanations must have taken place between the Corporation's officials and the consumers. If the majority of the Brighton consumers consisted of professors and amateur electricians, I could believe that matters have worked comparatively smoothly; but what does the average shopman think of these complicated methods of charging for the supply? My experience, both in London and the provinces, with less complicated methods of charging has not been such as to lead me to believe that the ordinary consumer will look upon the demand indicator as an unmitigated blessing. The consumer wants to know nothing about load factors and how he can assist the supply company. What he wants is to get his supply at as low a price as possible per unit, and he does not want to be told that he should be careful to ask if the lights are switched off in the dining-room before he switches on those in the drawing-room. He considers that he had the electric light laid on in his house for his own convenience, and to use exactly as he likes and when he likes. The idea of his having to give 24 hours' notice to the Corporation that he wishes to switch on an extra number of lamps for a particular night, as otherwise his account for the whole month will show a serious increase, may appear very simple, but in actual practice the annoyance and trouble both to the consumer and to the Corporation would certainly be a very great objection. The electric light companies which are on the best terms with their customers are those who make it a rule to have the least to do with them. Consumers object to frequent visits of the supply company's officials; a monthly call of the meter inspector is as much as most of them will stand.

Some customers have a firm conviction that electric lighting companies are great monopolies, which were formed with the express object of swindling the public. The humble meter reader is looked upon as the wicked agent of the company, who will stick on a few extra units if he only gets the chance. These people like to be able to calculate the amount actually used at certain times in pounds, shillings, and pence. For this reason they like to have meters which read direct in Board of Trade units, as a constant multiplier with decimals is too much for them. What would these people have to say to the demand indicator and the Brighton system of charge?

It may be said that the demand indicator was not worked out on the assumption that all consumers are devoid of ordinary intelligence. I do not in the least insinuate anything of the sort. What I say is, that the average consumer does not like a complicated system of charging; he can easily understand the charges of the gas company, and he does not see why the account for electric light should not be equally simple. I assume that there is not much difference between the London customers and those of the Brighton Corporation, and I think I know the species fairly well.

The increased clerical work which must be necessary in getting out the accounts on this system of charge must be by no means a negligible quantity.

The instrument and the system are a credit to the inventor's ingenuity, but surely they are more suitable for use in connection with small plants, with a limited number of consumers, than on a system of such large dimensions as that which the Brighton Corporation's promises to assume under Mr. Wright's able management?—Yours, &c., PERCY STILL.

Draycott-place, Cadogan-gardens, S.W.,
June 9, 1894.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As you have kindly favoured me with Mr. Still's remarks on my method of charging for electricity, it may be well to point out to him that the primary use of my instrument is to make the reduction of charge for electricity consumed depend on the actual use the consumer has made of the plant and mains laid down ready for him, and not necessarily on his intelligent appreciation of the equitable nature of the method of charge as Mr. Still seems to suppose. The subject is essentially a commercial one of how equitably and profitably to charge, as low rates as possible for electricity, and I therefore fail to see why it should be only understood by amateur electricians. It is not a matter of importance from a central station point of view whether the consumers understand the theoretical basis of the system or not; but every consumer appreciates a reduced charge, and our customers have no difficulty in understanding that the longer they burn their lights the cheaper the rate at which they will be charged for it. We cannot say whether, theoretically, our customers understand the system; but it will interest Mr. Still to learn that during the past year we have not experienced that abundance of argument from our customers that he anticipates, and the fact remains that they have taken advantage of the inducements we held out to them by lengthening their demand and improving the load factor at the central station 15 per cent., and this without any special instructions other than those shown on the indicator itself and a circular announcing the reduction. Mr. Still will probably fully appreciate an improved load factor in these days of shrinkage of earnings per lamp, as it clearly shows the method is a commercial success. Our customers can take their light how, when, and in what manner they please, and in any case they pay no more than they did before the reduction was inaugurated; but we offer a consumer every inducement to effect his own reductions by thoroughly wiring his premises, as in the ordinary course of things no one uses all their rooms or premises at one time, and your correspondent is hardly justified in assuming that a man will wantonly leave electric lights burning in empty rooms any more than that the same man at present recklessly wastes his gas in a similar way.

I noticed the average number of units consumed per lamp installed of the Company Mr. Still is connected with have fallen from 12·5 to 10·3, while ours in Brighton have risen from 19·5 to 22, and I venture to say the principal reason for this great difference is probably because in Brighton we encourage, by reducing the charges, the use of the light in basements, and long-used rooms. Mr. Still may probably reply that the reason of the small and decreasing earnings per lamp in Chelsea is because their new customers are largely composed of private houses, which have the light installed in the reception and best bedrooms only, while the basements, kitchens, passages, and other dark places requiring constant light are gas-lit, because gas is cheaper than electricity at 8d.; it is thus shown that the very places that electricity is most needed, and would be most used if charged at sufficiently low rate, have to go gas-lit, but on our system they would be the cause of effecting good reductions on the whole bill by increasing the average quantity consumed per lamp used. It must be borne in mind that those who are responsible for the financial success of electric lighting, must look at the manner of charging from the central-station point of view, and it is imperative for reductions to be equitable, that customers should benefit in the exact ratio to their profitableness.

Our system can claim all this, and by it we can afford to give larger reductions to the most profitable customers, whether large or small consumers, than by any other method. Again, his opinion regarding short circuiting, the demand indicator on

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special occasion being a source of annoyance to the consumer, overlooks the fact that it is only done at the request and for the benefit of the consumer; he is also unaware that the instruments are direct reading, and do all the necessary accountants' work themselves, as the scale used on each instrument dispenses with extra clerical work, and the clerks prepare the bills showing a certain number of units at 7d. and a certain number at 3½d.; and Mr. Still will be interested to learn that we have no difficulty in this respect.—Yours, &c., ARTHUR WRIGHT.

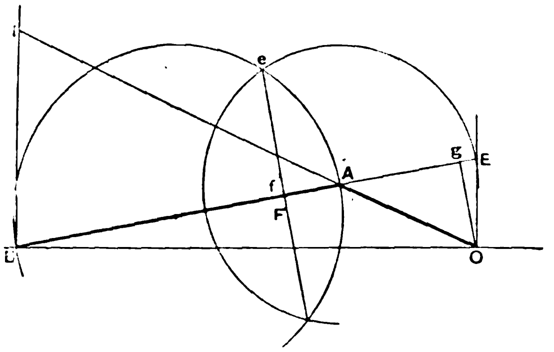
The Brighton Corporation Electricity Works,
North-road, June 13, 1894.

INERTIA OF THE RECIPROCATING PARTS OF A STEAM ENGINE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The very simple graphical construction of Prof. J. F. Klein, Lehigh University, for the determination of the acceleration of the piston of a steam engine seems to be little known on this side of the Atlantic, as several new text-books have appeared since its publication (*Journal* of the Franklin Institute, September, 1891), in which the analytical treatment of the subject is given, or the less simple graphic method of Ritterhaus.

The following is Klein's construction:—Let O A and A B be the crank and connecting rod in any position, let the lengths of the crank and connecting rod be r and l respectively. Produce the connecting rod B A to cut the perpendicular O E to the line of stroke. With A as centre, and A E as radius, draw a circle; on A B as diameter draw another circle, and let the common chord of the two circles cut the line of stroke in F. Then F O is the acceleration of the cross-head to the same scale as O A represents the centripetal acceleration of the crank pin.



The demonstration is as follows:—The motion of the cross-head B may be compounded of two motions: (*a*) a motion of constant velocity, V, in the crank-pin circle; (*b*) a motion of rotation about A, with angular velocity $\frac{V}{AI}$. The acceleration due to the motion (*a*) is $\frac{V^2}{r}$, and is in the direction A O. If the scale of velocity be chosen so that V is represented by the length A O, the acceleration $\frac{V^2}{r}$ may also be conveniently represented by A O; the component of this acceleration in the direction of the connecting rod will then be Ag (Og being drawn perpendicular to A E). The radial acceleration due to the motion (*b*) is $\frac{V^2}{AI^2}l$, and, making the same assumption as to scale, will be represented by the length $\frac{AE^2}{AB} = fA$ (since $\frac{fA}{Ae} = \frac{Ae}{AB}$). The tangential acceleration due to (*b*) has no component in the direction A B. Adding, the component of B's acceleration in the direction B A is fg. But obviously the total acceleration of B is in the direction B O, and must therefore be equal to F O, since fg is the component of F O in the direction B A.

If an ordinate be drawn from B of length equal to F O, and the construction repeated for a number of different crank-pin positions, the rectangular curve of piston acceleration is obtained.

Klein's construction does not fail (as Ritterhaus's does) at the dead points.

If w be the weight of the reciprocating parts per square inch of piston area, and f be the acceleration, the steam pressure in pounds per square inch required to accelerate the moving parts is $\frac{wf}{g}$.—Yours, &c., ARCHD. SHARP.

Guilds Central Technical College,
May 31, 1894.

LEGAL INTELLIGENCE.

Sellman v. Brasyer and Another.

In an action brought before Mr. Justice Mathew by Mr. Sellman, an "electro-masseur," against Col. Brasyer and Mr. F. T. Burbage to recover damages for an alleged malicious prosecution in the recent Medical Battery Company action. Col. Brasyer denied that he preferred any charge, and both defendants pleaded reasonable and probable cause. In 1884 plaintiff was a vocalist, and adopted the professional name of Dudley Towers. In 1886 he was introduced to Harness, and subsequently sang at some concerts given at 52, Oxford-street. Harness told him that he would make him a permanent member of the staff if he would study for an "electro-masseur," and, accordingly, he became a pupil of Dr. Stretch Dowse, and at the expiration of six months received a certificate, and was engaged by Harness as a masseur at a salary of £1 a week. He received an additional commission of 2½ per cent., when patients had a second course of treatment. He had a room in the saloon which was fitted up with batteries and other means of applying electro-massage. He was never known at the Oxford-street establishment as Dr. Towers. Mr. Burbage was a patient, and after reading his testimonials, in which references were made to presents, said if the plaintiff cured him he would give him a present of a box of cigars, which he subsequently did. The plaintiff left the services of the Medical Battery Company in January, 1893, and since that date had had nothing to do with the Company or its business. After leaving the Company he started business on his own account as a masseur, and subsequently at present address. His business increased rapidly, and at the time of his arrest his income varied from £10 to £15 per week. On the evening of November 15, 1893, he went out to post a letter, when he was arrested in the street on a warrant charging him with conspiring with others to defraud the individuals named in the warrant. After this charge against him had been withdrawn he gave evidence. He never told Mr. Pitman, nor Mr. Harvey, nor Mr. Collier, the solicitor, that Mr. Harness deserved five years, or that he was a rogue. He knew nothing about Mr. Harness's character. Plaintiff denied that Mr. Harness was paying the expenses of this action. He had given a bill of sale on his furniture to enable him to clear his character of this wretched stain. The plaintiff's wife also gave evidence, and said she was a saleswoman with Harness six or seven years. After hearing counsel on both sides, the Judge summed up, but the jury were unable to agree to a verdict, and were discharged.

Newgas and Co. v. The Gulcher (New) Electric Light Company.

On Tuesday Mr. Justice NORTH made an order in a debenture holders' action for the appointment of a receiver of the property of the defendant Company.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

TENDERS INVITED.—The Corporation of Cheltenham invite tenders for the supply and delivery of electric lighting cables. Copies of specification and forms of tender may be obtained from Mr. Joseph Hall, the borough engineer, and tenders must be delivered to Mr. E. T. Brydges, the Town Clerk, not later than noon on the 19th inst. Some further particulars appear in our advertisement columns.

———— The Cheltenham Corporation also require tenders for the erection of a central electric lighting station. All particulars can be obtained of the Borough Engineer, and tenders have to be in to Mr. E. T. Brydges, town clerk, Municipal Offices, Cheltenham, by noon of the 19th inst.

———— The Electric Lighting Committee of the Blackpool Corporation invite tenders for boiler-seatings and flues, engine and dynamo foundations, &c. Further particulars can be obtained from Mr. John Hesketh, the Borough Electrical Engineer, Electricity Works, Blackpool.

———— The Corporation of Kingston-upon-Thames require tenders for the supply of a gas or oil engine, for their electric light station, which tenders must be sent in by the 20th inst. Particulars can be obtained of Mr. A. H. Preece, 39, Victoria-street, Westminster, S.W.

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TENDERS INVITED.—The Vestry of St. Pancras (London) invite tenders for the buildings required at the electric lighting and refuse destructor station in King's-road, Camden Town, N.W. Drawings, &c., can be inspected and specifications obtained at the offices of Prof. H. Robinson, C.E., 13, Victoria-street, Westminster, and tenders must be sent in to Mr. A. E. Pycraft, chief clerk, Electricity and Public Lighting Department, Vestry Hall, Pancras-road, N.W., by noon of the 18th inst.

TENDERS ACCEPTED.—The following tenders have been received by the Paddington Board of Guardians for the electric lighting of the female wards of the Paddington Infirmary, to the specification of Mr. A. W. Sclater, Assoc.M.Inst.C.E. :—

	£	s.		£	s.
J. E. Spagnoletti & Crookes (accepted)	101	13	D. Bate	156	0
New and Mayne	107	0	Newton and Co.	159	0
Sotheby and Ridout	109	10	Henry F. Joel and Co.	159	9
Pritchett and Gold	122	10	Strode and Co.	167	0
Wenham and Waters	122	10	Girdlestone and Tatham	173	15
Peto and Radford	125	0	Vaughan and Brown	174	0
Jarvis and Berry	128	10	F. Geere Howard	175	0
Roger Dawson	132	0	Walter, Andreae & Co.	175	0
Dawson, Hammond & Co.	135	0	W. Mackie	176	0
Russell and Co.	139	0	Laing, Wharton and Down	182	11
D. Hulett and Co.	142	15	E. P. Allam and Co.	184	5
Crompton and Co.	143	0	Harrison, Coles and Co.	210	0
Lund Bros.	146	0	Peter Jones	214	0
J. W. Carpenter	146	13	Benham and Sons	235	0
Fenton and Barnes	153	0	H. Thorpe	284	15

——— For the generating plant required at the works of Messrs. C. H. Glover and Co., of Hatcham, S.E., the tender of Messrs. J. G. Statter and Co. has been accepted.

——— The tender of Messrs. W. Gradwell and Co., of Barrow-in-Furness, has been accepted by the Newport (Mon.) Corporation for the erection of an electric lighting station.

TENDERS RECEIVED.—The London County Council have received six tenders for the gas engines required for the proposed pumping station at Nine Elms Lane :—

Robey and Co., Lincoln	£4,079
J. E. H. Andrew and Co., Stockport	3,550
Fielding and Platt, Gloucester	3,500
Dick Kerr and Co., London	3,045
Tangyes, Birmingham	3,006
Crossley Bros., Openshaw, Manchester	2,724

LIQUIDATIONS.—A petition has been presented for the compulsory winding up of the Collier Audible Telephone Syndicate (Limited), and is down for hearing at the Royal Courts of Justice, Strand, on June 21st.

——— At a meeting of the Lithanode and General Electric Company (Limited), held on June 5th, it was resolved that the Company be voluntarily wound up, and Mr. J. H. Hays, 11, Abchurch-lane, E.C., was appointed liquidator. We learn that it is probable an attempt at reconstruction will shortly be made.

——— Claims against Roper's Electrical Engineering Company, Limited (in voluntary liquidation), must be sent to Messrs. Neill and Holland, solicitors, Bradford, by July 20th.

APPOINTMENT.—Mr. R. R. Binnie, chief engineer to the London County Council, has been appointed county surveyor to the same body. Mr. Binnie had previously performed the duties of the office without having been formally appointed.

VACANT APPOINTMENTS.—The Committee of Management of the Municipal Technical School, Brighton, require an assistant lecturer in mechanical engineering, &c., salary £150 per annum ; an assistant lecturer and instructor in electrotechnology, salary £20 per session ; and an engineering workshop mechanic, salary £95 per annum. Further particulars can be obtained from Mr. F. J. Tillstone, town clerk, the Town Hall, Brighton, to whom applications must be sent in before 10 a.m., 18th inst.

REMOVAL NOTICE.—Mr. William Kingsland, A.I.E.E., has removed from Clarence-buildings to 139, Upper Mostyn-street, Llandudno. We are informed that Messrs. Kingsland and Bellis are pushing on with their scheme for lighting Llandudno, notwithstanding the recent decision of the Local Board. It is stated that a strong directorate has been formed, and that the Llandudno Electric Supply Company (Limited) will be registered in a few days.

RE WOODHOUSE AND RAWSON UNITED (LIMITED).—It is announced that, on the application of the Official Receiver, Lord Aberdare, Sir R. W. Rawson, Sir John Stokes, Samuel Pope, Q.C., F. L. Rawson, W. T. Stutchbury, A. Hoster, T. H. Lambert, C. L. Baker, A. L. Foley, J. H. O. M. Dundas, Mr. Mumford, Philip Rawson, and F. W. Pixley are to attend to be publicly examined before one of the Registrars in Bankruptcy, at the Bankruptcy Buildings, Carey-street, London, W.C., on the 18th, 19th, and 20th inst., at 11 a.m.

MESSRS. FARADAY AND SON.—This firm inform us that the leases of adjoining premises having been acquired, the area of their show-rooms has been more than doubled, and the workshops greatly enlarged and new plant put down. The increased room has enabled them to add new departments to the business.

MR. WILSON HARTNELL.—Amongst the contracts recently obtained by this firm, and which have either been just completed or are in hand, is the electric lighting installation for the Leeds County Liberal Club, the plant for which includes two 12,000-watt Hartnell dynamos of the latest type, driven by two Crossley gas engines. The plant for the lighting of two corn mills, one at Stockport and one near London, are also in hand, in addition to several large dynamos and patent governors for electric light engines.

NEW FIRM.—Messrs. J. Fecher and Co., manufacturers at Bavaria of electrical porcelain work, have opened offices and show rooms at 11, Idol-lane, Great Tower-street, E.C., where a stock of their specialities will be kept.

PHOTOGRAPHIC APPARATUS.—Mr. C. C. Vevers, of 12 and 12A, Market-street, Briggate, Leeds, has sent us an illustrated catalogue of photographic apparatus, materials and chemicals, together with a scale of charges for trade printing, enlarging, finishing, &c.

ACTON.—The Acton Local Board have agreed that the district shall be supplied with the telephone, provided 900 subscribers are willing to come forward to meet the necessary expenditure.

AVILA (SPAIN).—A correspondent describes an interesting ceremony which took place at Avila a short time back at the opening of the electric lighting station on the Sunday. At four o'clock a procession appeared, headed by the Bishop of the diocese, who came down to bless the installation and open the works. The appearance of the Bishop was the signal for a flight of rockets, after which the Bishop walked to the boiler-house, where he delivered a short prayer, and sprinkled the two Babcock-Wilcox boilers with holy water. The engines and dynamos were similarly treated, much to the dismay of the engineer. Fortunately only a few drops fell, and no harm was done. The Bishop subsequently delivered an eloquent sermon on the advantages of modern science as given to the people. About 2,000 persons were present.

ANTWERP EXHIBITION.—This exhibition is now nearly completed, and by the end of the month the Machinery Hall will contain the whole of the exhibits intended to be shown. Very few English firms are exhibiting, but notwithstanding this, the electrical and engineering exhibits are, many of them, extensive and complete. Messrs. Crompton and Co. have a good show, as have many of the well-known Belgian, French, and German houses. The British section is particularly weak, excepting in the display of models of ships built for British and foreign Governments and for the leading steamship lines. These models are especially fine, and attract much attention. Notwithstanding the bad weather of the past fortnight, the Exhibition has been fairly well attended, thanks largely to the interest taken in the progess of the work by the King of the Belgians. Novelties are rare, but many of the stands show conspicuous ability on the part of those responsible for their construction. The popular side-shows are numerous, and are likely to attract large crowds as soon as the weather adapts itself to outdoor amusements. The London, Chatham, and Dover Railway Company are issuing cheap tickets, available for 30 days, *viâ* Queenborough-Flushing by the boats of the Zeeland Steamship Company, which are the largest passenger boats plying between Great Britain and the Continent.

AYR.—At the last meeting of the Town Council a letter was received from the Ayr Harbour Trustees, asking what charge would be made for supplying eight 3,000-c.p. arcs for the north side of the river and dock, and four for the south side. It was agreed to supply these lamps at the rate of 4d. per unit, the trustees providing lamps and requisite plant.

BARNET.—The Electric Lighting Committee of the Local Board have reported on the result of their endeavours to obtain the views of the ratepayers on the electric lighting question. A circular had been issued, and a house-to-house visitation made, with a more or less satisfactory result. Many of the ratepayers recommended that the matter should be postponed until the election of the District Council, the question being a test one at the election. There was general agreement as to the badness of the gas supplied to the district and its high price. A letter was read from the Brush Company, and also a communication from Messrs. Crompton and Co. The latter firm stated that they would be quite prepared to accept the general principle of undertaking the risk for a period of years, supplying the light without any guarantee, the local authority finding the necessary capital. It was ultimately decided that the Board should discuss the matter with Messrs. Crompton on the basis of the necessary capital being found by the Board, other matters being left open for consideration.

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BARROW.—At the last meeting of the County Council, the Clerk announced that the Board of Trade had granted the Electric Lighting Provisional Order.

CANTERBURY.—A public meeting is shortly to be held to consider a proposal for raising the necessary capital of the Canterbury Electricity Supply Company (Limited).

CARDIFF.—The Borough Engineer has been requested to report on the advisability of extending the electric light to the Market Hall and Town Hall. The Electric Lighting Committee have asked Mr. W. H. Massey and the Borough Engineer to prepare a pamphlet upon the subject of the electric light for distribution throughout the town.

CHESTER.—The dispute as to the site to be selected for the electric lighting station has now been settled by a vote of the Town Council, which has rescinded a former resolution adopting the Hop Pole site. A new site will now have to be selected.

CHISWICK (LONDON).—The plans sent in by Messrs. Bourne and Grant, who hold the Provisional Order for lighting the Chiswick district by electricity, of the proposed buildings and engines for the generating station have been referred to a committee for consideration and report.

COLCHESTER.—The Lighting Committee of the Corporation have received a report from Mr. W. H. Massey as to the advisability of the Corporation undertaking the supply of the electric light, which has now been submitted the same to the Councillors. Mr. Massey says that he is still of the opinion expressed by him some years ago that electric lighting in Colchester cannot be carried on at a profit by a company, but he thinks that the Corporation may be able to run electric lighting works with advantage. He has inspected several suggested sites for a central station, and suggests that a piece of land between the milk factory and the Corporation-yard is the best, as there it would be possible to arrange for electric light works side by side with apparatus for burning refuse. Mr. Massey estimates the total initial expenditure at about £18,000, and recommends, if the above site is selected, the low-tension three-wire system. The Lighting Committee are considering the report, and will probably make a recommendation to the Council at the next meeting.

CHURCH AND CHAPEL LIGHTING.—At Castle-gate, Nottingham, the Congregationalist chapel is to be lighted by electricity. The chapel is undergoing complete renovation, and the opportunity is being taken to instal the electric light.

DERBY.—The Baths Committee of the Town Council recommended in their report to defer for the present the consideration of the question of lighting the Full-street Baths by electricity, but as this was objected to by Mr. Marsden, it is probable that the matter will receive the immediate attention of the Council. Owing to the interest taken in the electrical exhibition, a much wider interest in the public electric lighting scheme has been created. Visits have been made from several of the Midlands' Engineering and Colliery Managers' Associations, and Mr. Stewart, the manager of the electric lighting works has been busy conducting demonstrations and in describing the machinery at the works in Full-street.

DUBLIN.—The Corporation are extending the electric lighting area from Cavendish-row and Rutland-square in continuation from the Rotunda in Upper Sackville-street.

EALING.—A request made by Dr. Scott to the Local Board for permission to lay telephone wires in the trenches in which the electric light mains are laid was refused at the last meeting of the Board.

ECCLES.—The Electric Lighting Committee have received a report from Dr. J. Hopkinson on the electric lighting scheme, and also a letter stating that with respect to the names of places at which the street lamps were lighted by electricity, Whitehaven was the only place he knew of in this country wholly thus lighted. The Council agreed that the Committee should inspect the lighting of the Whitehaven streets, with the view of obtaining information to enable them to report fully on the subject. We understand, however, that Prescot has been similarly lighted by the British Insulated Wire Company.

ELECTRIC LIGHT IN GREENHOUSES.—In a recent report published by the authorities of Cornell University, Prof. Bailey states that for four winters study has been made of the influence of the electric arc lamp upon plants grown in greenhouses under varying conditions. It was found that lettuce was greatly hastened in growth by the electric light, and various flowers were earlier and better under its influence. Many plants were injured by the naked electric light, but sustained no injury by a light which was modified by passing through an opal globe, or even through common glass. Radishes and other plants injured by the naked light in the greenhouse, and even by the light modified by an opal globe, were benefited by a light above the roof, and lettuce and flowers still showed a marked benefit from this arrangement. Other experiments have been made, and a series of bulletins have been issued (Nos. 30 and 42).

FAREHAM.—From the *Hampshire Evening Mail*:—"We are sorry to hear that the Fareham Electric Lighting Company is about to collapse, but the townspeople having said pretty plainly that they would have nothing to do with it as a public undertaking the demise is inevitable. The concern has had a brief career of four years, and the reason for its failure is the insufficiency of public and private support. It was started with a capital of £5,000, and with this a fairly satisfactory system of lighting was started, but the overhead wires have been a constant cause of contention, and now that the Board of Trade insist on the cables being placed underground the Company want capital, and cannot obtain it. Under these circumstances it is impossible to go on, and it now rests with the Local Board to say whether they can and will come to the rescue."

FLEETWOOD.—The Board of Trade have fixed October 20th as the limit of time for work to be commenced under the Fleetwood Electric Lighting Order of 1890.

GLASGOW.—Mr. W. Lackie, Electrical Inspector to the Corporation, is of opinion that no ventilating system is requisite in electrical conduits. Although there are nearly 500 manholes in Glasgow, only in six has any trace of gas been discovered, and this has been caused by the railway operations which have been conducted throughout the city.

HARTLEPOOL.—At the last monthly meeting of the Town Council the Lighting Committee's report was brought up for discussion; and Mr. Foxton called attention to the necessity for the Council securing powers for electric lighting before they were acquired by the Tramways Company. In reply, Mr. Watson said that the matter had been allowed to rest pending further information, as it had been discovered that the cost of obtaining powers amounted to nearly £300.

ISLINGTON (LONDON).—The thirty-seventh annual report of the Islington Vestry, recently published, contains a history of the electric lighting question, and sets out the progressive steps taken from time to time to bring the Vestry's electric lighting scheme into practical working.

LAUNCESTON.—The Town Council have received an offer from the Western Electric Company to purchase the existing waterworks for electric lighting purposes. The letter came up for discussion at the last meeting of the Council, but no action was taken.

LLANBERIS.—A survey is being made by Mr. A. Smith, with the view of constructing an electric railway to the summit of Snowdon. The tourist traffic from the Llanberis side has recently fallen off, owing, it is stated, to the counter attractions from the Beddgelert route.

LYNTON.—It is stated this is the only town in the kingdom where the ancient and modern lights, oil lamps and electricity, may be seen burning at the same time. Gas is unknown at Lynton.

MAIDSTONE.—In answer to a question from Alderman Long at the last meeting of the Local Board as to the position of affairs with regard to the Electric Lighting Order, which expires in a few weeks, it was stated that the Board were awaiting a reply from a London company.

MILL LIGHTING.—In reference to the Trade Note in our last issue under this heading, Mr. Wilson Hartnell wishes us to state that the plant at Messrs. Fletcher's mill at Milford, near Belper, was put down by him, and has been running for more than a month with every satisfaction.

MONTROSE.—Mr. C. L. Hett writes to say that in the description of the lighting of Kinnaber waterworks in our last issue we omitted to mention that the Pelton water-wheel, from which the motive power is derived, was constructed by Mr. Hett, and is fitted with the Hett patent adjustible nozzle.——The Scottish House-to-House Company have intimated their intention to apply to the Board of Trade for a Provisional Order to supply electricity within the borough of Montrose, and have asked the consent of the Town Council to their application. A motion was proposed that before entering into any negotiations the Lighting Committee should ascertain the terms upon which the electric light undertaking could be carried out in Montrose, either under a Provisional Order obtained by the Council or by a company. This was agreed to. Notice was given that at the next meeting Mr. Whiteman would move that the Council themselves apply for a Provisional Order to supply electricity within the district.

NEWCASTLE.—The Corporation has published in pamphlet form the report prepared by Mr. W. G. Laws, the city engineer, on "Three Systems of Tramway Haulage," horse, electric, and cable. The City engineer has also presented a report as to the estimated cost of renovating the Town Hall, installing the electric light, &c., which is to cost about £3,000. The Corporation have voted £200 to the Special Committee which is considering the subject of a municipal electric lighting scheme.

NEWPORT (MON.).—The Corporation have decided to make the following charges for electric current:—Under 1,000 units, per quarter, 6d.; above 1,000 and under 2,000, 5½d.; above 2,000, 5d. It has also been decided that all Corporate buildings, including the

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Town Hall, free library, markets, baths, slaughter-houses, &c., are to be lighted by electricity.

"PALL MALL BUDGET."—It has been decided to start a new series of this popular weekly, increased in size and containing many novel features. The *Budget* is associated with the *Pall Mall Gazette* establishment, and has become a public favourite.

PROVISIONAL ORDERS.—The House of Commons Committee on Local Bills have approved the Grimsby Electric Lighting Provisional Order No. 2 Bill, and ordered it for third reading.——The Plymouth Electric Lighting Provisional Order has been read a third time, and confirms a Provisional Order made by the Board of Trade applying to the Saint Austell district.——The Monmouth Electric Lighting Provisional Order has passed the House of Lords Committee, and is reported for second reading.

RADCLIFFE.—A meeting of the Local Board has been held, at which a discussion took place on the question of applying for a Provisional Order for lighting the district by electricity. Mr. Cuncliffe argued strongly in favour of the Board taking up the subject, and pointed out that they had already experts from whom they had received favourable reports, and finally moved that the Board should take the necessary steps for obtaining a Provisional Order. The motion was agreed to.

RURAL TRAMROADS.—It is stated that experimental electric railtracks, so constructed that ordinary vehicles as well as electric cars can be used upon them conveniently, are about to be laid on some of the country roads in Ohio, U.S.A.

SHOREDITCH (LONDON).—In further discussing the Vestry's scheme for combining dust destruction, baths and washhouses, and the construction of an electric lighting station on the Pitfield-street site, after a heated debate on Tuesday last it was decided to purchase the property referred to for the sum of £33,500. This matter has been before the Vestry for the past eighteen months, and has been discussed on various occasions without any definite result being arrived at. The Pitfield-street site is in the centre of a densely-populated district, and it remains to be seen whether the decision arrived at by the members of the Vestry is a wise one. The voting was very close, 32 being in favour of the purchase of the site and 29 against. The opposition chiefly centred in the unsuitability of the site for the purposes of the scheme.

SOUTHAMPTON.—At the last meeting of the Town Council, the Works Committee reported that the town clerk had been instructed to inquire of the local electric lighting company the terms upon which they were prepared to enter into negotiations for the sale of their undertaking to the Corporation.

SOUTHPORT.—A report of the Gas and Electricity Committee submitted to the last meeting of the Corporation contained several references to the differences of opinion existing between the Committee and the Corporation's electrical engineer, on the question of foundation plans for engines, dynamos, and boilers. The town clerk reported that in his opinion the electrical engineer had become incapacitated within the meaning of Clause 18 of the agreement entered into between him and the Corporation, and it was resolved that the Committee hear with regret of the indisposition of Mr. Wilkinson, and instruct the town clerk to effect a friendly arrangement for a legal discharge from all liabilities under the agreement.

ST. LUKE'S (LONDON).—The Vestry having received from the County of London and Brush Provincial Electric Lighting Company an undertaking not to offer any opposition to the Vestry's application at any future date for a Provisional Order, have notified the Board of Trade that they have no objection to offer to the Company carrying out the work of lighting the parish.

ST. PANCRAS (LONDON).—Mr. A. Sweet, the Chairman of the Electricity Committee of the Vestry, presented the annual report at the last meeting of the Vestry. The report shows a satisfactory result on the year's working. The total income was £15,002, which is sufficient to clear off a deficit of £1,543 for the first year's working, and after paying all working expenses and £927 in maintaining the works in the highest state of efficiency, leaves a balance of £4,669, out of which interest and repayment of loans has been met. The extension of the Stanhope-street station, which is now nearing completion, and the provision of a new station in King's-road will, it is anticipated be in working order, and available for the next winter supply. The report states that the ratio of cost of public lighting for the year by electricity as compared with gas was high, but the charge of 6d. per unit is to be reduced to 5d. per unit (as previously announced) from Michaelmas next. The report further states that the supply of current for private lighting, although not large, is promising, and the number of private consumers has doubled during the past year. The report was adopted.——A letter was subsequently read from the Gas Light and Coke Company announcing that from the end of the current quarter the price of gas for public lighting is to be increased from 2s. 2d. to 2s. 4d. per 1,000. The amount paid by the Vestry to the gas company for the year ended March 25th last upon the basis of 2s. 2d. per 1,000, was £8,788, and the increased price would add to this sum no less than £676. The Vestry, after discussing the letter from the Company, passed a resolution emphatically protesting against the increase, and Mr. Sweet, the Chairman of the Public Lighting Committee, recommended the Vestry to checkmate the Company by lighting all the main streets of the district by electricity, which it will shortly be in a position to do.

STRAND (LONDON).—At the last meeting of the Strand Board of Works a special report was presented from the Works Committee respecting a memorial from the Charing Cross and Strand Electricity Supply Corporation proposing to supply the electric current to the parish of St. Paul's, Covent Garden, at £26 per 2,000-c.p. arc lamp, for 10 hours per day, this sum to include maintenance, lighting, and supply. The Committee reported that if competitive powers were granted to a second company they should apply to the whole district, and not to one parish, and this opinion of the Committee was endorsed by the Board.

SUNDERLAND.—Fifty-nine applications were received by Prof. Kennedy for the position of Electrical Engineer to the Sunderland Corporation at a salary of £200 per annum. Acting on the instructions of the Committee, this large number had been reduced to seven, and of these Prof. Kennedy specially recommended Mr. C. S. Vesey Brown, of Deptford, London; Mr. J. F. S. Snell, of St. Pancras, London; and Mr. F. L. Todd, of Glasgow. It was ultimately decided that Messrs. Snell and Brown be recommended, the final selection to be made by the Council.

TUNBRIDGE WELLS.—It has been decided by the Town Council to erect the central station in a portion of the Lower Yard near Stanley-road. The specifications and plans for the machinery have been completed, and advertisements inviting tenders have been issued.

WESTON-SUPER-MARE.—Messrs. Segundo, Bate, Ball and Metzger have each offered their services to the Board on the electric lighting subject, but a resolution that "Mr. Medhurst's offer to report fully and to advise the Electric Lighting Committee on the question of electric lighting and tramways, and on the utilisation of dust destructors for the production of electric power at a fee of 50 guineas and personal out-of-pocket expenses" be accepted, was carried, on the understanding that the Town Commissioners do not commit themselves to anything beyond the first stage of the proceedings.

WOLVERHAMPTON.—The plans for the new works to be erected in Wednesfield-road for Thomas Parker (Limited) have been approved by the Public Works Committee of the Town Council. The architect for the works, which will cover nearly five acres of ground, is Mr. A. P. Brevitt.

WORCESTER.—The Corporation have decided to lower the price per unit for the electric current from 6d. to 5d.

WORTHING.—The £200 limit agreed upon by vote of the Town Council for the cost of the experiments of the Hermite system of electrical sanitation was not reached, the expense incurred only being £169.

WREXHAM.—Mr. A. C. Baugh, architect and surveyor, has received instructions from the Altrincham Electric Supply (Limited), for the plans of the new electric light station to be built for Altrincham and Bowden. Mr. Baugh has also in hand a commission for part of the extensive new electric lighting works now being built for the Manchester Edison-Swan Company.

YARMOUTH.—The Electric Lighting Committee of the Town Council have recommended that an overhead travelling crane be provided. The surveyor has been instructed to confer with Mr. Preece to fix the rate of charge for electric current to consumers, and at the last meeting of the Council it was decided that immediately after the electric light works were started in Yarmouth, the Surveyor should report upon the lighting of Gorleston and Southtown by the electric light.

COMPANIES' MEETINGS AND REPORTS.

Swan United Electric Light Company (Limited).

An extraordinary general meeting of this Company was held yesterday at the Cannon-street Hotel, Mr. J. S. Forbes presiding.

The SECRETARY (Mr. H. Charles Gover) having read the notice calling the meeting,

The CHAIRMAN said that the object of the meeting was to give effect to what the Directors had from time to time ascertained to be the wish of a considerable majority, if not of the entire number of shareholders interested. At the last meeting of the Swan Company, although they had to deal chiefly with the accounts, he entered very fully into the matter which he now desired to lay before the shareholders. They were the proprietors of the Swan Company, and they happened in that capacity to be the largest proprietors of the Edison and Swan Company, in which they held 60 per cent. of the whole capital. Their partners, as they knew, repre-

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sented Mr. Edison and his friends, and in the old days when they made an amalgamation the difficulty of carrying it out entirely was that the Edison patents were secured only for Great Britain, whereas they had secured the Swan patents for Great Britain and the rest of the world, excepting America. They had a share under the fusion of the Edison and Swan undertaking amounting to £208,000, and as holders of that security they had been for a number of years receiving in payment from that Company the dividend accruing from their investment, which they brought into a separate account, they meantime carrying on a separate business in Germany, and having also interests in France. Of course the business had developed. There were up to the present time practical difficulties in the way of dealing with this residuum, if he might so call it. It had taken some time to ascertain what was the best way to simplify matters. What they had got to sell and what the Edison and Swan Company were prepared to buy was their residuum outside that Company, of which, as he had just said, they held 60 per cent. of the business which was limited to Great Britain. They had a manufactory in Germany, they had a considerable holding in a French company for the manufacture of incandescent lamps, namely, £30,000, and they had certain patents in Germany which might or might not be of value. Meanwhile the protection period covered by the patents had gone both in this country and for the most part in Germany. They had duplicate interests, duplicate establishments, and the Directors thought that it would be very much in the interests of all the shareholders, being large holders in the Edison and Swan Company, that the residuum should be brought into the general pot. One of the conditions of the Swan Company imposed on the Edison and Swan Company was that the latter could not manufacture for exportation, and it would be greatly to their interest that restrictions of that kind should be removed. The proposal embodied in the resolution he was to propose would do so. They had the option at the end of this year, of determining whether it was worth while to go on as partners in the French Company, in which their holding was £30,000, or by agreement with their partners realise the assets and regain possession of the whole continent of Europe. At the present moment they were precluded from manufacturing lamps in England for consumption on the Continent outside Germany. There would be a greater facility of administration, unity of management, and what was, perhaps, most agreeable to the shareholders, more economy in carrying on the business which would be consolidated and conducted probably in a more efficient way, and at a greater profit than would be the case if they remained separate companies. Their capital, as they all knew, consisted of two kinds, fully-paid and partially-paid shares of £5 and £3. 10s., of each of which there were a larger number of holders. And the Board remitted to two very competent gentlemen—Mr. Swan, representing very largely the fully-paid shareholders, and Mr. Quilter, representing largely the partially-paid shareholders – to reconcile the two interests. The conclusion which those gentlemen had arrived at had been recorded, and if it were approved it would be given effect to by the agreement and resolution they were now asked to pass. After reading and explaining the heads of the agreement, he concluded by moving the resolution set out in our last issue on page 169.

Mr. QUILTER, M.P., seconded the resolution, which was carried unanimously.

A vote of thanks was passed to the Chairman and Directors, which the former briefly acknowledged, and the proceedings ended.

Sheffield Electric Light and Power Company (Limited).

The third ordinary general meeting of this Company was held on Wednesday in the Cutlers' Hall, Alderman G. Franklin presiding.

The CHAIRMAN, in moving the adoption of the report and balance-sheet, gave a brief statement of the profit and loss account for the year ending December, 1893. That year was notoriously the most unfavourable for electric lighting companies on account of the almost perpetual sunshine and the absence of fogs. Notwithstanding this, the increase had continued in the revenue derived from the sale of current. In 1892 the accounts of the Company were made up for only nine months, but equalising the periods for the purpose of comparison, it would be found that the income from the sale of current during 1893 had been £3,555. 11s., an increase at the rate of £750 a year over 1892. On the other hand, the cost of generation of electricity had increased by £180 a year, which was more than accounted for by the extra cost of fuel during the coal strike. Shareholders should also take into consideration the exceptional difficulties which the Directors had had to contend with by reason of the erection of a new electric lighting station over the site of the old, at the same time keeping the machinery going, so that the light should never be allowed to go out. The capital expenditure last year, owing to the circumstances which he mentioned, amounted to £19,689. 4s. 1d., almost entirely accounted for by the construction of the electric lighting station and also the underground mains, which were laid throughout the whole of the centre of the town. The Company were now liable to be called upon to supply 13,200 8-c.p. lamps, and had machinery enabling them to supply 15,000. The application of the Company for new shares and debentures had been subscribed particularly well, and the Directors would now be able to go forward, and give the enterprise a fair chance of becoming a good business, and securing for the Company the position of being a prominent dividend-paying concern. The balance of profit for the past year was equal to a dividend of 2½ per cent. on the capital then in the concern; but the Directors, having regard to the fact that a number of new shareholders had taken shares, thought it inadvisable to declare any dividend for last year, but to carry the balance forward to strengthen the current year's revenue. The report and balance-sheet were adopted, and the retiring Directors, Ald. Franklin and Ald. Gamble, were re-elected.

Electro-Chemical Company (Limited).

The first ordinary general meeting of this Company was held on Tuesday at the Cannon-street Hotel, under the presidency of Col. Holland, C.B.

The SECRETARY (Mr. W. J. Finch) having read the notice calling the meeting,

The CHAIRMAN stated that as the allotment of shares was made only three months ago, and as they had had a good deal to attend to since in arranging and organising the details connected with and incidental to the affairs of a new undertaking such as theirs, they had not yet been able to conclude the purchase of land for their works. Until they were in possession of the land it was impossible for them to complete contracts for buildings, plant, and machinery. They would under ordinary circumstances have delayed holding the meeting until these matters had been settled, but as the present was their statutory meeting, they were compelled by the Act of Parliament to hold it on or before the 14th inst. He was, however, glad to in form them that the more they had looked into everything relating to their affairs the more satisfied had they become that in the Electro-Chemical Company they had a genuine, sound, good business, which should prove, if properly inaugurated and efficiently worked, very remunerative to all who were interested in it. New manufacturing undertakings in these days generally had various drawbacks, to which he alluded, but this Company would be free from such disadvantages, and they would not have to sell their products at reduced prices, as prices in the alkali trade were fixed at a good and profitable figure by the Alkali Union—a great combination of almost all the alkali works in the kingdom, manufacturing chemicals which this Company proposed to make. They had allotted 16,745 Preference shares, representing £83,725, and 14,000 Ordinary shares, representing £70,000. The purchase of their patent rights had been completed, and all the British, foreign, and Colonial patent rights had been, or were in course of being transferred to the Company. No cash has yet been paid to the vendor Company, which had taken £25,000 out of the £30,000 cash due to it in shares; and the remaining £5,000 which was due had, by mutual consent, been allowed to stand over without interest for six months, and it would be paid in shares or cash according to the requirements of the Company. It was intended, in the first instance, to put up and work machinery for manufacturing about 5,000 tons of caustic soda and bleach, and after testing it, to double and quadruple the plant later on. Negotiations were now proceeding for the purchase of one of the sites that had been offered to them for their works. They hoped the plant and machinery which they now contemplated erecting might be in operation within the next few months. Negotiations were in progress for selling some of the foreign patents. The specifications of all their patents were either originally drawn up or amended and approved by Mr. Fletcher Moulton, Q.C., M.P., and they believed that they had absolutely valid patents. After speaking in hopeful terms of the profits which might be anticipated from their manufactures, and stating that Mr. James Swinburne had been appointed their consulting electrician, and that the services of Mr. J. Leith had been secured as manager of their works, he said that if anyone present doubted the practicability of making the best caustic soda and bleach by electricity, he would ask his attention to the excellent samples of soap that were on the table, which had been made by electrolytic caustic soda by the Company's process at the works of Messrs. J. C. and J. Field, of Lambeth. Mr. Field, who was a practical chemist himself, was present, and, no doubt, could tell them that electrolytic caustic soda was, from his own experience, whiter, purer, and better for making soap than any other soda made by other processes. He (the speaker), as a practical paper-maker, working one of the largest mills, and being probably one of the largest users of bleach in the kingdom, could tell them that he had made tons of caustic soda and bleach by the Company's electrolytic process, and that he had used them in boiling fibre and bleaching paper, and had found the articles in every way equal to the best he had ever bought from the Alkali Union, and perhaps a little purer and better.

On the motion of Mr. MARCUS, seconded by Mr. VOGAN, a resolution was passed confirming the appointment by the Board of Col. Holland as a Director and Chairman; and on the motion of Capt. Wemyss, Messrs. Gane, Jackson and Jefferies were elected auditors to the Company for one year.

Mr. JAMES C. RICHARDSON, the inventer of the process, afterwards addressed the meeting, and spoke highly of the prospects of the undertaking.

A vote of thanks to the Chairman closed the meeting.

Electric and General Investment Company (Limited).

The following is the report of the Directors for the year ended May 31st last, to be submitted to the fifth ordinary general meeting of shareholders to be held at Winchester House, London, E.C., on Tuesday, the 26th inst. at 3 p.m :—

The profit and loss account shows a gross profit on the transactions of the year (including the balance of £65. 16s. 5d. brought forward from last year) of £10,735. 6s. 8d., and after deducting all standing charges and the interim dividend already paid on the Ordinary shares, there remains a net balance available for distribution of £7,369. 10s. 4d. The Directors now recommend the payment of a further dividend upon the capital paid up on the Ordinary shares at the rate of 40 per cent. per annum for the past six months, and a dividend on the Founders' shares of £30 per share for the year. This will leave a balance of £369. 10s. 4d., which the Directors recommend should be added in equal moieties to the Ordinary and Founders' reserve funds. It is proposed to make the dividends payable on June 27, 1894.

The Directors who retire this year are Mr. G. Herring and Mr. B. H. Van Tromp, who offer themselves for re-election, as do the auditors, Messrs. Rait and Kearton.

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NEW COMPANIES, STATUTORY RETURNS, &c.

DAWSON GAS ENGINES SYNDICATE (LIMITED).—This Company was registered on June 12, 1894, with a capital of £70,000, in £10 shares, to acquire certain inventions in the nature of engines to be worked by gas, petroleum, oil or other methods, and all the patent rights and privileges which now are or may be secured to Henry Thomas Dawson, engineer, and to carry on the business of mechanical, electrical, gas, and general engineers, electricians, suppliers of electricity for the purposes of light, heat, motive power, or otherwise, and manufacturers of and dealers in electrical apparatus and appliances.

ENGLISH AND COLONIAL ELECTRIC LIGHT COMPANY (LIMITED).—This Company was registered on June 11th with a capital of £50,000, in £1 shares, to acquire, work, and use patents and patent rights in connection with electricity, and in particular those of Samuel William Maquay, specified and enumerated in an agreement dated June 4th, between Samuel W. Maquay and John S. Forbes, and to carry on the business of electrical engineers, and makers or providers of electric machinery and apparatus of all kinds, or all business and matters connected with electricity, including the supply of power. The subscribers (with one share each) are:—Lewis Chalmers, M.E., William Gunn, Charles T. Kingsford, William A. Byron, William Chalmers, Charles Purrott, and Frederick W. Cartwright.

LOANDO GAS COMPANY (LIMITED).—This Company was registered on June 12th, with a capital of £50,000, in 4,000 Preference and 1,000 Ordinary shares of £10 each, to acquire the concession granted by the Municipal Board of the City of Loanda, South-West Africa, to Antonio A. Lorenço de Carvalho and Dr. Alfredo Troni, for public and private lighting in the City of Loanda, by means of gas, electricity, or other system for a period of 50 years, and to manufacture and supply gas, electricity, electric power, plant, and apparatus for all purposes.

AFRICAN TRANSCONTINENTAL TELEGRAPH COMPANY (LIMITED).—The first annual return of this Company, made up to May 24th, has been filed. 75,436 shares have been taken up out of a nominal capital of £140,000, in £1 shares. Upon 1,296 shares the full amount has been called, in upon the remaining 74,140 shares a call of 5s. per share has been made, resulting in the payment of £19,581, and leaving £250 in arrears. The principal shareholders are the Hon. Cecil J. Rhodes, of Cape Town, South Africa (28,500); Alfred Beit, of 29 and 30, Holborn Viaduct, London, E.C. (10,000); Right Hon. Baron Nathan M. Rothschild, of New Court, St. Swithin's-lane, London, E.C. (5,000); and Sigmund Neumann, of Warnford-court, London, E.C (5,000).

ALBERT ELECTRIC LIGHTING COMPANY (LIMITED).—The annual return of this Company, made up to May 18, 1893, has only been recently filed. Out of a nominal capital of £10,000, in £5 shares, 407 shares were taken up. Upon 400 of these the full amounts had been called, and upon the seven signatories' shares a call of £1 per share had been made, resulting in the payment of £2,007.

AUTOMATIC ELECTRIC RAILWAY SIGNAL COMPANY (LIMITED).—The annual return of this Company, made up to May 7th, has been filed. 4,905 shares have been taken up, out of a capital of £10,000, in shares of £1 each, and of these 3,300 have been issued as fully paid. Upon the remaining 1,605 shares, calls amounting to 15s. per share have been made, resulting in the payment of £1,010, and leaving £193. 15s. as yet unpaid.

BAILEY, GRUNDY, AND BARRETT (LIMITED).—The first annual return of this Company, made up to June 4th, has been filed, 662 shares have been taken up out of a nominal capital of £10,000, in £5 shares. Upon each of these the full amount has been called, resulting in the payment of £3,300, and leaving £10 in arrears.

EASTBOURNE ELECTRIC LIGHT COMPANY (LIMITED).—The annual return of this Company, made up to April 2nd, was recently filed. Out of a nominal capital of £50,000, in £10 shares, 1,017 Ordinary and 40 Preference shares have been taken up, the full amount called, and £10,570 paid. A notice was filed on June 9th, stating that a resolution for the extension of the debenture issue from £25,000 to £35,000, with the consent of the present holders, the new debentures ranking *pari passu* with present issue, was passed on March 19th, and confirmed on April 9th.

ELECTRIC WIRINGS AND FITTINGS COMPANY (LIMITED).—The annual return of this Company, made up to March 14, 1893, was only recently filed, together with the return for 1894, made up to the same date. 1,382 shares out of a capital of £5,000 in £1 shares have been taken up, and the full amount called. The calls paid have realised £1,375, leaving £7 in arrears.

ELECTRICITY SUPPLY COMPANY FOR SPAIN (LIMITED).—The annual return of this Company, made up to July 10, 1893, was only recently filed. The whole nominal capital of £100,000, divided into 19,900 Ordinary and 100 Founders' shares of £5 each, was taken up. The Founders' shares were issued as fully paid, while the full amount has been called and paid on the Ordinary shares.

EVERED AND CO. (LIMITED).—The annual return of this Company, made up to April 14, was recently filed. Out of a nominal capital of £200,000, in £10 shares, 16,496 shares have been taken up and allotted. The full amount has been called on 6,744 shares, and a call of £7 per share has been made on 9,752 shares, resulting in the payment of £135,704.

CHINA AND JAPAN TELEPHONE COMPANY (LIMITED).—The annual return of this Company, made up to May 16th, has been filed. Out of a nominal capital of £20,000, in £1 shares, 14,761 have been taken up, and all have been issued as fully paid. 14,101 of these are held by the Oriental Telephone and Electric Company (Limited).

FOWLER, LANCASTER AND CO. (LIMITED).—The statutory return of this Company, made up to May 2nd, was recently filed. Out of a nomina capital of £50,000, in shares of £10 each, 554 have been taken up. Upon 54 of these the full amount has been called, and upon the remaining 500 shares calls amounting to £5 per share have been made, resulting in the payment of £3,040.

KENNEDY STORAGE BATTERY COMPANY (LIMITED).—The annua return of this Company made up to January 12, 1894, was recently filed. The whole nominal capital of £100,000 in shares of £1 each was issued as fully paid to Patrick Kennedy, of 105, Johnson-street, Brooklyn, U.S.A., and Charles J. Diss, of 334, Pearl-street, Brooklyn, N.Y., in consideration for the sale to the Company of British Patents No. 16,934 of 1891, No. 16,938 of 1891, and No. 9,014 of 1892 for "improvements in the manufacture of secondary or storage batteries." The vendors hold 23,750 shares between them, while George C. A. Kohler, of Broad-street House, London, E.C., holds 37,050.

LONDON ELECTRIC SUPPLY CORPORATION (LIMITED).—The annual return of this Company made up to May 23rd has been filed. The nominal capital is £1,250,000 divided into 200,000 Ordinary and 50,000 Preference shares of £5 each. 111,000 Ordinary and 48,050 Preference shares have been taken up and the full amount per share called. The calls paid amount to £798,990. A sum of £3,740 has been received in respect of 1,950 forfeited shares.

CITY NOTES.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended June 10th were £911, as against £759 in the corresponding period of 1893, being an increase of £152. The total receipts for the half-year amount to £20,923, as against £20,252 for the corresponding period of 1893, an increase of £671.

COMMERCIAL CABLE COMPANY.—This Company announce a quarterly dividend at the rate of 7 per cent. per annum, payable on the 2nd prox.

DERMATINE COMPANY (LIMITED).—A private meeting of the shareholders of this Company was held on Tuesday last at Winchester House, E.C.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).—This Company notify that the coupon on their Five per Cent. Australian Government Subsidy Debentures, due on the 1st July next, will be paid on that date at Messrs. Barclay Bevan and Co's bank, 54, Lombard-street, E.C, Coupons must be left three clear days for examination.

GULCHER (NEW) ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—Notice is given that an extraordinary general meeting of the shareholders of this Company, will be held at Winchester House, E.C., on Tuesday, the 19th inst., at 11:30 a.m., when the resolutions passed at the meeting held on the 4th inst., for the voluntary winding-up of the Company, and the appointment of Mr. C. F. Kemp as liquidator, will be submitted for confirmation as special resolutions.

NATIONAL TELEPHONE COMPANY (LIMITED).—The transfer books of the Four and a-Half per Cent. Debenture Stock of this Company are announced to be closed from the 18th to the 30th inst. inclusive preparatory to the payment of the half-yearly interest due July 1st.

SOUTH STAFFORDSHIRE TRAMWAYS COMPANY (LIMITED).—An extraordinary general meeting of this Company was held on Tuesday, at Cannon-street Hotel, London, E.C., for the purpose of electing Directors and auditors. Mr. W. S. Schuster, who was voted to the chair, said that the proceedings were formal. The petition presented for the winding up of the Company, with a view to its reconstruction under the Court, was adjourned by Mr. Justice Vaughan Williams to give the shareholders an opportunity of expressing their views upon it. Since then the present Directors had signified their intention to retire, in order that a new Board might be constituted; and, under those circumstances, the petition would not be proceeded with. If satisfactory arrangements could not be brought about, the new Board would recommend the shareholders to litigate or wind up. Investigations made for the purpose of litigation had thrown a great deal of light upon the history of the Company, which it was not proposed, having regard to possible future litigation, to introduce to the meeting. Mr. Elliott said it was within the knowledge of the members that a petition was presented for winding up, alleging various acts on the part of the Directors and others, as grounds for so doing; but the judge, after reading the affidavits, said his opinion was that the matters stated in them were not grounds upon which he could order the winding up.—Mr. Munns said they hoped that some settlement would be come to with the debenture holders, which would take the line out of their hands, and also with the Electric Construction Corporation, by meads of which the charges which the Company was liable to pay under the contract would be modified. Ultimately, Messrs. W. S. Schuster, S. R. Blundstone and A. Dawson were appointed Directors, and the resignation of the old Board was accepted.

STOCK EXCHANGE NOTICES.—The Stock Exchange Committee have ordered the vendors' shares, Nos. 7 to 214 and 719 to 10,000, of the Charing Cross and Strand Electricity Supply Corporation (Limited) to be quoted in the Official List.——Application has been made to the Committee to allow the £30,000 Four and a-Half per Cent. Debentures of the Direct Spanish Telegraph Company (Limited) to be quoted in the Official List.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the week ended June 8th (after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited), were £2,576.

WESTERN UNION TELEGRAPH COMPANY.—This Company has declared a quarterly dividend of 1¼ per cent.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, June 6.	Price Wednesday, June 13.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending June 13. Highest	Lowest
			TELEGRAPHS.			£ s. d.		Highes	Lowest
£1,012,880	Stock	9/0	Anglo-American	43 45	43 45	5 4 4	Jan., Apr., July, Oct.	43	..
£2,933,560	Stock	18/0	Do. Preferred	82 83½	82½ 83½	5 13 9	,, ,,	83	81
£2,933,560	Stock	5/0	Do. Deferred	7¾ 8¼	7½ 8	..	..	..	..
£184,500	100	4%	African Direct Telegraph 4% Deb. (Reg. & Bearer)	102 105	102 105	3 16 2	January and July	..	..
130,000	£10	3/0	Brazilian Submarine	12 12½	12 12½	5 4 0	Mar., June, Oct., Dec.	12½	12 1/16
£18,700	£100	5%	Do. 5 per Cent. Bonds	100 103	101 104	4 16 2	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	108 112	109 113	4 8 6	June and December		.
10,000,000	$100	$1¾	Commercial Cable Capital Stock	140 145	140 145	4 16 7	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	12 13	12 13	6 3 1	February and August	..	..
6,000	10	10%	Do. Preference 10 per Cent.	18 19	18 19	5 5 3	,, ,,	..	..
12,931	5	1/7½	Direct Spanish (fully paid)	3¾ 4¼	4 4½	4 8 11	April and October	..	..
6,000	5	10%	Do. Preference 10 per Cent.	9 9½	9 9½	5 5 3	,, ,,	..	..
60,710	20	2/0	Direct United States Cable, 1877	9¾ 10¼	9¾ 10¼	5 17 1	Jan., Apr., July, Oct.	10 1/16	9⅞
400,000	10	2/6	Eastern	14⅞ 15⅛	15 15¼	4 5 3	,, ,,	15 1/16	14⅞
70,000	10	6%	Do. 6 per Cent. Preference	15¾ 16¼	15¾ 16¼	3 13 10	,, ,,	16 5/16	16 3/16
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	113 116	113 116	3 9 0	May and November	115	114
£102,100	100	5%	Do. 5 per Cent. Debentures, 1899	107 110	107 110	4 10 11	February & August	..	..
250,000	10	6/6	Eastern Extension	15½ 15¾	15⅝ 15⅞	4 8 2	Jan., Apr., July, Oct.	15⅞	15½
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	114 117	114 118	3 7 10	February & August	117	115½
£62,700	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	104 107	105 108	4 12 7	January and July	..	..
£95,100	100	5%	Eastern and S. African 5 per Cent. Mor. Deb., 1900	104 107	105 108	4 12 7	,, ,,	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures, 1909 (regd.)	104 107	105 108	3 14 1	February & August	..	..
£200,000	£25	4%	Do. 4% Mauritius Sub. Debs.	106% 109%	107% 110%	3 12 9	May and November	107	..
180,227	10	2/6	Globe Telegraph and Trust	8⅞ 9⅛	9 9¼	4 6 6	Jan., Apr., July, Oct.	9⅛	9
180,042	10	6%	Do. 6 per Cent. Preference	15¼ 15½	15⅜ 15⅝	3 16 10	,, ,,	15 9/16	15¼
150,000	10	7/2	Great Northern	21 21½	21 21½	3 19 1	Jan., April, and July	22⅜	21
£190,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	104 107	105 108	4 12 7	March & September	..	..
17,000	25	37/6	Indo-European xd & bonus	43 45	43 45	5 11 1	May and November	45	..
37,548	10	5/0	London Platino-Brazilian	4 6	5 7	..	,, ,,	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106 109	107 110	5 9 1	March & September	..	..
£100,000	£100	4%	Pacific European Tel. 4% Guar. Debs. "Red" 1942	102 105	103 106	3 15 6	.	..	..
11,839	8	4/0	Reuter's	5 6	5 6	..	April and October	..	..
3,381	£100 Cert.	35/0	Submarine Cables Trust 6 per Cent.	113 118	112 117	5 2 7	,, ,,	..	..
15,609	10	5/0	West African Telegraph	3 5	3 5	..	January and July	..	..
£249,900	100	5%	Do. 5 per Cent. Debentures	101 104	102 105	4 15 3	March & September	..	..
30,000	10	2/0	West Coast of America	2½ 3	2½ 3	..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	100 105	100 105	7 12 5	June and December	..	..
88,321	10	9d.	West India and Panama	1⅛ 1⅜	1⅛ 1⅜	..		–	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10¼ 10¾	10¼ 10¾	5 11 7	May and November	10 9/16	10¼
4,669	10	6%	Do. 6 per Cent. 2nd Preference	9 10	9 10	6 0 0	,, ,,	..	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	109 112	109 112	4 9 3	June and December	..	..
64,242	15	7/6	Western and Brazilian xd	7¼ 7¾	6¾ 7¼	..	May and November	..	..
33,129	7½	7/6	Do. 5 per Cent. Cumulative Preferred .. xd	6¼ 6¾	6 6½	..	..	..	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	2 2½	2 2½	..	.	2	..
£171,900	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	106 109	107 110	5 9 1	February & August	..	..
£214,800	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	106 109	107 110	5 9 1	,, ,,	..	..
$1,211,000	$1,000	7%	Western Union 7% 1st Mort. (Building) Bonds	111 115	111 115	6 1 9	May and November	..	..
£166,900	£100	6%	Do. 6 per Cent. Sterling Bonds	100 104	100 104	5 15 5	March & September	..	..
			TELEPHONES.						
44,000	5	10/0	Chili Telephone (fully paid)	1½ 2½	1½ 2½	..	..	..	..
224,850	10/0	3½d.	Consolidated Telephone Const. & Maintenance	⅛ ⅜	⅛ ⅜	..	May and November	..	..
171,504	£1	6d.	Oriental Telephone and Electric (fully paid)	½ ⅝	½ ⅝	..	Yearly	..	..
484,597	5	2/6	National	4⅞ 5⅛	4⅞ 5⅛	4 17 7	June and December	5⅛	4 15/16
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	15 16	15 16	3 15 0	,, ,,	15	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	14½ 15½	14½ 15½	3 17 5	,, ,,	14 13/16	..
119,234	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	5½ 5¾	5½ 5¾	4 6 11		5 11/16	5⅝
1,000,000	Stock	4½%	Do. Debenture Stock, 4½%	115 117	115 117	3 16 11	January and July	115	–
58,000	5	1/0	United River Plate	1½ 2	1½ 2	..	,, ,,	..	..
£146,733	Stock	5%	Do. 5 per Cent. Debenture Stock	90 100	90 100	5 0 0	,, ,,	..	–
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	..	City of London Electric Lighting (fully paid)	12 13	12 13	..	..	12¾	..
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	13½ 14	13½ 14	4 5 9	..	13⅞	13 11/16
19,900	£5	..	Electricity Supply Co. for Spain	..	..	..	..	..	..
£30,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	4½ 5½	4½ 5½	–	..	..	..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	..	..	..	..	..	..
8,322	£5	..	House-to-House Electric	..	..	.	..	..	–
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid).	..	..	..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..	..	..	January and July	..	..
5,523	£5	1/9	Liverpool Electric Supply (£4. 10s. paid)	..	..	..	..	..	–
39,477	£5	2/6	Do (fully paid)	6⅜ 6½	6⅜ 6½	–	..	..	..
111,000	5	..	London Electric Supply	½ ⅝	½ ⅝	..	..	..	..
49,900	£10	5/0	Metropolitan Electric Supply (fully paid)	8 8½	8¼ 8¾	2 17 2	..	8¾	8⅜
£100,000	Stock	5%	Do. 5% Debs. (Bonds of £10, £20, and £40), xd	107 110	107 110	4 10 11	June and December	109	108½
6,452	£10	..	Notting Hill Electric	4½ 5½	4½ 5½	–	..	..	..
19,980	£5	4/6	St. James and Pall Mall	6¾ 7½	7 7½	..	..	7¼	7⅛
20,000	£5	7%	Do. 7 per Cent. Preference	8 8½	8¼ 8¾	4 0 0	..	8½	..
59,900	5	2/6	Westminster Electric Supply (fully paid)	6¼ 6¾	6¼ 6¾	2 19 3	..	6¾	6½
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
90,000		1/6	Brush Electrical Engineering	2¾ 3	2¾ 3	6 0 0	..	3	2⅞
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	2⅛ 2⅜	2⅛ 2⅜	5 1 1	–	..	..
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	108 111	108 111	4 1 1	March & September	–	..
20,000	5	2/6	Crompton and Co., 7 per Cent. Cumulative Pref.	3 3½	3 3½	–	January and July –	..	..
12,139	5	..	Edison and Swan United	–	–	..	–	–	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	..	..	..	..	–	..
120,000	2	..	Electric Construction	¼ ¾	¼ ¾	..	..	–	–
12,845	2	..	Do. 7 per Cent. Cumulative Pref.	1¼ 1¾	1¼ 1¾	..	..	..	–
91,195	2	10/0	Elmore's Patent Copper Depositing	1¼ 1½	1⅛ 1⅜	..	..	1¼	..
20,000	5	..	Fowler-Waring Cables (fully paid)	½ 1½	½ 1½	–	..	..	–
50,000	10	15/0	India Rubber, Gutta Percha, &c., Works	23 24	23 24	5 4 2	February & August	23¾	23½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103 105	103 105	4 5 9	March & September	..	..
15,995	£10	6/4	International Okonite Ordinary	..	..	..		–	–
16,000	£10	..	Do. 8 per Cent. Preference	..	..	..	December and June	–	–
20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	— ⅛	— ⅛	..	..	–	..
78,949	5	3/6	Swan United (£3 10s. paid)	2 2½	2 2½	7 0 0	May and November	2⅛	2
37,350	12	36/0	Telegraph Construction and Maintenance	39 41	39 41	5 17 1	March and July	41	40
£150,000	100	5%	Do. 5 per Cent. Bonds	104 107	104 107	4 13 6	January and July	..	–
37,514	£5	–	Woodhouse and Rawson Ordinary (£3 15s. paid)	–	..	..	..	–	–
41,098	£5	–	Do. Preference (fully paid)	–	–	..	..	–	–
			RAILWAYS AND TRAMWAYS.						
£630,000	Stock	½%	City and South London Railway	36 38	36 38	1 16 2	May and November	..	–
£67,130	Stock	4%	Do. 4% Perpetual Debenture	119 121	119 121	3 6 2	May and November	120	..
7,000	10	..	Do. 5% Perpetual Preference	12 12½	12 12½	4 0 0	..	12½	12¼
37,500	£10	1%	Liverpool Overhead Railway	8¼ 8⅝	8¼ 8¾	..	..	..	–
6,295	10	5%	Do. 5% Preference	12¾ 13¼	12¾ 13¼	3 15 6	..	..	–
£125,000	Stock	4%	Do. 4% Debenture	110 112	12 114	3 10 2	January and July ..	–	–

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THE ELECTRICIAN:

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NOTES.

The interest of electrical engineers in the use of gas power for car propulsion was temporarily excited a short time ago by the favourable remarks of the President of the Institution of Mechanical Engineers in his presidential address. Our readers may therefore care to hear of an experiment in gas power propulsion which was commenced on the Croydon tramways last Tuesday. According to *The Times*, the motor is placed under the tramcar together with three cylindrical gas-holders. These three reservoirs hold a sufficient supply of gas to serve for an eight-mile run. The car is about 18ft. long, and, with the machinery, weighs 5½ tons. The motor, which is of the Otto type, and is specially constructed for tramway work, has a slow and a quick speed. The ignition of the charge in the motor cylinders is effected by electricity, and the cylinders exhaust into a condenser. At the charging station an 8-H.P. Otto engine drives a compressor. By this latter the gas, which is taken from the mains, is pumped into a steel receiver at a pressure of 150lb. per square inch. This plant is equal to the supply of five tramcars, the number which it is intended to place on the line at first. The pressure in the tramcar cylinders is about 120lb. per square inch at starting, and the cost of the gas used is stated to be 1d. per mile with a fully-loaded car.

Although apparently so direct a method of obtaining locomotion, gas power used in this way is really a very much more roundabout process than electric traction, and it involves a greater number of stages in the plant. The amount of capital per horse-power must therefore be relatively greater. Firstly, there is the series of plants belonging to the gas company, a share in the expenses of which has, of course, to be met by the tramway company. Next, there is the compressor plant, which must be adequate to compress gas at the maximum rate. Then there is the reservoir or storage plant. Lastly comes the gas motor with its system of gearing. From the point of view of capital charges, therefore, we are inclined to think that this system has some serious difficulties to surmount—the difficulties in working expenses, and the mechanical difficulties will probably be no less formidable. That great traction bugbear, the starting effort, must tell more forcibly upon gas motor plant—upon its reliability and on the margin of power which must be held in reserve—than on electromotors. Again, the necessity for cooling the cylinders must involve a very grave difficulty. However, the car is actually running, and it will be interesting to see with what measure of success its running may be continued.

In our issue of June 1st we commented on the apparently unfavourable verdict given by trials of the Welsbach light in the streets of Munich. Since then, however, Herr Murchall, of the Wiesbaden Gas Works, has quite another tale to tell. According to his experience with from 37 to 471 burners, the delicate constitution of the incandescent gas-burners withstands the "thousand natural shocks" of an open-air life far better than would have been thought possible; and Herr Murchall's figures as to cost, candle-power, duration, and gas consumption are worth attention. A light of some 60 candles can be obtained for a consumption of 3½ cubic feet of half-crown gas per hour. Chimneys, costing 6d., have to be renewed about every 600, and mantles, costing 1s. 6d., about every 500 hours. The falling off in candle-power during this brief span of life is barely 4 per cent., though a mantle, the existence of which is protracted to the Methuselah age of 2,000 hours, gives 46 candles instead of the 60 candles of its prime. The Welsbach light has not, however, as yet become quite indifferent to its surroundings, since its life when placed on a bracket is decidedly longer than on an ordinary lamp-post. From Glasgow we learn that the electric lighting of the streets is not to be extended; but the incandescent gas lamp is to be tried. It is evident that electricians must be prepared with a counterblast to this latest device of the enemy; that is to say, if street lighting according to the present practice be worth fighting for at all, which may well be doubted, except from the advertising point of view.

A Paper by O. Lehmann which we print elsewhere records some observations on the local alteration of colour and the segregation of the pigment to which the colour is due, produced by the passage of a current of high pressure through a badly-conducting liquid. Halos form at each electrode, and their advance is retarded, and the ease of their observation is enhanced by increasing the viscosity of the liquid in which they are formed by the addition of glycerine or sugar thereto. From the detailed account of the experiments referred to above, it appears that the electrolytic decomposition of the colouring matter is attended by the diffusion of the products and their encounter at a point intermediate between the electrodes, where actual mechanical disturbance, resulting in the deposition of the re-formed pig-

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ment, occurs. Thus, Congo red (amidosulphonaphthaleneazodiphenylazonaphthylamine sulphonic acid), which is a fairly sensitive indicator, becoming blue with acids and red with alkalies—the reverse of the colour change of ordinary litmus—gives not only, as might be expected, a blue colour at the anode and a red at the cathode, but yields a precipitate of pigment at the point where the two halos of colour meet. Liquids enmeshed in gelatine, their free movement being thus hindered, proved particularly suitable for the study of the action of currents at pressures that would have tended in ordinary mobile solution to an unduly rapid translation of the decomposition products.

In the Foreign Abstracts of the *Proceedings* of the Institution of Civil Engineers, Vol. CXVI., there is an interesting account of an investigation which has recently been made by M. P. Joubin, into the law of magnetisation of soft iron. This investigation forms the subject of a Paper communicated to the Académie des Sciences. Struck by the similarity existing between the curves, which represent the relation existing between the intensity of magnetisation and the susceptibility of the object submitted to that intensity, and the curves which represent the density of a saturated solution as a function of the temperature, the author has transformed Van der Waal's well-known formula for the density and pressure of a gas into corresponding quantities in magnetic terminology, and arrives then at Frölich's formula for the magnetic circuit, which was enunciated by empirical solution of numerous experimental researches. As in the fluid instance, there is an abrupt change in the curve when the vapour tension becomes zero, and a change of state occurs, so there is an abrupt change in the magnetic curve, and it is the intention of the author to investigate this point, and to obtain if possible a simple fundamental equation for the magnetic resistance.

Cable Extension.—The Halifax Board of Trade has unanimously passed a resolution asking the Dominion Government to subsidise an extension of the Bermuda cable to Jamaica.

Waterloo and City Railway.—Work on the electric railway between the City and Waterloo Station has been commenced by the contractors, Messrs. John Mowlem and Co.

Royal Society.—The following Papers were down for reading yesterday:—Sir D. Salomons, Bart, "On Some Phenomena in Vacuum Tubes;" Alexander P. Trotter, "The Rotation of the Electric Arc."

Cambridge.—Notice has been issued by the Cambridge Electric Supply Company that, on and after October 8th, there will be an uninterrupted supply of current at all hours of the day and night throughout the year.

Cable Interruptions and Repairs:—

	Date of Interruption.	Date of Repair.
Brest-St. Pierre (P.Q. Co.) ...	Mar. 29, 1894	June 13, 1894.
Bissao-Bolama	Nov. 24, 1893	—
Tarifa-Tangier	June 12, 1894	—

Electrical Bills in Parliament.—On Friday last week the London County Council (General Powers) Bill was read a second time in the House of Lords. The Central London Railway (Extension of Time) Bill was read a third time and passed.

Cable Laying.—The "Faraday" has picked up the Irish shore end of the Commercial Cable Company's new cable between Ireland and Nova Scotia, which was laid in April, and having spliced on the deep sea section is now paying out westward.

Telegraphic Communication in Western Australia.—Although the foreign business increased to the extent of £13,000, the returns of the Telegraph Department of Western Australia show a falling-off in receipts during last year of £7,586.

A Turkish Treatise on Telegraphy.—We are given to understand that the Turkish Council of State at Constantinople has decided to publish at the expense of the State a treatise on telegraphy giving all the information required by telegraphists and the public in general.

Indian Telegraphs.—The Revenue earned by the Indian Telegraph Department during 1893-94 shows an increase of four lakhs of rupees on private messages, as compared with the previous year. There has been a decrease of one lakh in expenditure on State telegrams.

Society of Arts.—The Council of the Society of Arts have awarded one of their silver medals to Mr. W. Worby Beaumont for his Paper on "Automatic Balance of Reciprocating Machinery, and the Prevention of Vibration." The thanks of the Society were voted to Mr. W. H. Preece for his Paper on "Electric Signalling Without Wires."

King Conduit System of Electric Traction.—The King system of electric traction with underground conduit is being tried on the Tenleytown Railway at Washington, D.C. Two ploughs on the car force back the flexible cover of the slot, which consists of hinged iron plates with a continuous strip of water-proof rubber belting underneath. The cost is estimated at £2,000 to £2,400 per mile.

The Consumption of Gas in Paris.—The quantity of gas supplied to Paris and the 59 suburban parishes was, during the year 1893, nearly 11 million thousand cubic feet, or less than the quantity supplied in 1892. The output of 1892 was itself less than that of 1891. The diminution is 1·75 per cent., which is a good deal less than the diminution reported by the Gas Light and Coke Company.

The British Association Report for 1893.—The transactions of the British Association for 1893, being the report of the meeting at Nottingham, have been published. Only two of the Papers read have been ordered to be printed *in extenso*. One is the Paper by Mr. W. Worby Beaumont on "The Automatic Balance of Reciprocating Mechanism," and the other is by Prof. Frankland on bacteriology.

Northern Society of Electrical Engineers.—A visit is to be paid by this Society to-morrow to the Liverpool Overhead Railway generating station, and the Oldham Place central station of the Liverpool Electric Supply Company. Arrangements are also being made for an excursion to the Antwerp Exhibition in July. Upwards of 20 members have already signified their intention of joining the party.

Nelson.—An additional engine and dynamo have been satisfactorily started in the electric-generating station of the Nelson Corporation. The Corporation has now been supplying electric energy for 18 months without a single failure. This installation has made a profit the first year with the selling price at 5d. per unit. The generating station is situated at the gasworks, and is superintended by a son of the gas manager.

Electrical Utilisation of Water Power.—An important electric power generation and transmission plant is now being erected on Williamette River, at a distance of about 12 miles from the town of Portland, Oregon. At this point the river falls 40ft., and there is available some 16,000 H.P. Some 20 Victor turbines, having an aggregate capacity of 12,000 H.P., are to be erected, and will drive alternators by means of belting. The current will be transmitted to Portland, and utilised there.

The City Transformer Sub-Stations.—There are in all twenty-two transformer stations in the City of London, whose situations are as follows, viz.:—Bartholomew Close, Crosby-square, Coleman-street, Falcon-square, Farringdon-street, Finsbury-circus, Fetter-lane, Lime-street-square, Milk-street, New-square, (Minories), Red Cross-street, Rood-lane, Salisbury-square, St. Andrew's-hill, St. James's-place (Duke-street), Watling-street, and Warwick-square; Copthall-avenue, St. Benetfink-churchyard (at the rear of the Royal Exchange), Queen

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Victoria-street (St. Nicholas-churchyard), Nicholas-lane (in churchyard), and Pancras-lane.

Electro-Chemistry in Germany.—Electro-chemistry is making great progress in Germany at the present time. The electro-chemists have already a society of their own, and also a technical organ, and now we learn that it is desired to see established in connection with the well-known German Technische Hochschüle, Chairs of Electro-Chemistry. A deputation consisting of representatives of the Union of Industrial Chemists of Germany and the German Electro-Chemical Society recently waited on the Ministers of Finance and Education in Berlin with the object of asking that provisions for such Chairs be made in next year's estimates. The deputation was well received, the ministers promising to give the matter their consideration. According to later information, Chairs of electro-chemistry are to be founded at the Polytechnic Academies of Berlin, Hanover, and Aix-la-Chapelle.

Electrical Utilisation of Water Power in Austria and Hungary.—Messrs. Brown, Boveri and Co., of Baden, Switzerland, have recently put down an electric-power transmission plant at Burrida. The machinery, which is driven by water power, the hydraulic plant having been supplied by Signor Albertos Riva of Milan, comprises three generating machines of 150H.P., and three motors of the same power. The energy generated is transmitted to the cotton-spinning mills of Messrs. Amman and Co., one at Pordenone, and one at Fiume, at distances of 2½ miles and 6½ miles respectively. It is stated that a syndicate has acquired the Austrian and Hungarian patent rights of carborundum, and is establishing works for its manufacture at Benatek. The machinery at the works is to be driven by electricity, it being intended to put down a plant for the electrical utilisation of certain available water power.

Technical Education.—*Nature* announces that the Scottish Association for the Promotion of Technical and Secondary Education have presented a memorial to Mr. Acland asking that the yearly examinations of the Department of Science and Art shall be held in the day as well as in the evening. It is pointed out that originally arranged, as they were, to suit the convenience of artisan pupils who could not be expected to attend during the day, these evening examinations are now taken by large and increasing numbers of pupils of secondary and higher grade schools. While, therefore, fully recognising the necessity which exists for examinations in all stages of art and science subjects being continued in the evenings as heretofore, the memorialists urge the desirability of provision being made by the Department for the examination, within school hours, of pupils attending day schools.

Lamp Shades.—Referring to M. Dupré's letter to *The Times* of May 23rd (*The Electrician*, May 25th, p. 96), Messrs. J. R. Crompton and Bros., of Elton Paper Mills (Lancs.), stated in *The Times* of Tuesday that since reading the letter they have made numerous experiments, and particularly with the chrome colours, and in no single instance can they get any one of them to fire spontaneously. They have had the papers in question heated in a heating-chamber to nearly 400°F., with the result that in every case the papers when taken therefrom remained in their original uninjured condition, notwithstanding their being subjected to the heat named for several hours. They have also saturated the papers with chromic acid and dried them, and even after this severe test have failed to get them to fire spontaneously at the heat named, or under similar circumstances.

Barmen.—According to *Engineering*, an electric rack tram line has been erected at Barmen, to the designs of Messrs. Siemens and Halske. The rack line is about 1 mile long, the total rise being 550ft. The average grade is thus about 1 in 10; but the steepest portion is 1 in 5·4. The sharpest curve on the line has a radius of 500ft. The rack is of the Riggenback pattern, having teeth 3½in. long set at a 3in. pitch. It has been constructed in sections 10ft. long. Both rack and adhesion rails are fixed to the same sleepers, which are of steel spaced at 40in. centres. To prevent a bodily slipping down of the whole line, concrete anchors are sunk in the ground below the rails at intervals of 50 to 60 yards, to which a couple of the sleepers are firmly secured. The cars used have accommodation for 28 passengers, and are fitted with two 36-H.P. electric motors. Overhead conductors are used for conveying the current to the cars. Steam is used to supply power at the generating station.

A Bird in the Hand is worth Two in the Pipe.—For about an hour and a-half on the morning of the 7th inst. the electric lighting in the streets of Bath failed. Mr. Gatehouse reports that the failure "was due to a sparrow's nest having been built in the pipe which conveys the leads up the side of No. 10, Stall-street, to lamp No. 6. The nest probably pressed the leads close to the side of the pipe, and the rain trickling down the pipe saturated the nest with moisture, forming a semi-connecting circuit between them. These leads (or conductors) are covered externally with prepared hemp and jute, which absorb moisture readily, and when they become saturated act in conjunction with the insulating material beneath them as a kind of condenser. When in this condition they are sufficiently close together for a small induced spark to pass, which ultimately destroys the insulation. This appears to have occurred in the present case, with the result that the nest took fire and the insulation broke down at this point."

Electric Lighting in Japan.—A state of affairs regarding electric lighting in Japan, which is not without its moral, has come to light in connection with the recent celebrations of the silver wedding of the Mikado of Japan, when the Imperial palace was lighted by no less than 1,000 candles. Originally the rooms were lighted by electricity, and the magnificent electroliers constituted quite a feature of their internal decoration. It appears, however, from a Japanese paper that the installation, although superintended by a foreign expert, was more or less defective from the first, and complete confidence in immunity from fire was never felt. After the destruction of the Parliament buildings some years ago by fire, which catastrophe was generally attributed to the electric lighting, the Mikado conceived a dislike and distrust of that method of illumination, and that fact supplementing the uneasiness already felt about the security of the installation in the palace, settled the doom of the whole affair, candles having ever since been used.

Lawrence Conduit System of Electric Traction.—The Lawrence Electric Company, of New York, are bringing forward a new form of conduit for electrical lines. The essential feature of the system is a working conductor consisting of a section of a T-shaped rail 32ft. long, which is carried on pivoted arms placed in the conduit. Each section of rail is insulated from those before and behind it, but is joined to them by plates of hard vulcanised fibre. All sections of the conductor, save those under the trolley, are completely insulated from the main lead from the generating station, which is laid alongside the track. The current collector depresses the conductor section immediately underneath, being able to do so, since this section is supported on pivoted arms or levers, the other ends of which then make contact with the main from the generating station. The current can then pass through these arms to the conductor section, and thence through the collector to the car. The plant is said to have worked well, even when the track and conduit were flooded with 3ft. of salt water.

A 10,000-Volt Arc Light Dynamo.—Considerable interest attaches to a new type of arc light dynamo recently brought out by the Excelsior Electric Company, of America. The machine is the first 10,000-volt continuous current dynamo designed for running arc lamps in series, and it has a capacity of 200 10-ampere lamps. The general design of this machine is on the lines of the 5,000-volt Hochhausen dynamo, for 100 lights, brought out by the same Company some four years ago. It runs at a speed of 625 revolutions per minute, developing 10 amperes at 10,000 volts. There are 48 coils on the armature, each consisting of 220 turns or windings; and there are, of course, 48 commutator segments. The external diameter of the armature ring is 33in., and its internal diameter 20in. The ring is of square section, 6·5in. each way. The pole-pieces are hinged so that they can be swung back for inspection. There is only one bearing, namely, in the interior between the armature and

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the pulley. The weight of the complete machine is 7 tons 2cwt. 96lb. The regulation of a machine of this type is no easy matter; it is effected, in the present case, by means of a supplementary electromotor, arranged to shift the brushes according to the load. This motor is controlled by a constant-current regulator. It is said that the flashing which results is by no means abnormal, which, however vague, is probably nearer the truth than if it had been said the flashing is small.

Boiler Explosions.—We have received a copy of the last Report of the National Boiler and General Insurance Company. The whole of this report is well worth reading, and it contains much valuable information for steam users. Among the records of boiler explosions we notice two which may be of special interest. The first of these was a Babcock and Wilcox boiler, which burst a tube and caused one death, owing to the accumulation of mud deposits in the headers and about the ends of the tubes at the back of the boiler. The rupture occurred along about 4ft. 8in. of the tube, and commenced at about 2ft. 6in. from the front end. The engineer who had charge of the boiler was found to have been very negligent, and the direct cause of the explosion was over-heating of the tube due to infrequent cleaning. The second explosion we may notice relates to an economiser, consisting of 224 pipes. It appears that this large economiser was fitted with only one safety-valve, and the explosion occurred during a time when this valve had been removed for repair. There was no pressure-gauge on the economiser. Owing to the bad fit of the economiser dampers, which were closed, a considerable quantity of hot gas escaped into the economiser flue and raised steam sufficiently to burst a pipe. The Company recommends that two safety-valves be fitted to all economisers, and more than this where the number of pipes is very large.

Overhead Troubles from Railway "Earth" Currents.—In building the extension of the Fifth-avenue branch of the Brooklyn Elevated Railroad to the city line at Sixty-seventh-street and Third-avenue the Company found difficulty in securing certain property rights between Thirty-eighth-street and Fifth-avenue and Fortieth-street and Third-avenue. Pending the settlement of this matter the structure south from Fortieth-street was erected. Upon its completion the work of joining the two parts was pushed forward, commencing at Thirty-eighth-street, the former terminus. Whilst hoisting into position the first of the last four 65ft. longitudinal girders necessary to connect the two sections, the end not yet in position came in contact with the transverse girder. Immediately the metal was melted and an electric arc was formed, and the melted iron fell to the street. After several attempts to swing the girder into position, the engineer succeeded in locating the trouble. The insulation of one of the positive feed wires of the Brooklyn City Railroad's trolley line, which were strung on one side of the elevated posts, had so worn that the live wire came in contact with the structure. The negative cable, which completed the circuit, reached the ironwork from underground at a point on the other side of the unfinished section, and the contact between the two parts of the structure completed the circuit and caused the fusion.

An After-Dinner Phenomenon.—When the guests adjourned to the engine room of the Portsmouth electric supply station after the inaugural banquet, they found one of the alternators at work, and the place brilliantly illuminated by the arc lamps. The other alternator was then started, and the massive fly-wheel, crowned with a diadem of glittering copper coils, began to smoothly turn, gradually quicken, and finally spin round at full speed. But as it did this, the bystanders were amazed to see the rim slowly revolving the wrong way, while the crank and piston rod were running on without change. In another moment the field magnets stopped, and then began to turn the right way, but leisurely. Again they reversed, and finally stopped! Some of the guests gave vent to expressions of amazement; but the more cautious, remembering the good things generously provided by the mayor, rubbed their eyes, clutched a hand-rail and held their tongues. The precursory symptoms of a plague which devastated Jeddah some time ago were strange hallucinations. An English resident stained his dog blue, and painted it with red stripes and yellow spots. It ran about the streets for a week, and nobody made a single remark about it. It is only necessary to add that the rectified current, giving as it does one hundred flickers per second, shows a series of momentary glimpses of the armature, which, if running synchronously, appears stationary, and if a little slow or fast, seems to revolve backwards or forwards.

Systematic Workshop Instruction.—Some time ago, says Mr. Franklin L. Pope in the *Engineering Magazine*, the General Electric Company established at its works in Schenectady a student's course of instruction in electrical engineering, intended for young men who have had at least three years' experience in electrical or machine-shop work, or who have obtained from some technical institution the decree of civil, mechanical, or electrical engineer. At first the Company felt compelled to exact a fee for admission to this course, but experience soon demonstrated that this had the effect of excluding the very kind of men who were likely to be of most value to the Company—those who had worked their own way through college, but who could not afford to pay the fee, and hence the requirement was abolished. The object of the course is to give the student a thorough practical knowledge of the various processes through which a piece of electrical apparatus is carried while in course of construction, and also of the electrical and mechanical principles involved in the different operations. He is placed for a stated time in each of the departments of the works, in which he is required to perform actual work under the supervision of the foreman, and receives such instruction as will enable him to do so. The time occupied by the complete course is ordinarily expected to be about two years, and the learner is paid at rates varying from 8 to 17½ cents per hour, according to his experience and proficiency. The students are required in all cases to observe the same rules and regulations as the regular workmen respecting conduct and hours of work. It is stated that the complement of students is at present filled, and that there is likely to be no vacancy during the present year.

The Oxford Meeting of the British Association.—There are already signs, says *Nature*, that the meeting of the British Association, to be held this year at Oxford, will be a success. It is unfortunate, perhaps, that the City of Oxford is this year destitute of municipal buildings, the old buildings having been pulled down, while the new have scarcely their walls raised to the level of the first floor. But this deficiency is amply compensated by the numerous University and College buildings which have been placed at the disposal of the Local Executive Committee. The reception room will be in the entrance hall of the new Examination Schools in High-street. Section A (Mathematical and Physical Science) will meet in the Lecture Theatre of the Clarendon Laboratory, and the allied Section G (Mechanical Science) will meet in close contiguity in Keble College Hall. Section B (Chemistry) will meet in the Chemical Theatre, and for larger meetings will have the use of the large Lecture Theatre in the Museum. The proceedings will begin on the evening of Wednesday, August 8th, when Prof. Burdon Sanderson will resign the presidency, and the new President, the Marquis of Salisbury, Chancellor of the University, will deliver the opening address. On the Thursday evening there will be a conversazione in the University Museum. On the Friday evening Mr. W. H. White, C.B., will give an evening lecture in the Sheldonian Theatre, on "Steam Navigation at High Speeds." The Saturday evening lecture to working men will be given by Prof. Sollas; and Tuesday evening will be occupied by a conversazione. Invitations to foreign investigators have been issued by the Local Executive Committee, and nearly eighty have already signified their intention to attend the meeting. Nearly every prominent English man of science has already expressed his intention of being present, and there can be little doubt that the Oxford meeting of 1894 will equal in interest the last Oxford meeting of 1860, which was made celebrated by Prof. Huxley's spirited defence of the then novel doctrine of Darwinism. The local secretaries for the Oxford meeting are Messrs. G. C. Bourne, G. Claridge Druce, and D. H. Nagel, and any communications respecting the meeting should be addressed to them at the University Museum, Oxford.

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BOILER TRIALS.*

Some careful trials of the Babcock-Wilcox boilers at the Bankside station of the City of London Electric Lighting Company have recently been undertaken, with a view to determine the most economical class of fuel and the best method of stoking it. We are able to give, this week, a summary of the results of these trials.

Summary of Trials of Boilers at the City of London Electric Lighting Station, Bankside, E.C.

—	Babcock and Wilcox Boilers.	
	Hand-firing.	Vicars' Patent Mechanical Stoking System.
Date of trial	April 26, 1894.	June 4, 1894.
Duration of trial	Nine hours.	Six hours.
Description of fuel used	Nixon's Navigation.	Bituminous rough, small.
Price of fuel used per ton	16s.	10s.
Fuel consumed	13,664lb.	9,184lb.
Ashes and clinker	532lb.	1,022lb.
Weight of combustible	13,132lb.	8,162lb.
Per cent. of ash	3·9	11·1
Draught in flues (average)	0·48in.	0·55in.
Temperature in flues (average)	412°F.	453°F.
Water evaporated	118,535lb.	82,100lb.
Temperature of feed water	54·3°F.	62°F.
Average steam pressure	145·9lb.	157·5lb.
Water evaporated per hour	13,170lb.	13,683lb.
Water evaporated per pound of fuel used	8·67lb.	8·94lb.
Ditto per pound of combustible	9·02lb.	10·05lb.
Ditto per pound of fuel used, from and at 212°F.	10·50lb.	10·78lb.
Ditto per pound of combustible from and at 212°F.	10·93lb.	12·12lb.
Cost of evaporating 500 gallons of feed water, in pence	40·8	24·8

Our readers will be interested to know that, in consequence of these trials, all the boilers at the Bankside station of the City of London Electric Lighting Company are forthwith to be fitted with the Vicars mechanical stokers and coal-conveying and elevating plant. We may point out that the essential fact to be deduced from the trials is that an equivalent or slightly better evaporation per pound of coal is to be obtained from the steady continuous stoking of cheap bituminous slack by mechanical means, than can be obtained from the best and most costly qualities of smokeless steam coal fired by hand. The chief element of saving lies in the reduced cost of the coal per ton, the evaporation per pound of the bought coal being only slightly improved (in this case, at any rate) by the use of the mechanical appliances. Our readers will remember that this electric light company was under an injunction to cease from causing smoke to escape from the works chimney, during the time when, owing to the coal strike, it was compelled to burn inferior fuel by hand firing. But though inferior bituminous coals cannot be fired by hand without developing heavy smoke, it has been demonstrated over and over again that their combustion may be quite smokeless if carried on by mechanical coking firing, such as is now to be adopted at Bankside. A further point of interest in the trials lies in the fact that the well-known Babcock-Wilcox water tube boilers were tested. These boilers up to the time the trials were undertaken had invariably proved themselves better adapted to the production of steam from smokeless dry coals, and had not given very satisfactory results with bituminous coals. It is therefore interesting to observe that, with continuous coking firing, very good results with cheap bituminous slack may be obtained in this class of boiler.

* Compiled from "Motive Power and Gearing," a forthcoming work to be published by *The Electrician* Printing and Publishing Company.

ON THE FINDING OF FAULTS IN COILS WOUND ON CONDUCTING BOBBINS.

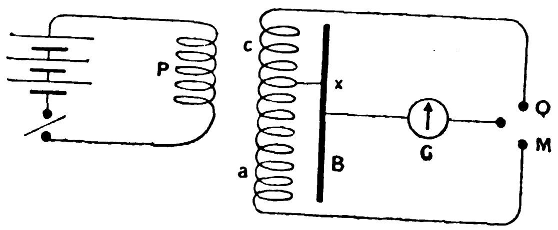
BY ALBERT CAMPBELL, B.A.

In many galvanometers and other measuring instruments, as well as for the field-magnets for dynamos and motors, it is usual to have coils of insulated wire of many turns wound on metallic bobbins. Unless the winding is done with care, sometimes faults are found in a coil, such as points where the wire is almost short-circuited to the metallic bobbin.

A short time ago a field-magnet coil was brought to the writer to be tested. Ordinary resistance tests showed that between the coil and the bobbin there was a fault of about 100 ohms resistance. As this resistance was found to be very unsteady, resistance tests were abandoned, and the writer devised the following simple method of localising the fault by induced currents. As far as he knows, it is novel, and it certainly proved quite effective; for, on unwinding the coil, a little sharp piece of brass turning was found to have pierced the vulcanised fibre insulation quite near the point predicted by the test.

The method of carrying out the test will be made more clear by reference to the accompanying diagram, in which $a\,c$ represents the coil to be tested, B being the bobbin on which it is wound.

A fairly high resistance galvanometer, G, has one of its terminals connected to the bobbin B, whilst the other terminal can be connected at will with either of the free ends of the coil at M and Q. A number of turns of insulated wire, P, are wound over the coil to be tested; this coil P we shall denominate the primary. Let the fault be at x.



G is now connected to M, and a fairly strong current is switched on in the primary P. The throw of the galvanometer is observed. G is next connected to Q instead of M, the same current is switched on again in P, and the new throw is observed in the galvanometer.

If the two throws be D_1 and D_2 respectively, we have approximately

$$\frac{\text{No. of turns in branch } a}{\text{No. of turns in branch } b} = \frac{D_1}{D_2}.$$

This relation at once localises the fault x in the coil.

A few remarks should be made on the practical working of the test. It will be noticed that if the galvanometer be fairly sensitive, a fault of high resistance presents no difficulty. If the resistance of the fault be variable, the galvanometer resistance ought to be high compared with the fault resistance. If possible, a ballistic mirror galvanometer should be used. The test may be roughly done, however, with any form of detector or galvanometer in which the swings are fairly proportional to current impulse. If the galvanometer is not sensitive enough, an iron core should be inserted in the coil. This, if practicable, should consist of strips of sheet iron, whose ends are doubled round so as to overlap and form a closed magnetic circuit. In this case we get a far greater flux of magnetic lines, and therefore much larger throws on the galvanometer. Besides, since by far the greater proportion of the lines go through the iron, we may assume with great accuracy that a given primary current will insert the same number of lines of force into the circuit a as into the circuit c. Without a closed iron circuit this is only roughly approximate, and that only where the coil is shallow in comparison with its diameter. If preferred, the primary coil need not be wound over the coil to be tested, but may instead be wound on the iron core or on a bobbin to be slipped over the core.

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Of course, if an alternating-current supply is available, and a suitable voltmeter, the method may be modified by putting the voltmeter in place of the galvanometer, and using alternating current in the primary P. The voltmeter would have to be of high resistance, or an electrostatic one.

Without a galvanometer at all, a very rough test may be made by simply placing a compass needle at the centre of the coil, and observing its deflections when one pole of a battery (with high resistance in circuit) is connected to the bobbin, whilst the other pole is joined successively to the two free ends of the coil.

THE WORK OF HERTZ.*

(Concluded from page 190.)

Holtz Sparks not exciting Tube: except by help of a polished knob.

The powerful disturbance caused by the violent flashes of a Wimshurst or Voss machine it is blind to. If the knobs of the machine are well polished it will respond to some high harmonics, due to the vibrations in the terminal rods, and these are the vibrations to which it responds when excited by a coil. The coil should have knobs instead of points. Sparks from points or dirty knobs hardly excite the coherer at all. But hold a well-polished sphere or third knob between even the dirty knobs of a Voss machine, and the coherer responds at once to the surgings got up in it.

Feeble short sparks again are often more powerful exciters than are strong long ones. I suppose because they are more sudden.

This is instructively shown with an electrophorus lid. Spark it to a knuckle, and it does very little. Spark it to a knob and it works well. But now spark it to an insulated sphere, there is some effect. Discharge the sphere, and take a second spark, without recharging the lid. Do this several times, and at last, when the spark is inaudible, invisible, and otherwise imperceptible, the coherer some yards away responds more violently than ever, and the spot of light rushes from the scale.

If a coherer be attached by a side wire to the gas pipes, and an electrophorous spark be given to either the gas pipes or the water pipes or even to the hot-water system in another room of the building, the coherer responds.

In fact, when thus connected to gas-pipes one day when I tried it, the spot of light could hardly keep five seconds still. Whether there was a distant thunderstorm, or whether it was only picking up telegraphic jerks, I do not know. The jerk of turning on or off an extra Swan lamp can affect it when sensitive. I hope to try for long-wave radiation from the sun, filtering out the ordinary well-known waves by a black-board or other sufficiently opaque substance.

We can easily see the detector respond to a distant source of radiation now, viz., to a 6in. sphere placed in the library between coil knobs.

Also I exhibit a small complete detector made by my assistant, Mr. Davies, which is quite portable and easily set up. The essentials are all in a copper cylinder three inches by two. A bit of wire a few inches long, pegged into it, helps it to collect waves. It is just conceivable that at some distant date, say by dint of inserting gold wires or powder in the retina, we may be enabled to see waves which at present we are blind to.

Observe how simple the production and detection of Hertz waves are now. An electrophorus or a frictional machine serves to excite them, a voltaic cell, a rough galvanometer, and a bad contact serves to detect them. Indeed, they might have been observed at the beginning of the century, before galvanometers were known. A frog's leg or an iodide of starch paper would do almost as well.

A bad contact was at one time regarded as a simple nuisance because of the singularly uncertain and capricious character of the current transmitted by it. Hughes observed its sensitiveness to sound-waves, and it became the microphone. Now it turns out to be sensitive to electric waves if it be made of any oxidisable metal (not of carbon), and we have an instrument which might be called a micro-something, but which, as it appears to act by cohesion, I call at present a coherer. Perhaps some of the capriciousness of an anathematised bad contact was sometimes due to the fact that it was responding to stray electric radiation.

The breaking down of cohesion by mechanical tremour is an ancient process, observed on a large scale by engineers in railway axles and girders; indeed, the cutting of small girders by persistent blows of hammer and chisel reminded me the other day of the tapping back of our cohering surfaces after they have been exposed to the welding effect of the electric jerk.

If a coherer is shut up in a complete metal enclosure, waves cannot get at it, but if wires are led from it to an outside ordinary galvanometer, it remains nearly as sensitive as it was before (nearly, not quite), for the circuit picks up the waves and they run along the insulated wires into the closed box. To screen it effectively, it is necessary to enclose battery and galvanometer and every bit of wire connection; the only thing that may be left outside is the needle of the galvanometer. Accordingly, here we have a compact arrangement of battery and coil and coherer, all shut up in a copper box. The coil is fixed against the side of the box at such height that it can act conveniently on an outside suspended compass needle. The slow action of the coil has no difficulty in getting through copper, as everyone knows; only a perfect conductor could screen off that, but the Hertz waves are effectively kept out by sheet copper.

It must be said, however, that the box must be exceedingly well closed for the screening to be perfect. The very narrowest chink permits their entrance, and at one time I thought I should have to solder a lid on before they could be kept entirely out. Clamping a copper lid on to a flange in six places was not enough. But by the use of pads of tinfoil, chinks can be avoided, and the inside of the box becomes then electrically dark.

If even an inch of the circuit protrudes, it at once becomes slightly sensitive again; and if a single branch wire protrudes through the box, provided it is insulated where it passes through, the waves will utilise it as a speaking tube, and run blithely in. And this whether the wire be connected to anything inside or not, though it acts more strongly when connected.

If wires are to be taken out of the box to a coherer in some other enclosure, they must be enclosed in a metal tube, and this tube must be well connected with the metal of both enclosures, if nothing is to get in but what is wanted.

Similarly, when definite radiation is desired, it is well to put the radiator in a copper hat, open in only one direction. And in order to guard against reflected and collateral surgings running along the wires which pass outside to the coil and battery, as they are liable to do, I am accustomed to put all these things in a packing case lined with tinfoil, to the outside of which the sending hat is fixed, and to pull the key of the primary exciting circuit by a string from outside.

With reference to the reflecting power of different substances it may be interesting to give the following numbers, showing the motion of the spot of light when 8in. waves were reflected into the copper hat, the angle of incidence being about 45deg., by the following mirrors:—

Sheet of window glass..................	0	or at most 1 division.
Human body..............................	7	divisions.
Drawing board............................	12	,,
Towel soaked with tap-water...........	12	,,
Tea-paper (lead ?)........................	40	,,
Dutch metal paper	70	,,
Tinfoil	80	,,
Sheet copper................................	100	and up against stops.

Even then, with the lid of the hat well clamped on, something gets out, but it is not enough to cause serious disturbance of qualitative results. The sender must evidently be thought of as emitting a momentary blaze of light which escapes through every chink. Or, indeed, since the waves are some inches long, the difficulty of keeping them out of an enclosure may be likened to the difficulty of excluding sound; though the difficulty is not quite so great as that, since a reasonable thickness of metal is really opaque. I fancied once or twice I detected a trace of transparency in such metal sheets as ordinary tinplate, but unnoticed chinks elsewhere may have deceived me. It is a thing easy to make sure of as soon as I have more time.

One thing in this connection is noticeable, and that is how little radiation gets either in or out of a small round hole. A narrow long chink in the receiver box lets in a lot; a round hole the size of a shilling lets in hardly any, unless, indeed, a bit of insulated wire protrudes through it like a collecting ear trumpet.

It may be asked how the waves get out of the metal tube of an electric gas-lighter. But they do not; they get out through the handle, which being of ebonite is transparent. Wrap up the handle tightly in tinfoil, and a gas-lighter is powerless.

Optical Experiments.

And now in conclusion I will show some of the ordinary optical experiments with Hertz waves, using as source either one of two devices; either a 6in. sphere with sparks to ends of a diameter (Fig. 20), an arrangement which emits 9in. waves, but of so dead-beat a character that it is wise to enclose it in a copper hat to prolong them, and send them out in the desired direction; or else a 2in. hollow cylinder with spark knobs at ends of an internal diameter. This last emits 3in. waves of a very fairly persistent character, but with nothing like the intensity of one of the outside radiators.

As receiver there is no need to use anything sensitive, so I employ a glass tube full of coarse iron filings, put at the back of a copper hat with its mouth turned well askew to the source,

* A lecture delivered at the Royal Institution on Friday, June 1st, by Prof. Oliver Lodge, F.R.S., ably assisted during both preparation and performance by Mr. Edward E. Robinson.

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which is put outside the door at a distance of some yards, so that only a little direct radiation can reach the tube. Sometimes the tube is put lengthways in the hat instead of crossways, which makes it less sensitive, and has also the advantage of doing away with the polarising or rather analysing power of a crossway tube.

The radiation from the sphere is still too strong, but it can be stopped down by a diaphragm plate with holes in it of varying size clamped on the sending hat.

Having thus reduced the excursion of the spot of light to a foot or so, a metal plate is held as reflector, and at once the spot travels a couple of yards. A wet cloth reflects something, but a thin glass plate, if dry, reflects next to nothing, being, as is well known, too thin to give anything but "the black spot." I have fancied that it reflects something of the 3in. waves.

Refracting Prism and Lens.

A block of paraffin about a cubic foot in volume is cast into the shape of a prism with angles 75deg., 60deg., and 45deg. Using the large angle, the rays are refracted into the receiving hat (Fig. 21), and produce an effect much larger than when the prism is removed.

a third grid, with its wires at 45deg. between two crossed grids, restores some of the obliterated effect.

Radiation reflected from a grid is strongly polarised in a plane normal, of course, to that of the radiation which gets through it. They are thus analogous in their effect to Nicols, or to a pile of plates.

The electric vibrations which get through these grids are at right angles to the wires. Vibrations parallel to the wires are reflected or absorbed.

Reflecting Paraffin Surface.

To demonstrate that the so-called plane of polarisation of the radiation transmitted by a grid is at right angles to the electric vibration,* *i.e.*, that when light is reflected from the boundary of a transparent substance at the polarising angle the electric vibrations of the reflected beam are perpendicular to the plane of reflection, I use the same paraffin prism as before; but this time I use its largest face as a reflector, and set it at something near the polarising angle. When the line of wires is parallel to the plane of incidence, in which case the electric vibrations are perpendicular to the plane of incidence, plenty of radiation is reflected by the paraffin face. Turning the grid so that the electric vibrations are in

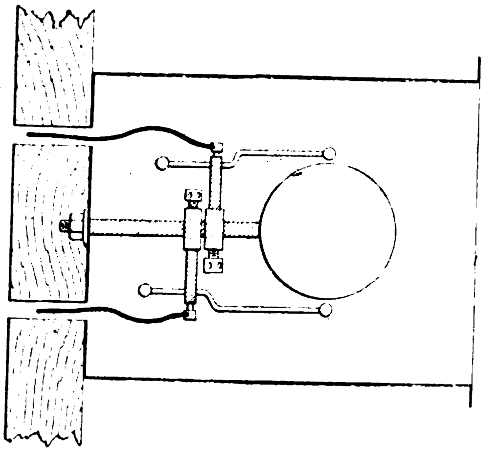

Fig. 20.—Spherical Radiator for emitting a Horizontal Beam, arranged inside a Copper Hat, fixed against the inside of a Wooden Box. One-eighth natural size. The wires pass out through glass tubes not shown.

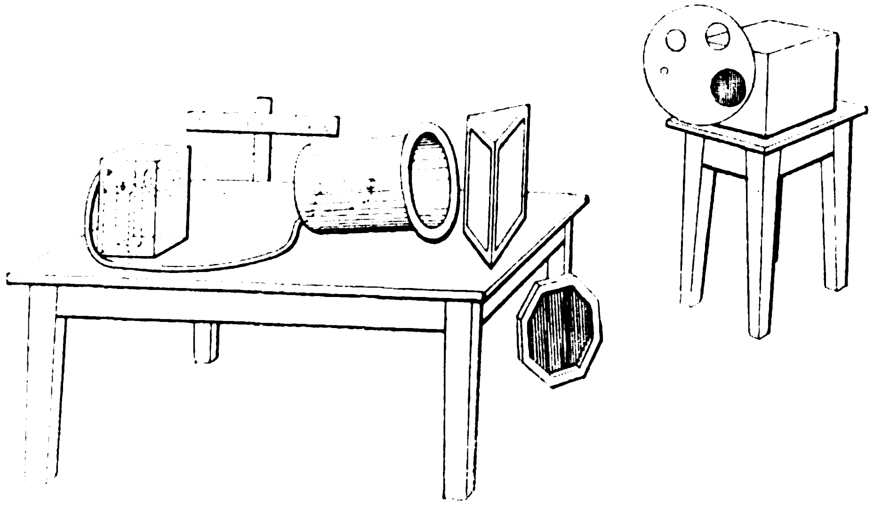

Fig. 21.—General arrangement of experiments with the Copper "Hat," showing Wooden Box on a Stool, inside which the Radiators were fixed; the Copper Hat containing the Coherer; the Metal Box containing Battery and Galvanometer Coil; a Paraffin Prism; and a Polarising Grid.

An ordinary 9in. glass lens is next placed near the source, and by means of the light of a taper it is focussed between source and receiver. The lens is seen to increase the effect.

Arago Disc; Grating and Zone-plate.

The lens helps us to set correctly an 18in. circular copper disc in position for showing the bright diffraction spot. Removing the disc the effect is much the same as when it was present. Add the lens and the effect is greater. With a diffraction grating of copper strips 2in. broad and 2in. apart, I have not yet succeeded in getting good results. It is difficult to get sharp nodes and interference effects with these sensitive detectors in a room. I expect to do better when I can try out of doors away from so many reflecting surfaces; indoors it is like trying delicate optical experiments in a small whitewashed chamber well supplied with looking-glasses; nor have I ever succeeded in getting clear concentration with this zone-plate having Newton rings fixed to it in tinfoil. But really there is nothing of much interest now in diffraction effects except the demonstration of the waves and the measure of their length. There was immense interest in Hertz's time, because then the wave character of the radiation had to be proved, but every possible kind of wave must give interference and diffraction effects, and their theory is, so to say, worked out. More interest attaches to polarisation, double refraction, and dispersion experiments.

Polarising and Analysing Grids.

Polarisation experiments are easy enough. Radiation from a sphere is already strongly polarised, and the tube acts as a partial analyser, responding much more vigorously when its length is parallel to the line of sparks than when they are crossed; but a convenient extra polariser is a grid of wires something like what was used by Hertz, only on a much smaller scale; say an 18in. octagonal frame of copper strip with a harp of parallel copper wires (*see* Fig. 21). The spark-line of the radiator being set at 45deg., a vertical grid placed over receiver reduces the deflection to about one-half, and a crossed grid over the source reduces it to nearly nothing.

Rotating either grid a little rapidly increases the effect, which becomes a maximum when they are parallel. The interposition of

the plane of incidence, we find that the paraffin surface set at the proper angle is able to reflect hardly anything. In other words, the vibrations contemplated by Fresnel are the electric vibrations; those dealt with by McCullagh are the magnetic ones.

Thus are some of the surmises of genius verified and made obvious to the wayfaring man.

A NEW PHENOMENON OBSERVED IN THE PASSAGE OF ELECTRICITY THROUGH BADLY CONDUCTING LIQUIDS.†

BY O. LEHMANN.

During the electrolysis of good liquid conductors the changes are known to be confined to the proximity of the electrodes. As far as I know, no changes have hitherto been observed in the interior of badly conducting liquids (if we disregard convection currents and electric osmosis). On the other hand, I have found the passage of electricity through various badly conducting solutions, especially of aniline dyes, to be attended by changes propagated quickly and continuously from the electrodes to the centre, and, finally, by the formation of a precipitate in the middle of the liquid, or at least between the electrodes. The phenomena are most easily observed by means of a microscope and an arrangement previously‡ described.

If, for instance, a current of about 70 volts pressure is conducted through an aqueous solution of Congo red, a pretty sharply marked halo is formed round both electrodes of a beautiful blue colour at the anode and somewhat paler than the rest of the solution at the cathode, but divided off from it by a darker boundary (Fig. 1).

* *Cf.* Trouton, in *Nature*, Vol. XXXIX., p. 393; and many optical experiments by Mr. Trouton, Vol. XL., p. 393.

† *Wiedemann's Annalen*, Vol. LII., No. 7, 1894.

‡ O. Lehmann, "Molecular Physik, 1," p. 834, 1888.

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The two halos extend rapidly, and finally meet in the middle. As soon as this happens a *dark blue pigment precipitate* is produced there on the side of the anode, while towards the cathode the solution becomes *colourless*, both phenomena taking place in the small zone where the halos meet, while the rest of the solution remains unaltered (Fig. 2).

At the same time the liquid shows great disturbance where the dark blue and the colourless strata meet, while the rest remains perfectly still. An E.M.F. of a single secondary cell suffices to produce the halos, but their advance is more rapid the higher the E.M.F. When the latter is too high, the observations are impeded by the quantity of gas bubbles appearing at the electrodes.

The experiment is made more covenient by thickening the solution with gelatine, sugar, or glycerine. It is then easy to prove that the extension of the halos is not due to a flow of the liquid, for even with a rapid extension suspended particles of dust and air bubbles remain almost perfectly stationary, so that we can only have to deal with a rapidly advancing constitutional change in the liquid. At the same time it may be observed that the rapidity of expansion of the halos is inversely proportional to the viscosity of the solution. If the expansion is to be observed in very viscous solutions the E.M.F. must be correspondingly increased. The boundaries then become serrated, and the divisions are the finer the higher the E.M.F. By dissolving the pigment in glycerine, and saturating the warm solution with sugar, solutions can be produced of such viscosity that even with 10,000 volts the rate of expansion is not greater than it is with a few volts in an aqueous solution.

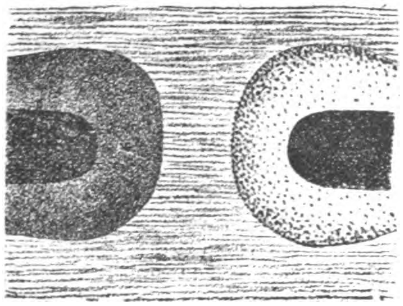

Fig. 1.

Now, as regards the explanation of the phenomenon, one might think of a kind of electric osmosis in the capillary layer between the object carrier and the cover-glass of the microscope; but this is contradicted by the fact that no motion of the liquid itself is visible, but only a progressive change of colour. It can also easily be proved that the migration takes place in the same way in the absence of the walls of the vessel, by immersing two platinum wire electrodes in a larger glass vessel filled with the solution, as in the usual demonstration of electrolysis. If water is the solvent, the convection currents produced by the heating of the solution will indeed disturb the regular expansion of the halos ; but these currents may be obviated by adding to the solution sufficient gelatine to make it form a loose jelly. Even in a perfectly free-coloured gelatine block not enclosed in a vessel the migration of the halos and the formation of the precipitate at their junction may be observed without a magnifier, with any distance between the electrodes. With a very loose jelly, and 90mm. distance between the electrodes, for instance, the halos met nearly half way between the electrodes 10 minutes after the current had commenced to pass. At the place where they met a precipitate was formed, attended by violent commotion in the interior of the mass ; but soon the precipitate was redissolved, and in consequence of the strong heating the gelatine at that point was liquefied. Measured by a thermometer, the temperature was uniformly 24°C. between the electrodes and the centre ; *i.e.*, in the narrow space where the halos met the temperature was 32deg., which accounts for the liquefaction of the mass at that point. The rapid movements and the striking increase of temperature at the centre of the mass show that there the greatest amount of work is done by the current, so that there also a relatively high fall of potential must take place.

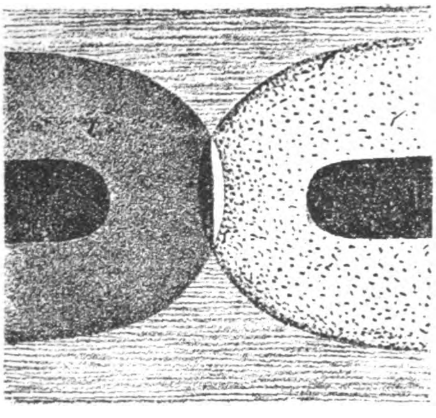

Fig. 2.

A clue to the explanation of the phenomenon is given by the changes of colour, which indicate that the products of electrolysis appearing at the electrode (especially oxygen and hydrogen) have something to do with the formation of the halos. The extension of the boundaries points to the conclusion that these products of decomposition diffuse with a relatively high speed in the direction of the current, and the occurrence of a considerable fall of potential at the boundary of the two halos proves that the diffusing particles carry strong electric charges of the same sign as their electrodes. Thus we may take the following view of the nature of the phenomenon. The dissociated molecules appearing at the electrodes are given charges of the same sign by contact with them, and approach each other along the lines of force, due to the fall of potential in the liquid, until they encounter molecules, with which they combine chemically. New molecules of the dissociation products follow, and reach greater distances from the electrodes until they are also chemically bound. Thus the solution will be chemically changed near the electrodes for constantly increasing distances, producing steadily expanding halos of different colour. When their edges meet the same phenomena take place as are seen when the electrodes are moved very close together ; *i.e.*, convective electric discharges take place, with turbulent motions in the liquid.

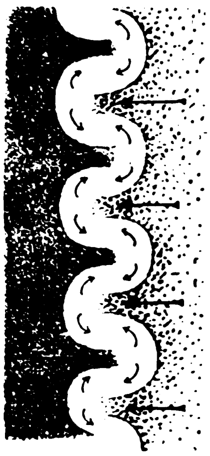

Fig. 3.

Observations of the nature of these currents appear, in fact, to corroborate this view. Fig. 3 shows the course they take before they are disturbed by the formation of the pigment precipitate. Each of the two electric surfaces acquires a wavy outline, the crests of the waves get sharper and send out jets of liquid into the corresponding hollows of the opposite surface. This is accompanied, firstly, by a neutralisation of the opposite chemical changes of the two liquid portions, and a regeneration of the original pigment with development of heat ; and, secondly, by a separation of the electrified particles of pigment from the oppositely electrified solution, so that the pigment particles are accumulated towards the electrode as a precipitate, while the colourless solvent occupies the other half of the mixed region.

While in the above we have only spoken of solutions of Congo red it is not to be supposed that this is the only solution showing the phenomenon in question. The examination of a large number of other solutions gave precisely corresponding results, sometimes with very interesting details. The following gelatinous aqueous solutions were especially noteworthy, the colours of the halos proceeding from the electrodes being given in brackets :—Marine blue (blue—violet), saffranin (red—violet), chrysoidin (reddish yellow—brownish yellow), tropeolin (violet—reddish yellow), Bordeaux red (brick red—blue), eosin (yellow—bluish red), malachite green (colourless—bluish green). In every case the experiments also succeed on the larger scale.

When a current of 70 volts pressure was conducted through a layer of gelatine a few millimetres thick, spread over a sheet of glass and coloured with malachite green, the electrodes being 99mm. apart, hilly elevations were formed round both electrodes, which extended with the migration of the halos and met in about thirty minutes at a distance of 55mm. from the anode. The boundary of the elevation round the anode was perfectly round,

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and its colour a bluish-green; the elevation round the negative electrode was colourless and showed radiating projections recalling a positive Lichtenberg figure. At the junction of the two elevations a dark green precipitate appeared towards the cathode, a narrow colourless zone towards the anode. Over the dark green precipitate the gelatine rose as if strongly attracted towards the cathode; whereas the colourless zone was more and more depressed, and finally disappeared entirely, so that the glass plate was laid bare and the current interrupted. These expansion phenomena of the gelatine are doubtless connected with the chemical changes in the liquid, and are exhibited in the same manner in the case of other pigments. They resemble experiments by E. du Bois-Reymond with coagulated albumen, which have not hitherto been explained in detail.

Besides the solutions mentioned, numerous others were examined with varying success. Specially suitable for the study of the vortex phenomena at the meeting of the halos was a solution of methyl violet charged with sugar. Other thickening substances, instead of gelatine, sugar, and glycerine, were gum arabic, dextrin, barley sugar, inulin, emulsin, and starch paste, some of which were fairly successful.

Water could also be replaced by other solvents. Very fine experiments were made, for instance, with solutions of Congo red in glycerine, methyl blue in propyl alcohol, phenyl blue in chinoline (yellow-white), and methyl blue in aniline, with a little alcohol. Whether colourless solutions also show the phenomenon is difficult to say, since the migration of the halos is only indicated by changes of colour, not by the formation of stripes, &c. In solutions provided with fine dust particles, a jerky motion of these is often observed where the edge of a halo passes such a particle, as if they were attracted by the approaching halo and then were once more quiet. By such a motion of small suspended particles of lamp-black or inulin I could recognise, for instance, the progress of halos and the occurrence of vortex motions in an aqueous solution of amygdalin.

By filling a liquid with numerous small particles the migration of the halos may be observed by means of changes in their density of distribution with nearly the same ease as by the employment of pigments. Specially well suited to this purpose is the commercial liquid Indian ink (E. Wolff and Son) strongly diluted with water and thickened by adding a little sugar or glycerine. This (pseudo) solution is highly sensitive to various foreign admixtures; mere traces of salts, pigments, &c., precipitate the carbon in a flocculent form, usually in conjunction with the precipitating body; while other bodies, even if highly concentrated, have no influence upon the distribution of the carbon particles. It is probably this property of the liquid Indian ink which specially adapts it to the purpose of recognising the advance of the halos. This is in accordance with the fact that thickening substances like sugar and glycerine, which hinder sedimentation, also impede electric sedimentation. Besides Indian ink, some other commercial tube pigments are suitable, such as carmine, Berlin blue, &c. But the phenomena are complicated by the well-known migration of such powders to one pole, by the distribution of the particles along the line of force, and their conglomeration into small heaps acting as secondary electrodes. The phenomena are beautifully shown by means of the pigments supplied by Th. Günzberg, of Würzburg, especially Indian ink, Berlin blue, cadmium yellow, crimson lake and Florentine lake, dissolved in acetal. The migration of the powders also exhibits well under the microscope the species of motion in the liquid during convective discharge, about which more will be said on another occasion.

LIGHTING BY RESONANCE.*

In describing Dr. Pupin's system of "resonating conductors" and its application to telegraphy and telephony in our issue of May 23rd, reference was made to the fact that Dr. Pupin also contemplated the utilisation of this method for the production of light. As a matter of fact Dr. Pupin has for some time past devoted his attention to this subject, and has progressed sufficiently to encourage him in the belief that at no distant time practical results will be obtained. At the invitation of Dr. Pupin a small party of gentlemen gathered at Columbia College on the evening of May 30th to witness some experiments on the production of light by resonance effects.

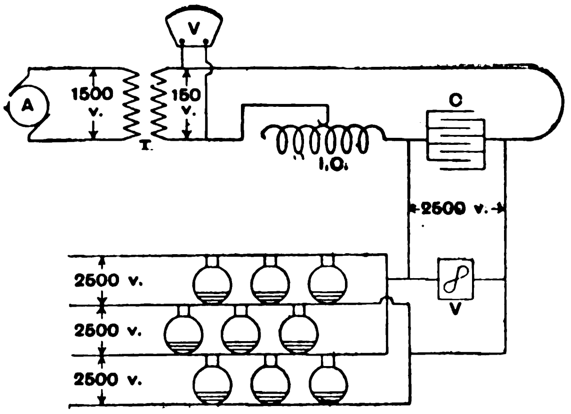
Before passing to the description of these experiments, it may be well to point out briefly that Dr. Pupin has started out with the object of obtaining light effects at low frequencies and comparatively low potentials, having in view the utilisation of existing alternating circuits. By creating resonance effects, Dr. Pupin increases the potential at the lamp terminals so as to produce luminous effects in vacuum tubes.

* From the *Electrical Engineer* of New York.

The experiments showed how it was a simple matter to operate practically any number of vacuum tubes or lamps in parallel, and for that purpose Dr. Pupin employed 100 Edison 100 c.p. lamps. These were used merely for convenience, as a sufficient number of vacuum tubes without filaments was not available. From what follows it is evident that the filaments played no part in the phenomena of light production.

The arrangement of the apparatus employed is shown diagramatically in the accompanying engraving. A 1,500-volt Slattery alternator, A, of the usual type, giving 130 cycles per second, furnished current for a transformer, T, which reduced the pressure to 150 volts at the secondary terminals. In series with the secondary were two inductance coils indicated at I C, one of which could be regulated by throwing sections of the coil in or out. Included in the circuit, also in series, were two condensers, C, of $\frac{1}{2}$ microfarad each.

The lamps, L, were connected as a shunt to the condensers, as shown and arranged in three rows of 33 each, all being connected in parallel across the circuit. Each lamp (100 c.p. Edison) was connected to one side of the circuit by the metal base, and connection to the other side of the circuit was effected through the medium of a tinfoil coating at the bottom of the globe, which covered about one-sixth of the surface of the lamp. A Weston voltmeter, V, measured the potential at the terminals of the transformer secondary, and an electrostatic voltmeter, E S V, measured the potential at the lamp terminals.



Dr. Pupin's Resonance Circuit for Lighting.

The alternator being started, the circuit was turned by means of the adjustable inductance coil, the potential at the lamps gradually increasing up to 2,500 volts, at which the maximum potential was obtained. The glow of the lamps gradually increased in the same manner, and maintained their intensity as long as the coil was allowed to remain at the point of resonance. During all the variations of potential on the lamp circuit while the turning was in progress, and after resonance had been obtained, the voltmeter, V, connected to the secondary terminals showed invariably 150 volts, indicating that the rise in potential at the lamp terminals was due entirely to resonance effects.

As it was Dr. Pupin's sole object to show that glow effects could be obtained from circuits at ordinary commercial frequencies no attempt was made to bring the lamps up to a high degree of luminosity; but, as Dr. Pupin stated, the raising of the frequency to only 1,000 periods per second, which is well within commercial limits, would have brought out a greatly-increased luminosity, while at the same time cutting down the capacity of the condensers required to nearly $\frac{1}{64}$th of that employed by him in the experiment.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(TO-DAY) FRIDAY, June 22nd.

PHYSICAL SOCIETY.

5 p.m. (1) An Exhibition of Photographs of Flames, by Capt. Abney; (2) "An Elementary Theory of Planimeters," by Prof. Henrici; (3) "The Hatchet Planimeter," by F. W. Hill; (4) "A New Integrating Apparatus," by A. Sharp. Other Papers if time allows.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

University Intelligence.—The University of Cambridge has offered, and will shortly confer, its degree of D.Sc. upon Prof. Demetri Ivanovitch Mendelejef.

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ELECTRICITY IN THE KITCHEN.

Many a cautious consumer of electrical energy has wired all the rooms in his house except the kitchen and those necessary parts of the messuage which are known as "offices." The reason is simple; these rooms generally require more artificial light than others, and in order to save trouble, it seems to be an almost invariable practice among servants to light up all or nearly all the gas burners before getting the breakfast ready, and not to give them another thought until bed-time. Automatic switches can be used in connection with the doors of cellars, larders, and cupboards, but even a fifteen-minute or half-hour switch would defeat its own purpose if applied to a glow lamp, for it would be always used, if at all, to its full period, and would be very unpopular. A separate meter is the only check on extravagant consumption in the "offices," a consumption which sometimes exceeds one half of the total. But serious proposals are now being made to introduce electrical supply into the kitchen for a very different purpose, and no exhibition or conversazione is complete without a demonstration of electrical cooking, coffee-grinding, knife-cleaning, and other domestic operations, such as ironing. Leaving, then, the weighty questions of science and engineering, which claim so large a share of our attention, let us give some consideration to this new branch of industry. Hitherto the use of electrical tea-kettles has been a mere novelty, and electric ovens a curiosity, if for no other reason than their costliness; but by degrees prices are becoming more reasonable, probably on account of improvement in the manufacture rather than any considerable increase in quantities made. It is only natural that in its early stages the details of the

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construction of these appliances should be kept more or less secret. The craft of working in enamels and cements has always been surrounded with mystery, and the completed article is not easy to imitate, because inspection of it gives little or no clue to the process of manufacture. At one time there was a mystery about dynamos and transformers; but it is now quite the exception to find a maker who declines to allow a scale drawing to be published.

If an electric kettle or frying-pan still costs four or five times as much as one of the ordinary make, supply companies are doing their best to popularise such things by offering to provide current at a specially low rate. The idea is that they may be used during the day time, and thus help to increase the day load. Careful experiments in one instance have shown that for general cooking, other than boiling, the electrical system may be actually cheaper; and it is not unlikely that with careful management the electric oven may prove to be of considerable value. Since "science is measurement," and electrical engineers profess to be more or less scientific, some data as to cost are likely to be forthcoming before long. As far as the quality of the cooking is concerned, the new method is, of course, unimpeachable, and although we understand that some gas ovens are practically faultless in skilled hands, it is well known that a little carelessness with the burners, the taps, or the ventilation brings about most objectionable results. A classical test of a gas oven, by a committee of the Gas Institute, records that "a roast leg of mutton, 7lb. 7½oz.; two soles grilled, 1lb. 14oz.; rice pudding, rhubarb tart, puff pastry, and 5lb. roasted potatoes," were cooked by the consumption of only 25 cubic feet of gas; and "the whole of the cooking was very well done." Against this we have the solitary information that an oven of unrecorded cooking capacity was heated in a quarter of an hour to 350°F., taking 25 amperes, or rather more than half a supply unit. This amount of energy is offered by more than one company, for cooking or other day work for 2d., and when it is considered that 25 cubic feet of gas at 3s. costs only 0·9d., it seems that electrical cooking is out of the running. It is certainly severely handicapped, but in a long enough race it will win, and for the following reason:—A gas oven must be thoroughly and continuously ventilated, or the consequences are disastrous; and the gas, though not blazing away full on all the time, has to maintain the draught and uselessly heat the wasted air. The electric oven, on the other hand, can be kept almost closed, and can be so well lagged that four or five amperes will suffice to keep up the full temperature. A difficulty in the way of cooking, either by gas or by electricity, is that a hot water service is provided in all modern houses, and nothing but a coal fire will maintain the circulation with economy. In a large house it may be worth while to put in a special boiler; but as a rule the fire must be kept in, and being kept in, it must be an important factor in the question of daily cooking. Since an electric oven needs no special ventilation or arrangement, it ought to be easy to fit up an existing range with electric heating plates, and thus avoid not only the expense of a new and complete oven, but of the room that it would occupy, and of the current required for the preliminary heating.

Passing by the important problems concerning frying-pans, saucepans, and grills, the teapot and coffee-pot deserve a word. We have never heard of a gas-boiled kettle in a lady's drawing-room, though it is common enough in a bachelor's chambers. Competition, if it is worth mentioning, is with the spirit lamp. To boil water for tea on a small scale electrically, costs, we believe, one-sixth of a penny, probably twice as much as with the impossible gas burner. The convenience makes it well worth while, but the first cost of the kettle is a serious obstacle. A little hot-plate can be bought for about £1, and any flat-bottomed kettle can be used with it, at a rather lower efficiency. The electric kettle is a very efficient piece of apparatus, since the heat is generated where it is wanted; but a still more efficient one, which would have several conveniences, would be a boiling stick, to be plunged into the water like a red-hot poker. Such things have been made, but nothing has been heard of them. A silver tube with double walls, containing between them a resistance of about 14 ohms, ought to boil a pint of water in five minutes; free circulation through the middle of the tube would give a large heating surface. Such a boiling appliance could be put into a tea kettle or coffee pot, or anything else; the heat would not have to force its way through the bottom, but would be generated in the middle of the work. As in many cases of household economy, a small increase of actual cost, if accompanied by a great reduction of labour, more than justifies itself. Some occupations, such as cooking by a coal fire, are so unpleasant that menial services are commonly confounded with mean services; nor is the use of gas stoves much better, for while the interior has to be carefully ventilated this is often done at the expense of the rest of the house, which reeks of acetylene, carbonic oxide, sulphurous acid, and other "by-products"; with electrical cooking the odours of the food and nothing else have to be got rid of. The vast increase of machinery and inventions contribute very little to ease, comfort, and well-being, the general tendency is to increase the luxury of the luxurious with but little diminution of the drudgery of drudges. A revival of the art of cookery seems to be spreading, and newspapers open their columns to recipes, few of which probably descend to the kitchen unless as waste paper. Remove the disagreeables of cooking, and the reader of the *Daily Telegraph* will be able to spread open his paper on his mahogany sideboard and compound his own *bouillabaisse* according to the latest leading article thereon, the devotee of the *Westminster Gazette* will bend over his Irish stew, and, *fin de siècle*, the subscriber to the *Pall Mall Gazette* will prepare with cultured hands among his books and household gods, with suitable ecstatic exclamations, the onion soup of his last Saturday's number. But judging from painful experience at electrically-cooked dinners, where for the novelty of the thing the cooking was done in the dining-room, it must be remembered that the delectable leek and the savoury cutlet will ever exhale their native odours; and to even the most poetic of us, a cooking apparatus by the table's brim a cooking apparatus it must always be to him. And this bringing us to dinners, we must refer to the numerous and influential company which assembled last Friday evening at the Cannon-street Hotel, by invitation of the Chairman and Directors of the City of London Electric Lighting Company. An electrically-cooked banquet was the chief attraction of the evening, and after the company had dined Sir David Salomons informed his guests that "the cost per head was twopence per ten courses, and, consequently, the actual cost of each guest that evening was threepence." This sounds cheaper even than a vegetarian dinner; but the Chairman only referred, of course, to the price of the electrical energy consumed in the cooking. The cost of the food was modestly suppressed. The Chairman further announced that, on coming to the dinner that evening, he found that the ovens erected for the occasion were capable of providing for 120 guests, and consumed 60 units. Each guest, therefore, had the satisfaction of knowing that he had consumed the thermal equivalent of 500 watt-hours, less losses from radiation, convection, and conduction.

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REVIEWS.

A Short Practical Treatise on Municipal Electric Lighting. By Francis Hastings Medhurst, B.Sc. M.I.E.E. (London: J. J. Keliher and Co.)

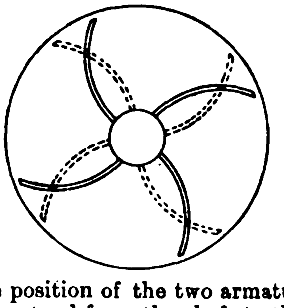
If journals specially devoted to his enlightment, popularly written guides, and a grand army of consulting electrical engineers, do not keep the town councillor in the way he should go in the matter of electric lighting, it is evident that he must be suffering from a double dose of original sin. Mr. Medhurst's contribution to the town councilor branch of electrical literature runs to a length of 125 demy-octavo pages, some hundred of which are taken up by reprints of the Electric Lighting Acts, a Deed of Provisional Order Transfer from a Corporation to a Company, and the Weston-super-Mare Electric Lighting Order. The author's introduction to these documents is a plea for municipalisation, with its useful and necessary accompaniment of work for competent consulting engineers. Printed matter intended for general consumption cannot, we fully recognise, be expected to be mathematically accurate; nevertheless, when out of ten metropolitan supply companies only six are as yet dividend-paying concerns, and the sums set aside for depreciation, &c., are mostly extremely modest, why give the reader to understand that the dividends range between 4½ per cent. and 7½ per cent., and that considerable sums have been set aside? The profits at Bradford we are also told have enabled the Corporation to reduce the rates; a rather wonderful feat to perform out of a total net profit up to June last year of under £1,000. On page 8 the author tells us that it cannot be denied that one of the reasons why electric lighting has been more universally adopted in Germany, in France and in America than in England is the "unreasonable" opposition of the gas companies. In the United States there is undoubtedly more electric lighting than here, but scarcely less opposition from the gas interest. In France there is less electric lighting than in England and considerably more opposition from the gas interest. In Germany there is probably just as much of both as in England. This opposition may be mistaken; it is certainly not "unreasonable," and where gas is dear and electricity is cheap it can be disregarded. It is not the difference in the gas opposition which causes the difference in the relative *vogue* of electric lighting in various countries, but mainly the difference in price. Town councillors may like to orate about "unreasonable opposition" and "effects prejudicial to the general community," but if electrical engineers had once tasted the sweets of 10 per cent. and 12 per cent. dividends we doubt if even they would embrace with open arms a formidable rival.

AN OPTICAL PHASE INDICATOR AND SYNCHRONIZER.*

BY GEORGE S. MOLER AND FREDERICK BEDELL.

Various devices have been employed to indicate synchronism and to show when an alternate current motor is in opposite phase to the generator, one of the simplest of these devices consisting of an incandescent lamp used as a pilot lamp. This device does not, however, indicate the moment when exact synchronism is reached, nor does it show whether the motor is running at a greater or less speed than that corresponding to the generator. It does not show the exact phase difference between the motor and generator, and does not indicate the phase relations after the motor has been connected to the alternator and is being driven by it. The following instrument has been devised by the writers to give definite information in regard to the relative speeds and phase positions of the motor and generator in laboratory investigation.

The motor and generator are placed together with shafts in line and abutting, but not quite touching. The two machines must have the same number of poles, so that a revolution of the armature of each represents the same number of alternations. The abutting ends of the shafts carry two discs. In these discs are curved slits, one slit for each pair of poles of the machines. The two discs are in every way similar, the one being the reverse of the other. The curvature of the slits is such that the distance to or from the centre that the intersections of the two sets of slits move is proportional to the change in relative position of the two armatures. When the two armatures are running at the same speed in the same direction and there is a source of light on one side of the discs, the intersection of the slits, as seen from the other side, appears as a continuous ring of light. A slight difference of speed causes this ring of light to move outward or inward, according to which disc is revolving the faster. The position of the ring of light



indicates the relative position of the two armatures. A stationary scale is fixed so as to extend from the shaft to the edge of the discs on the opposite side from the lamps, so that the distance of the changing line of light from the centre may be read so as to give the phase difference of the two machines by direct reading. To enable one to see the scale and line of light most conveniently, a mirror is arranged at 45 deg. with the discs, and a glow-lamp and screen of oiled paper is placed behind them.

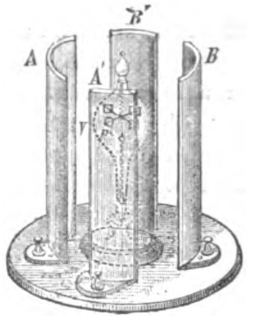
* Abstract of a paper read before the Philadelphia meeting of the American Institute of Electrical Engineers, May 17, 1894.

ELECTROSTATIC ROTATIONS IN RAREFIED GASES.

BY RICCARDO ARNÒ.

Crookes found that a rarefied gas, through which an electric discharge is passed by means of two electrodes, exercises upon a small mill-wheel resembling that used in a radiometer certain actions which, if the various parts of the apparatus are suitably disposed, have the effect of producing a continuous rotation of the mill-wheel, as it would take place if its vanes were driven from the cathode to the anode.*

The object of the present note is to describe certain experiments which show that a phenomenon of the same kind may be obtained by subjecting the rarefied gas in which the mill-wheel is immersed to the action of a rotating electric field.



The method previously employed† has also been used for obtaining the rotating field necessary for these experiments, being based upon a simple alternate difference of potential between two fixed points, represented by the extremities of the secondary coil of a large Rhumkorff coil without a commutator, acting like an ordinary alternate current transformer.

To exhibit the new phenomenon referred to, it is not advisable to employ the ordinary radiometers with mica vanes, since even when these are surrounded by gas at ordinary pressure, forces act upon them which are due to the action of the rotating electric field upon the mica.‡ I therefore had recourse to an apparatus specially constructed for the experiments, consisting of a mill-wheel, *m*, with four very delicate brass vanes mounted in a glass bulb, V, containing very highly rarefied air. It was in fact only by working with a completely metallic mill-wheel that I could make sure of having eliminated all direct action of the rotating field upon the vanes of the wheel, and of ascertaining the new effects due to the presence of the rarefied gas.

If the apparatus described is introduced between two pairs of copper strips, A B and A′ B′, arranged crosswise and enclosing

* *Phil. Trans.*, 1879, I., p. 152.

† *Rendiconti dei Lincei*, October 16, 1892, p. 284; *The Electrician*, Vol. XXX., p. 516, March 3, 1893.

‡ It has in fact been proved, in the paper quoted above, that a dielectric placed in a rotating electric field is subjected to a couple tending to make it rotate in the direction of the field itself.

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the rotating electric field, and the field intensity is great enough and the bulb well dried, it is observed that the brass vanes commence to rotate in the same direction as the field itself. And if the field is reversed while the vanes are turning in one direction, the metallic wheel is rapidly brought to a standstill, and then commences to rotate in the opposite direction.

In my experiments, performed with an alternating current of frequency 40 and a distance of 15cm. between the strips, the effective difference of potential between the terminals of the secondary wire of the induction coil was about 7,500 volts. Under these conditions, corresponding to an electric field rotating with a velocity of 40 turns per second and having an intensity of 1·67 C.G.S. electrostatic units, the metallic wheel acquired a velocity of 50 turns per minute.

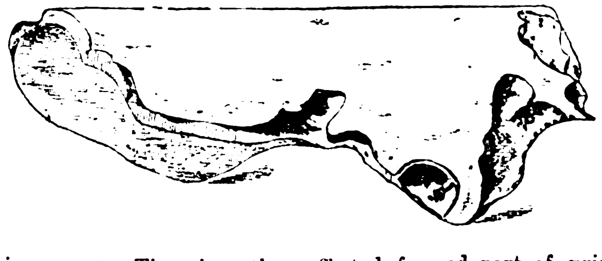
I have said that, to exhibit the new phenomenon described, the experiments must be conducted with wheels with conducting vanes. I must add that this condition, necessary in order to avoid the direct action of the rotating electric field upon the wheel, is also sufficient. Suitable experiments have, indeed, shown me that, whilst in air under ordinary pressure four mica vanes arranged crosswise rotate with the field like all dielectrics, there was not the slightest couple exerted upon an entirely metallic wheel. Such a wheel, even when suspended in a very intense rotating field by a very fine and long silk thread, remained fixed in the field.

It should be mentioned that under the conditions of my experiments, the action of the rotating field upon the rarefied gas was such as to illuminate uniformly the interior of the glass bulb, in such a manner that, even when working in total darkness, the rotating wheel could be distinguished well enough to count the number of revolutions.

It follows from the results specified that the cause of the phenomenon must be looked for in forces developed inside the bulb, which are indirectly excited by a special action exercised by the rotating field upon the rarefied gas. It would be, in fact, owing to this action that the gaseous molecules contained in the glass bulb are, under the influence of the rotating field, influenced by forces tending to drag the molecules themselves along with the rotation of the field. The air enclosed in the apparatus is in such a condition of rarefaction that the paths described by each molecule, in the interval comprised between two successive encounters with its neighbours, are not, as in gases under ordinary pressures, extremely short. It is therefore clear that the gaseous molecules under the influence of the electric field can in their turn act upon the metallic vanes of the wheel, and generate within the bulb a couple tending to make the wheel rotate in the direction of the field itself.

THE CORROSION OF CAST-IRON WATER MAINS.*

A somewhat peculiar case of external corrosion of two cast-iron water mains has recently come under our notice, and will no doubt interest a number of our readers. It is a case in which results very similar to those which are now so frequently ascribed to wandering electric currents, that it receives additional interest



in this respect. The pipes thus affected formed part of private service mains in the neighbourhood of the Strand, and consisted of two separate 4in. main pipes in 9ft. lengths, running side by side, and placed at a depth of some 3ft. below the level of the ground. The mains, which were laid some twelve years ago, were surrounded chiefly by gravel and clay; but the portions at which the corrosive actions took place exclusively were embedded in cinders. The annexed sketch portrays the character of the wasting or pitting, and it will be observed that the holes would almost appear to have been gouged out. This, however, is disproved by the number of lengths affected, namely, six. The defective portions were discovered owing to the pipes having in some cases become so much reduced in thickness as to be unable to withstand the pressure within them. We have ascertained that there are no electric mains in the neighbourhood of the pipes, so that this phenomenon cannot have been produced by short circuiting or earthing. The crown plates of steam boilers, upon which ashes have been employed as a non-conducting material, have been known to suffer in a very similar manner where any moisture has been allowed to collect. Numerous experiences of this kind might be mentioned, and the partial conversion of the affected parts into plumbago have been also known, and it is quite possible some of those now ascribed to electrolytic action may be due to similar causes.

* From the *Engineer*.

ELECTRICAL TRANSMISSION OF POWER WITH DI-PHASE CURRENTS FOR MINING PURPOSES.*

One of the most interesting cases of the electrical transmission of power for coal-mining purposes in Europe has been completed and set in operation at the Decize Collieries in the Nièvre Department of France, which are owned by MM. Schneider and Co. This installation is remarkable from the fact that diphase alternating currents are employed for the transmission, and diphase alternating-current motors are used for reconverting the electrical energy into mechanical power at the different pits. A brief outline of the principal features of this plant should prove of special interest to English readers, more particularly as no installation of this nature has yet been put down in the United Kingdom. In designing this plant the problem to be solved was to erect a central generating station for the distribution of electrical energy at the different pits, where it could be utilised in electromotors for operating ventilating fans, hauling machinery, pumps and for lighting purposes. A general idea of what had to be accomplished is shown in the annexed table :—

Site.	Distance from generating station.	Electrical machinery or lamps receiving the current transmitted.
1.—*West.*	Yards.	
Puits des Chagnats ...	5,090	30-H.P. electric motor.*
Fendue des Lacets ...	3,466	" " *
Puits des Coupes	2,058	" " *
Puits des Zagots	1,084	Electric hauling machine of 15 H.P.†
2.—*Generating Station.*		
Various installations...	...	Six arc and 100 incandescent lamps.‡
3.—*East.*		
Fendue des Marizy ...	1,300	30-H.P. electric motor & 24 arc lamps§
Sort'g & wash'g shops of the Pré-Charpin...	2,490	500 incandescent lamps of 16 c.p.‡
Champvert	3,250	12-H.P. power electric motor.‖

* Used for ventilating fan. † Inclined plane. ‡ Lighting. § Ventilating fan and lighting. ‖ Pumping.

The generating station is situated respectively at distances of from 3·1 miles and 1·86 miles from the extreme points which have to be supplied with current. It contains a battery of six boilers and two units (steam engines and dynamos), each of a capacity of 100 kilowatts; a further unit will shortly be laid down. The two units may be worked singly or in parallel. The engines are of the horizontal non-condensing type, running at 200 revolutions per minute, and driving the diphase alternators by means of belting. A notable feature in this connection is the fact that each electrical unit comprises a twin alternator, or in reality two machines, placed one at each end of the shaft, the driving pulley carrying the engine belt being arranged in the middle of the shaft. The generators are Zipernowsky ten-pole alternators, with revolving field magnets. The ten field magnets are connected together in series, and the exciting current is led to them by means of two metallic rings carried on an extension of the driving shaft on the opposite side to that of the driving pulley—that is to say, on an outer extension of the shaft. Two ordinary brass brushes press upon these rings, to which the exciting current is furnished by a direct-current dynamo. This latter machine is operated by a belt from the shaft of the alternator. At 900 revolutions a minute this direct-current dynamo supplies the exciting current for the twin alternator, being between 25 and 30 amperes at 110 volts. The fixed armature of the alternators is formed of ten coils, any one of which can be withdrawn and replaced with little trouble.

The current is transmitted mainly by means of overhead wires to the points of utilisation, the only portion laid underground being towards the end of the principal line leading to the Chagnats Pit. The wires forming the overhead line are of silicon-bronze, and are carried on porcelain insulators attached to poles 24ft. high. The diameter of the wires constituting the principal line to the western part of the district is 6mm., and 4mm. in the case of the remainder of the line. It is noteworthy that the same poles carrying the transmission wires also support telephone wires, the latter being arranged 12ft. from the ground. In order to counteract the effects of induction in the telephone wires, the line

* Abstract from the *Colliery Guardian*.

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conductors are crossed at distances averaging 540 yards. The small portion of underground line forms a lead-covered cable, laid in a wooden conduit, as also does the telephone line for the same distance. Suitable lightning conductors are provided at the generating and distributing sub-stations and at intervals along the line. The electromotors at the sub-stations, where the current is utilised for the different purposes mentioned in the table given above, are of the same type as the generators. These diphase motors are easily set in operation, and are to all intents and purposes left to themselves for several hours together. The only attention they receive is the visit of an employé every six or eight hours to ascertain whether the motors are working properly. The sub-stations are situated in the forest, and the facility of working on this system as compared with the erection in each place of a boiler, steam-engine and ventilating fan, is considered to be remarkable, apart from the question of the cost of transporting fuel.

TRAMWAYS IN GERMANY: A COMPARISON BETWEEN THE COST OF HORSE TRACTION AND ELECTRIC TRACTION.*

The comparison is founded on many years' experience of an important German tramway company in horse traction (the situation of which, however, is not given), and by carefully-obtained trial-results in electric traction.

The tramway selected is 8·08 miles in length, and establishes intercourse between a large town and several suburbs. The time-table is so prepared that the trams run at 6, 6:30, 7 a.m., and then every quarter of an hour until 9 p.m., after which they run at 9:30, 10, 10:30, and 11 p.m. The car, which is a one-horse one, carries 30 persons inclusive of driver and guard; on 20 days of the year it is necessary to double this service.

With the use of horse traction a speed of 8 to 10 miles an hour is the limit, and 8 cars are required for the service; 126 (2 × 63) single tours are made daily, and 1018·08 (126 × 8·08) car miles are run, consequently 391,961 [(365 + 20) × 1018·08] car miles are run in the year.

As the daily performance of a horse in tramway work amounts on the average to 16 miles, theoretically 63 horses are required for the usual traffic, but in practice 10 per cent. more are added to make allowances for disease and rest, so that 70 horses are kept. The 70 horses represent a capital of £3,150 (70 × £45), and a further sum of £4,250 is required for land and buildings. The following Tables are then given as representing the yearly cost of horse-traction.

I.—*Payment of Interest and Depreciation.*

4 per cent. interest on £7,400 (3,150 + £4,250)	£296	0
15 „ depreciation of capital value of horses	472	10
1½ „ „ „ „ buildings	63	15
Total	£832	5

II.—*Cost of Management.*

Salary of manager	£90	0
Wages of eight drivers	360	0
Wages of six stable-boys	150	0
Provender for seventy horses	2,175	0
Harness and shoeing	287	10
Veterinary treatment	65	0
Repair of stables, &c.	100	0
Sundries	72	10
Total	£3,300	0

These two sums, amounting to £4,132. 5s. yearly for 70 horses, gives 3s. 2·8d. per horse per day. But to this sum is still to be added the hiring price of 63 horses for 20 days at 5s. per day, which amounts to £315. Therefore the total yearly disbursement for horse-traction is £4,447 5s., the cost per car-mile being 2 72d. $\left(\frac{\pounds 4{,}447.\ 5s.}{391{,}961}\right)$.

The estimate for electric traction is founded on the overhead line system of O. L. Kummer & Co., of Dresden. Each car is provided with two electromotors of 8 H.P. The capital required is estimated as follows:—

Land	£150	0
Buildings	1,600	0
Boiler and engine and two dynamos, including all fittings	3,750	0
Length of 8·08 miles of line work, fixed complete	3,500	0
Electric fittings for nine cars, one of which stands in reserve	2,250	0
Total capital expenditure	£11,250	0

* From the *Foreign Abstracts* of the *Proc.* Inst.C.E., Vol. CXVI.

The following tables are then given as representing the yearly cost of electric traction:—

I.—*Payment of Interest and Depreciation.*

4 per cent interest on £11,250	£450	0
1½ „ depreciation on buildings account	24	0
7½ „ „ engine, &c., account	281	5
5 „ „ line work account	175	0
15 „ „ electro-motors account	337	10
Total	£1,267	15

II.—*Cost of Management.*

Salary of manager	£90	0
Wages for three enginemen	180	0
Fuel	830	0
Carriage of Cinders	10	0
Lubricants	125	0
General repairs	225	0
Sundries	72	5
Total	£1,532	5

These two sums, amounting to £2,800, give 1·72d. per car-mile as the cost of electric traction.

The Paper concludes in enumerating several advantages that electrical cars possess over the horse cars in the matter of speed, safety, and size in crowded streets, as well as in cost.

ON THE WHIRLING AND VIBRATION OF SHAFTS.*

BY STANLEY DUNKERLEY.

It is well known that every shaft, however nearly balanced, when driven at a particular speed bends, and, unless the amount of deflection be limited, might even break, although at higher speeds the shaft again runs true. The particular or "critical" speed depends on the manner in which the shaft is supported, its size and modulus of elasticity, and the size, weights and positions of any pulleys it carries.

The theory for the case of an unloaded shaft first received attention at the hands of Prof. Rankine,† who obtained numerical formulæ for the cases of a shaft resting freely on a bearing at each end, and for an overhanging shaft fixed in direction at one end.

The theory has been further extended to the case of a shaft loaded with pulleys by Prof. Reynolds; and the object of this investigation is to apply that theory and so obtain formulæ—and by experiment to verify them—giving the critical speed in terms of the diameter of the shaft, weights of pulleys, &c., in particular cases applicable to the different conditions under which a shaft works.

In many cases, as might naturally be expected, the "period of whirl" of the shaft is merely its natural period of vibration. The two periods are coincident in the case of an unloaded shaft (however supported), and for a loaded shaft on which the pulleys are placed in such positions that they rotate, when the shaft is whirling, in planes perpendicular to the original alignment of the shaft. With pulleys placed in any other positions, when the shaft is whirling, there is a righting moment tending to straighten the shaft, which does not exist when it merely vibrates under the dead weight of the pulleys. Hence, in an unloaded shaft, the period of whirl coincides with the natural period of vibration; but, generally, in a loaded shaft, the period of whirl is less than the natural period of vibration to an extent depending on the size and positions of the pulleys.

If, therefore, the period of disturbance (that is, the period of one revolution) be decreased, the shaft runs true until that period approximates to the natural period of vibration of the shaft under the given conditions. If the shaft now receive any displacement, however slight, a violent agitation is set up, which will be most marked when the period of disturbance and the whirling period coincide. As the period of disturbance is further decreased the agitation becomes less and, at a period of disturbance slightly less than the whirling period of the shaft, the shaft again runs true.

As in the vibration of rods, so in the whirling of shafts there are a series of periods at which the shaft whirls.

Investigation shows that the formulæ obtained by considering the combined effects of the shaft and only one pulley, or the combined effects of two pulleys neglecting the effect of the shaft, are too complicated—even in the simplest cases—for actual use. The only alternative method is to consider the effects of the shaft and each of the pulleys (whatever be their number, position, and size) separately, and so obtain the whirling speed for each on the assumption that all the others are neglected. By means of an empirical formula the whirling speed, taking shaft and pulleys into

* Abstract of a Paper read before the Royal Society.

† Rankine's "Machinery and Millwork," page 549.

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account, may be calculated from the separately-calculated speeds of whirl.

Unloaded Shaft.—In the case of an unloaded shaft, the whirling speed is given by an equation of the form

$$(w\,\omega^2/g\,\mathrm{E\,I})^{\frac{1}{4}}\,l = a, \quad \ldots \ldots \quad (1)$$

in which

w = weight of shaft (in lbs. per foot run).
g = gravity.
E = Young's Modulus (in lbs. per square foot).
I = geometrical moment of inertia of cross section of shaft about a diameter.
ω = angular velocity of shaft when whirling.
l = length, in feet, of one of the spans, and
a = some numerical coefficient depending on the manner in which the shaft is supported.

By substituting the proper value for the coefficients in equation (1), we obtain the equations

$$\mathrm{N} = b\,d/l^2, \text{ for a solid shaft,} \quad \ldots \ldots \quad (2)$$

and

$$= b\,\sqrt{(d_1^2 + d_2^2)}/l^2, \text{ for a hollow shaft.} \quad \ldots \quad (3)$$

In these equations

N = number of revolutions shaft makes per minute when whirling.
d = diameter of the solid shaft in inches.
d_1, d_2 = the external and internal diameters of the hollow shaft, both in inches, and
b = some numerical coefficient depending on a, and also upon the constants in Equation (1).

For wrought iron or mild steel, $b = 3331a^2$, and for brass, $2222a^2$.

It should be noticed that each span of a continuous shaft supported on bearings placed at equal distances apart whirls independently of the rest.

Loaded Shafts.—The cases for a loaded shaft—as also those for an unloaded one—which have been considered in the investigation, embrace all those which are likely to arise in practice. With a continuous shaft supported on three or more bearings and loaded with a pulley on one of the spans, general equations have been obtained for unequal spans; but the complete investigation has only been extended to the case of equal spans—a relation between the spans which almost invariably exists in actual shafting. The results of the investigation show that however the shaft be supported, the whirling speed due to a single pulley on a light shaft is given by an equation of the form

$$\omega = \theta\,\sqrt{(g\,\mathrm{E\,I}/\mathrm{W}c^3)}, \quad \ldots \ldots \quad (4)$$

in which ω, g, E, I, have the same meanings as in Equation (1), and

W = weight of pulley in lbs.;
c = distance of pulley from nearest bearing in feet; and
θ = some numerical coefficient depending not only upon the manner in which the shaft is supported, but also upon the position of the pulley on the span which carries it and the size of the pulley.

For any particular mode of support of the shaft the coefficient θ is some function of the ratios c/l and c/k, where l = length of span which carries the pulley, and $k = \sqrt{g\,(\mathrm{A} - \mathrm{B})/\mathrm{W}}$, where A and B are the moments of inertia of the pulley about the axis of the shaft and a diameter of the pulley through its centre of gravity, respectively, both being expressed in gravitation units. Assuming, therefore, certain values for c/l and c/k, tables have been drawn up giving the corresponding values of θ. For each value of c/l there are two limiting values of c/k; viz., *infinity* and *zero*—the corresponding values of k being *zero* and *infinity*. When $k = 0$ the pulley may be considered simply as a dead weight, so that the "inferior period of whirl," as it has been termed, is the natural period of vibration of the light shaft under the given conditions. The "superior period of whirl," that is to say, the whirling period when $k = \infty$ is the inferior period multiplied by some function of c/l, and assuming the shaft to whirl at a speed corresponding to the superior or inferior limit, it would do so in such a manner that the pulley still rotated in a plane perpendicular to the original alignment of the shaft. These limiting values of the speed, below and above which whirling is impossible, have been calculated in each case.

Investigation shows that in a continuous light shaft supported on bearings placed at equal distances apart, the increase in the whirling speed due to those spans which are not immediately adjacent to the loaded one, on either side, cannot exceed by above 2 or 3 per cent. the whirling speed when only the loaded span and the spans immediately adjacent to it are taken into account. In other words, the stiffening effects of only those spans immediately adjacent to the loaded one, on either side, need be taken into account in calculating the whirling speed for the shaft.

By substituting the proper values for the constants in Equation (4) we obtain the equations

$$\mathrm{N} = \phi\,d^2/\sqrt{\mathrm{W}\,c^3}, \text{ for a solid shaft,} \quad \ldots \ldots \quad (5)$$

and

$$= \phi\,\sqrt{(d_1^4 - d_2^4)}/\sqrt{\mathrm{W}\,c^3}, \text{ for a hollow shaft,} \quad . \quad (6)$$

where W, d, d_1, d_2 have the same values as before, and ϕ is some numerical coefficient depending on the value of θ and of the constants in Equation (4).

The value of ϕ for wrought-iron or mild steel is $5389\,\theta$, and for brass $3772\,\theta$.

Having thus obtained formulæ giving the whirling speed due to each cause, on the assumption that all the others are neglected, it only remains to find an empirical formula giving the resulting whirling speed, when all the disturbing elements are taken into account, in terms of the separately-calculated whirling speeds due to the several causes. Since the whirling speed in every case varies inversely as the square root of the weight of the pulley (*see* Equation 4), the formula for calculating the resulting speed was to be of the form

$$\mathrm{N}_1\,\mathrm{N}_2/\sqrt{(\mathrm{N}_1^2 + \mathrm{N}_2^2)} \quad \ldots \ldots \quad (7)$$

for two disturbing elements whose whirling speeds taken separately are N_1, N_2; or of

$$\mathrm{N}_1\mathrm{N}_2\mathrm{N}_3/\sqrt{(\mathrm{N}_2^2\mathrm{N}_3^2 + \mathrm{N}_3^2\mathrm{N}_1^2 + \mathrm{N}_1^2\mathrm{N}_2^2)}, \quad \ldots \quad (8)$$

for three disturbing elements whose whirling speeds, taken separately, are N_1, N_2, N_3. The formula may be extended to any number of disturbing elements. It is not strictly accurate, for in addition to the whirling speed varying inversely as the square root of the weight of the pulley, it also varies as some function (θ) of the distance of the pulley from the nearest bearing and of the size of the pulley. The experiments, however, justify to a remarkable degree the assumptions that have been made in calculating the resulting whirling speed.

In calculating the speed at which a continuous shaft of given diameter, supported on bearings placed at equal distances apart, and loaded with pulleys on any or all of the spans, will whirl, the method to adopt is to first find the span which will have the biggest whirl (that is to say, the span which carries the heaviest and most advantageously-placed pulleys as regards whirling), and then to consider this span and the spans immediately adjacent on either side. The whirling speeds for the shaft and each of the pulleys on the three spans have then to be calculated according to the rules laid down in each case. The whirling speed for any pulleys on the two side spans will, of course, be different according as that side span is an end or an intermediate span in the line of shafting. Having found the whirling speed due to each cause, the resulting whirling speed is found from an equation of the same form as Equation (7) or (8)—the exact equation depending on the number of disturbing elements. The speed thus obtained will be slightly less than the actual whirling speed. A nearer approximation to the actual speed might be obtained by considering only those pulleys which lie near the centres, or between the centres of the side spans and the bearings of the middle span, neglecting the effect of those pulleys which lie beyond the centres of the side spans. In doing so, however, the experiments show that there is a danger of the calculated speed *exceeding* the actual, whilst by taking *all* the pulleys on the two side spans into account the calculated speed will be slightly *less* than the actual speed.

If the spans of a continuous shaft, supported on bearings placed at equal distances apart, are all loaded in the same manner, each whirls independently of the rest, and the problem reduces to that of a loaded shaft supported on bearings at the ends.

The experimental shaft was 2ft. 8in. long and ·2488in. in diameter. The motion was transmitted from the headstock spindle to the experimental shaft by a fine piece of steel wire (about 1½in. long and 21 B.W.G. diam.), so that the shaft was subjected to very little constraint at the end. The experimental pulleys were models of actual pulleys—being designed for both weight and inertia. The headstock spindle was driven from a turbine, the constancy of the speed being shown by the steadiness of a column of liquid forced by a centrifugal fan indicator up a glass tube. In taking the number of revolutions corresponding to any period of whirl an ordinary counter pushed into the end of the headstock spindle was used. In making any experiment three trials were made (each of three minutes' duration) and the mean of the results taken. Over 150 experiments have been made with this apparatus, and the observed results invariably approximate very closely to the calculated results. Experiments have also been made with actual cases of shafting, and it would appear that, following the method of solution sketched above, the calculated speed is about 3 or 4 per cent. *less* than the actual speed.

The experiments were carried out in the Whitworth Engineering Laboratory, Owens College, Manchester.

BOOKS RECEIVED.

"Les Oscillations Electriques," by H. Poincaré. (Paris: George Carré.)

Journal of the Institution of Electrical Engineers. Vol. XXIII. No. 112. Edited by F. H. Webb, secretary. (London: E. and F. N. Spon.) 3s. 6d.

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LEGAL INTELLIGENCE.

Re Woodhouse and Rawson United (Limited).

PUBLIC EXAMINATION OF DIRECTORS.

In the Bankruptcy Court on Monday, before Mr. Registrar Hood, the public examination was commenced of the Directors of Woodhouse and Rawson United (Limited). The examination was conducted by the Official Receiver, Mr. C. J. Stewart, and various parties were represented as follows:—Mr. Jenkins, instructed by Mr. Frederic Walker, represented Sir John Stokes and Mr. Samuel Pope, Q.C.; Mr. Eve and Mr. Mossop, instructed by Messrs. Travers, Smith and Co., represented Mr. Philip Rawson; Mr. Muir Mackenzie and Mr. Geake, instructed by Messrs. Lees and Pemberton, represented Lord Aberdare; Mr. Kartnell represented Mr. C. L. Baker; and Mr. Pilling, of Manchester, appeared for creditors.

The OFFICIAL RECEIVER said before the examination commenced he wished to state that the investigation had been a very difficult one, and he had met with especial difficulty in ascertaining the facts prior to the examination before his Honour, owing to the absence of a large number of original documents. The Directors and officers of the Company had been communicated with with respect to these, but without success. There were also books, particularly the minute book of Woodhouse and Rawson (Limited) acquired by Woodhouse and Rawson United under agreement, which, in spite of repeated applications to the liquidators of Woodhouse and Rawson (Limited) and to the officers of Woodhouse and Rawson United, he had been unable to obtain. He suggested that he should first of all put the liquidators of Woodhouse and Rawson (Limited) in the box and ask them where those books were, as he was unable otherwise to obtain any information.

The REGISTRAR assented to this course, and

Sir JOHN STOKES was called and examined by the Official Receiver. He said he was a Director of Woodhouse and Rawson (Limited), and subsequently became a liquidator. He had forwarded to the Official Receiver a letter he had received from Mr. Richard regarding the books in question, in which it was stated that the books had been ordered to be destroyed. That order was given as the result of a resolution passed at the final meeting of the shareholders in November last, the winding-up order of the United Company having been made on May 17, 1893. So far as he recollected, the order was given by himself as chairman.

The OFFICIAL RECEIVER: You knew an inquiry was on the eve of taking place in the United Company, and you were informed, I think, of the Receiver's observations. Under those circumstances you, I understand, proposed that these books, which must be very material to the United Company, should be destroyed?—We did not take the view that they were very material to the United Company. We had no reason to suppose so; we had never been asked for them.—Not at that date, but subsequently you were?—Subsequently; within the last few days. Can you speak from your own knowledge as to whether the minute-book has or has not been destroyed?—I cannot.

Examined by Mr. Jenkins: He had been applied to by the Official Receiver with regard to certain points, and had given information to the best of his power. He was requested to obtain information from Mr. Richard, who had had charge of the books, and the result was the letter which he had sent to the Official Receiver. That request was made in a personal interview recently, and no reference to the books was made in the letters he had received from the Official Receiver asking for information. He presided at the final dissolution meeting of Woodhouse and Rawson (Limited), and so far as his memory went there was a general resolution approving what had been done, and ordering the destruction of the books. That was put from the chair in the ordinary way and carried. No reason was suggested at that time why the books, of which there were a large number, should not be destroyed.

In reply to the Official Receiver, the WITNESS said if the minute-book had not been destroyed and it could be found, he would see that it should be produced.

Mr. FREDERICK L. RAWSON was next called, and, in reply to the Official Receiver, said he could throw no light upon the whereabouts of the minute-book. He had told Mr. Richard that all the books in his possession would be wanted, and asked him to keep them and bring them up when called upon. He understood afterwards that he had no books. He had nothing to do with destroying the books, and he was surprised to learn that they had been destroyed. He had no recollection of having been present at the meeting when the resolution referred to was passed. He would undertake that the minute book should be produced if it had not been destroyed.

Sir ALBERT J. LEPPOC CAPPEL, K.C.I.E., was then examined. He was one of the original Directors of Woodhouse and Rawson United, but retired on August 1, 1889, before the Company went to allotment. He was first approached by Mr. F. L. Rawson, who came to him with an introduction from a friend. He was not acquainted with any of the Directors at the time he joined the Board. He could only give a general impression, after so many years, of the representations made to him by Mr. Rawson. He understood that there were four excellent industrial undertakings, which for reasons of general policy and economy it was desirable to combine into one. These were—Woodhouse and Rawson (Limited), the Woodhouse and Rawson Electric Supply Company, the Woodhouse and Rawson Manufacturing Company, and the Woodhouse and Rawson Contract and Maintenance Company, and there was also C. L. Baker and Company (Limited), which it was proposed to take in.

The OFFICIAL RECEIVER: Did Mr. Rawson mention to you that there was any other branch which they were going to undertake except the industrial business?—Well, yes; he did say that by fostering patents there would be a good deal of money made. That is to say, men who were clever, but suffered from lack of introductions, and especially from want of means, would be helped by the knowledge and the money, primarily the money, of this combination.

Continuing, WITNESS said he certainly regarded it as mainly an industrial business. From what was told him the impression on his mind was that these were all profitable concerns, except, he thought, one of the small ones, which was not in quite so good a position, but which, when absorbed, would not be in any way detrimental. He did not remember whether that was the Manufacturing Company. There were several meetings prior to the incorporation of the Company on July 12, 1889, but no formal record was kept, and no resolutions were passed. He was present at most of those, but he could not recall all the steps that were taken or all the questions put to ascertain the value of the businesses which it was proposed that the new Company to be formed should purchase. He himself drew up a memorandum of points upon which information was required, and those points were dealt with. He did not recollect whether at that time he had seen the valuation of the patents made by Mr. Henry Edmunds.

The OFFICIAL RECEIVER read the document referred to, in which Mr. Edmunds referred to the fact that, although the patents held by the Woodhouse and Rawson Company were of considerable value, they had not realised a profit in working during the last few years; but it was to be borne in mind that the Company had been passing through a trying period, that very few electrical companies had made any money at all, but were building up their businesses in order to prepare for the large increase in electrical work which was anticipated. Reference was also made to the incandescent lamp patent litigation, in which the Company had been engaged. Great stress was laid upon the value of the licence held from the British Electric Light Company, which enabled them to manufacture under the Edison incandescent lamp patent.

WITNESS said he had seen this document, but he could not tell now what he understood to be the valuation put upon the patents by Mr. Edmunds. The £159,265 referred to in the document appeared to be built up of various sums; but it represented the idea in his mind of what the patents were valued at. He would like to state that these things took place a long time ago, and the matter not being a pleasant one he tried to dismiss it from his mind, so that he had some difficulty in taking up isolated facts connected with it, and he did not think he could do more than give a general impression of his recollections.

WITNESS, continuing, in reply to the Official Receiver, said he had seen a list of patents with the valuation by Mr. Edmunds, in which the total value was put at £159,265. Woodhouse and Rawson (Limited), paid the expenses of the promotion. He understood the valuation referred to in the prospectus was an independent one.

The OFFICIAL RECEIVER: Were you aware that this valuation was actually drafted by Mr. F. L. Rawson?—Certainly not.

Had you known that I take it you would have looked with—I don't say suspicion, but you would have thought Mr. Rawson, being in the position of vendor, would entertain rather an exaggerated idea of the value of what he was going to sell?—If I had had this knowledge I think I should have left the place there and then.

Did you understand that in this valuation the Elmore patents were to be included or whether they were not to be included?—I find a short note of mine, made for my own guidance in attending the meeting, to this effect: "Mr. Budd to explain with reference to patent valuation whether the needful information has been supplied by Mr. Rawson in a form which appears to him satisfactory." Then I find another note which shows that there was a deduction on account of the Elmore patents.

That looked, then, as if the Elmore patents were not included?—Certainly, I think so.

Mr. Edmunds is asked with regard to the Elmore patents, and he says: "I assented to the value given to me by Mr. Rawson in conversation." He further said, Mr. Rawson had very big ideas as to the value of the Elmore patents, and the witness considered that the things of great value were the Elmore patents and the lamps. Mr. Rawson gave him the idea, in conversation, that the Elmore patents were worth about £200,000. Were you aware that in that valuation Mr. Edmunds valued the Elmore patents, which apparently were not included in the patents taken over by the United Company, at somewhere about £120,000?—I had no knowledge at all of the valuation of the Elmore patents.

Did you understand that the Limited Company, or one of these companies, had taken over a licence from the British Electric Light Company?—I think I remember there was a licence, which was possessed for manufacturing incandescent lamps, and that great value was attached to it. I do not think I can go further that.

Are you aware that there was no power by which the Electric Light Company could transfer this licence? Did you become aware of that?—Never, that I remember.

May I take it that you were thoroughly satisfied as to the possession of these patents?—I think we were.

Had you any assurance from the solicitors that the patents were all in order?—That I do not know. We had a solicitor always present, advising us in every step we took.

You were giving a very large amount for these patents—£85,000. Supposing you were buying these as a private person, and they were offered you for £85,000?—Of course, one would endeavour to assure oneself that they were worth it.

I want to know what steps you took?—I do not remember.

After hearing that evidence (of Mr. Edmunds), would you have agreed to purchase those patents for £85,000?—Certainly not.

The price to be paid for these five businesses was £269,000, and that appears to be, for the stock £29,000, plant £10,500, patents £85,500, freehold property £47,000, and goodwill £97,000. What was your idea of good-will?—I believed that this was a successful industrial undertaking, which had a valuable connection, and that it was a business which, with proper business-like arrangement and care, would prove very valuable.

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Proceeding, WITNESS said it was represented to him that the profits of the business of Woodhouse and Rawson (Limited) for the year ending June 30, 1888, were £21,440, and that the profits for the following year were estimated at over £75,000. That was stated in the prospectus. It was a fair assumption that it was on those statements he based his idea of the value of the goodwill. It was stated that the profits were partly represented by shares in other companies, and the explanation given was that it was by no means uncommon for profits made in that way to be included.

The OFFICIAL RECEIVER read a special report of the auditors, Messrs. Pixley, giving details of the items of profit arising from the assumed value of interests acquired in other companies, and explaining that the realisation of the values given depended upon certain contingencies.

WITNESS had no recollection of having heard that report read, and did not think he would have been satisfied with the statement in the prospectus if he had read it or heard it read. He went and saw the works in the case of some of the businesses to be acquired. He was under the impression that Woodhouse and Rawson (Limited) was a small company in the sense that the shares were not very largely distributed, but he did not know that the shares were held almost entirely by Mr. Rawson and his friends.

You had not had much experience of companies? —I had had none then.

These negotiations apparently all went through in the course of about a month?—The thing was very much rushed. It was at a rather later period that he got this feeling that the matter was being rushed. He began to feel uneasy, and, in conjunction with Col. Howard Vincent and Sir John Coode, he was determined that the Company should not go to allotment unless the applications for shares reached a certain amount. They objected to some of the applications on the ground that they were not of a very substantial character. It was strictly because the amount which they had decided upon as a minimum had not been subscribed that he retired from the Board, but he must confess he was much relieved at that opportunity presenting itself to enable him to withdraw. When the first feeling of uneasiness arose he began to look into matters more, and he was much dissatisfied with the want of order and exactness with which everything was done. A meeting of the Directors was held on July 30th, and as the total applications were not sufficient to produce £200,000 a resolution was passed deciding not to proceed to allotment. Immediately after that decision he was "fired at" by several legal gentlemen, representing the several businesses to be acquired, who said they should hold him liable for expenses and damages. These letters were all couched in pretty much the same language. On August 1st there was another meeting of the Board, and after an adjournment it was agreed that those letters should be withdrawn, that the resolution of July 30th should not be immediately acted upon, and that a circular should be addressed to the applicants informing them that Sir Albert Cappell, Sir John Coode, and Col. Howard Vincent had withdrawn from the Board. He was anxious that if anybody had been attracted by his name appearing on the prospectus he should have the opportunity of withdrawing. A circular was sent out, but it was not quite satisfactory to him or in accordance with the resolution. For one thing, the applicants were not specifically informed that it was open to them to withdraw their applications. Lord Aberdare and Mr. Philip Rawson were the other provisional Directors, but it only came to his knowledge afterwards that himself, Col. Howard Vincent, and Sir John Coode were the only Directors who were not interested as vendors.

Examined by Mr. EVE on behalf of Mr. Philip Rawson, witness said they were advised throughout by a solicitor, and they went through the prospectus very carefully. He could not say whether they had also the advice of counsel. He did not remember the opinion of Mr. Buckley being obtained as to the way in which the profits of Woodhouse and Rawson (Limited) were to be dealt with, nor did he recollect that some new arrangement was made with regard to the £75,000 profits as a consequence of the opinion obtained.

He did not know that the circular alluded to was sent out on August 2nd, the Friday before Bank Holiday, and that the allotment was fixed for the day after Bank Holiday; and if that were the case he did not consider that it was a sufficient compliance with his desire that applicants should have an opportunity of withdrawing upon learning of his retirement.

By Mr. F. L. RAWSON: He did not recollect that it was at first contemplated not to include Woodhouse and Rawson (Limited) amongst the other companies to be acquired; but to have an Electrical Union, consisting more especially of the manufacturing companies. He did not recollect that, after some discussion, the Directors of Woodhouse and Rawson (Limited), having objected to the transfer of that Company in consequence of the delays that had taken place, it was agreed that that Company should be taken over as from June, 1889, if the £75,000 profits were lodged as a guarantee fund, and if, in addition, the United Company gave up their share in the Elmore patents, and he (Mr. Rawson) also gave up his share in those patents. He remembered that he (Mr. Rawson) did on more than one occasion talk about and explain from his point of view the value of the lamp patents; but he (witness) did not himself make any report, even a verbal report, to the Board regarding the lamps, as he had no knowledge which would justify him in doing so. With regard to what he had said about matters being rushed, he had no recollection of Mr. Rawson having told him that the thing must be settled before the Bank Holiday, or else it would have to be put off until the autumn. He believed Col. Howard Vincent raised an objection to the application of the Secretary, who applied for 200 shares. He did not recollect whether there were any other objections. His point was that they had not a sufficient subscription to satisfy their scruples. He recollected being told that Mr. Philip Rawson was not a relative or a connection in any way of Mr. Frederick Rawson. There were several drafts made of the prospectus before the final one—certainly over a dozen. The Directors had numerous meetings, and he personally took a great deal of trouble in the matter, but he could not remember the details of all that took place. He went carefully into the agreements, and insisted upon several alterations being made in them to suit his views. He did not recollect that the Foreign Elmore Company in June, 1889, purchased from Woodhouse and Rawson (Limited) their interest in the Elmore patents. He did not know anything of the circumstances under which Mr. Edmunds's valuation was made; that he came to town suddenly, and, not having his shorthand writer with him, asked him (Mr. Rawson) to have a shorthand writer in the room so that he could dictate his report, he (Mr. Rawson) commenting upon some matters as they arose to see that he got his facts right. He did not recollect that the £159,000 was arrived at by deducting the amount of the value of the foreign Elmore patent from the total amount of Mr. Edmunds's valuation. He certainly considered that if a lamp could be manufactured on royalty for 1s. 2d., and the selling price was 3s. 6d., the patent for that would be of considerable value, especially if he knew such a lamp fetched 6d. and 1s. more than other lamps in the trade. He did not know that some thousands of pounds were returned in consequence of the issue of the circular prior to the allotment.

By Mr. PILLING: He did not remember whether the balance-sheets of any of the companies to be acquired were shown to him or not. Sir John Stokes and other Directors of Woodhouse and Rawson (Limited), as well as Mr. F. L. Rawson, were sometimes present at the meetings. Mr. Rawson represented the selling Company. He knew that that gentleman was to be managing Director of the new Company, but not that he was to receive a large sum of money for promoting the Company. The more he went into the matter the less he liked it.

WITNESS, in response to the invitation of the Registrar to make any statement he might wish to make, said he took what he thought at the time was a good deal of pains to look into the matter, and as time went on he gradually found that it wanted more looking into. At all events, there was wanted an amount of supervision and control on the part of the new Directors which it would be almost impossible to exercise, and his desire was, when he resigned, that anybody who might have been attracted by his name in the prospectus should have an opportunity of knowing that he had retired. That object he thought he had secured by insisting upon the issue of the circular.

Col. HOWARD VINCENT, M.P., was the next witness, and, examined by the Official Receiver, said he was first approached by Mr. F. L. Rawson to become a Director of the United Company, which he understood was to be entirely an industrial concern. He had no idea that company promotion was to be one of the features. He knew a certain amount of the profits referred to of Woodhouse and Rawson (Limited) was in shares. He went into the thing rather later than the other Directors, and put in £5,000, and in making inquiries to make up leeway, he soon began to be suspicious and to think that the Company had been promoted in a very unbusinesslike manner; the minutes were not properly kept, and he had difficulty in obtaining accurate and exact information. In regard to the valuation of the patents and other matters, he put a good deal of confidence in the knowledge of Sir John Coode, who was President of the Institution of Civil Engineers. He thought he must have read the report of Mr. Pixley, the auditor, dated May 7, 1889. He was dissatisfied as to the manner in which the £21,440 profit in Woodhouse and Rawson (Limited) had been earned when he saw the report, and therefore required a personal explanation from the auditor; but was satisfied with the personal explanation, the character of which he could not remember. He understood that the profits for the then current year, 1889, were no less than £75,000, which amount was available in cash, and would be held in reserve for a few years. The persons applying for shares would probably have been put on their guard had they read the passage in the auditor's report, which said, "the accounts are in accordance with the books of the Company, but it is obviously impossible for us to be responsible for the net profit, having regard to the nature of the assets of the Company's interest in many trading concerns not yet fully developed, and without Stock Exchange quotations of their shares." The statement in the prospectus without the paragraph quoted, did not, he thought it very likely, give the shareholders the effect of the audit. With regard to the patents, he remembered that a great deal of value was put on the lamp. He remembered Mr. Rawson telling him that the partnership of Woodhouse and Rawson and the subsequent limited Company had been very successful. He would not say whether he was made aware that the bulk of the profits of 1889, £78,000, was made by a successful Stock Exchange transaction in Elmore shares; he knew he was very anxious to have the £75,000 deposited in cash. He thought the amount given for the goodwill of Woodhouse and Rawson (Limited), £75,000, was a good deal too much. He could not remember being told that the assets of that Company included a debt of £37,000 due from the Manufacturing Company. He knew he was exceedingly anxious that they should not proceed further until they had been to Manchester to see the works purchased there, but, as Sir Albert Cappell had said, the matter was hurried on a good deal and he was borne away. His impression was that the suggestion that they should not go to allotment unless £200,000 was available in cash was made by him.

By Mr. MUIR MACKENZIE (on behalf of Lord Aberdare): No doubt there were valuations of the actual assets in the component companies put before the provisional Directors; he did not recollect the details, but was quite sure they gained all the information they could. They took considerable pains to investigate the properties proposed to be purchased, but he thought now they ought to have taken more; they were, however, much pressed, as it was said the season was going on. His reason for retiring was that not sufficient capital was subscribed, added to the unbusinesslike character of the promotion. He thought they had been unduly hurried, and that the Managing Director would want more control than he would have time to give him.

By Mr. EVE: The only reason given at the time of his resignation was the insufficiency of capital; his other reasons were scarcely sufficiently definite to be given. They may have been imaginary, but they certainly existed in his mind. There was a certain reluctance in giving information,

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the papers were not sufficiently in order, the minutes were not sufficiently carefully kept, and so on.

Mr. F. L. RAWSON asked if it was not the fact that he was examined at considerable length as to the profits of Woodhouse and Rawson (Limited).—Witness replied that he (Mr. Rawson) was present at all the meetings, and he desired the presence of Mr. Pixley, the auditor, to confirm what was said. Up to the date of his retirement there had been nothing of a speculative or Stock Exchange character in the transactions of the Company; had there been, he should have withdrawn at once. Looking at the matter from a distance of five years, he thought they ought to have had more detailed information than they did; but it was difficult to suggest anything more that the Directors could have done that they did not do.

Mr. RAWSON: Have you ever heard it suggested that I ever had a penny for the promotion of Woodhouse and Rawson United?—It would not be credited that you would work for nothing.

Mr. RAWSON: As a matter of fact I did, but it has been stated that I had received a large amount for the promotion.

WITNESS, in conclusion, said he would confirm what Sir Albert Cappell had said that they went very carefully into the facts as far as they could in the limited time at their disposal. They were pressed not to quibble too much, as it was absolutely necessary to proceed at once if the Company was to be formed. When sufficient money was not provided they withdrew, and considered that that step would lead all sensible people to conclude that they did not approve of something in connection with the Company.

Further examination was adjourned until the following day.

TUESDAY, JUNE 19TH.

The first witness was Mr. C. L. BAKER, who stated, in reply to the Official Receiver, that he formerly acted as managing director of C. L. Baker and Co. (Limited), which was a Company subsequently acquired by Woodhouse and Rawson United (Limited). About the beginning of 1889 the question of amalgamation with Woodhouse and Rawson was brought before his Directors and shareholders, and, it being pointed out that unless they agreed to the scheme their Company would have to encounter very serious opposition, they agreed to the proposition. It was said that all the other companies concerned in the scheme were doing good business. He would not say that the Directors of C. L. Baker and Co. (Limited), understood that a large proportion of the proposed Company's business would consist of financial work or company promoting. It was known, however, that patents relating to electrical work would be "fostered." He was not aware of the sums to be paid for the other businesses acquired, but he knew that only an exceedingly small cash payment was to be made. C. L. Baker and Co. (Limited) received in all £24,000 for their business, being as to £5,000 in cash, and £19,000 in Preference shares, the amount for goodwill being £9,000, which was represented by *bonâ-fide* profitable contracts. Independent valuations were made of the plant and stock, and he was of opinion that they were under-valued. He saw the prospectus before it was issued, in which it was stated that the profits of Woodhouse and Rawson (Limited) for the year ending June 30, 1888, amounted to £21,440. He was not aware, however, that the auditors submitted a report to the effect that "the accounts are in accordance with the books of the Company, but it is obviously impossible for us to be responsible for the net profit, owing to the nature of the assets and the Company's interest in many trading concerns." Mr. F. L. Rawson assured him that great care had been exercised in the preparation of the prospectus, and he understood that every statement contained in it was correct. He was subsequently informed that a difficulty had been raised about going to allotment, owing to three of the Directors being dissatisfied with the amount of capital subscribed. He thereupon pointed out that if, from this cause, the Company did not go to allotment most serious injury would be inflicted upon C. L. Baker and Co. (Limited), as this Company had specially stipulated that they should not be dangled before the public as a bait, and he therefore instructed his solicitor to acquaint the Directors of the United Company with his intention to proceed against them for damages if they declined to go to allotment. The Company, however, went to allotment, and witness was appointed general works manager at Cadby Hall, Kensington, and Cornbrook telegraph works, Manchester. He had had considerable experience in managing works of this kind, having been for a great number of years an electrical engineer. Shortly after the Company was started he became aware that a sum of £85,000 had been paid for the patents acquired by the Company.

By the OFFICIAL RECEIVER: At the time he thought they might have been worth from £30,000 to £50,000; but now they were practically worthless, there being only one or two which were workable, but this was owing, to a great extent, to their being superseded by other inventions.

The OFFICIAL RECEIVER: I believe the industrial branch of the Company's business has been a failure throughout its existence, has it not?—WITNESS said that very heavy losses had been incurred, but he attributed this to the fact that the business had been cut up and distributed, instead of being carried on under the management of one person. He did not think the losses in question amounted to £50,000. The foundry at Kidsgrove, Staffordshire, was purchased by the Company for £30,000, in shares. It was represented that the business carried on there was producing £8,000 a year profit, and, thinking that they were acting in the interest of the shareholders, the Directors decided to acquire it. As a matter of fact it had shown a considerable loss, and the Directors estimated that the property had depreciated to the extent of £17,784 in July, 1892. When he entered upon his duties at Cadby Hall he experienced a considerable amount of difficulty in ascertaining anything about the concern, and to a great extent he was regarded as an interloper. Upon inquiry he discovered that affairs were in a very unsatisfactory condition, and upon his representing the same to the Directors they expressed some surprise, and Sir John Stokes said he was disgusted with the state of things. In April, 1892, he sent a letter to each of the Directors calling their attention to the position of matters, and suggesting certain alterations; but no action was taken upon it, and no mention of the matter was made to him. His only explanation of this was that the Board must have been engaged on more important business at the time. Ultimately he was unable to obtain funds for the purpose of carrying on the works, and a large proportion of the experienced hands were dismissed. In his opinion there had not been sufficient funds provided from the commencement, and difficulties had been experienced throughout. Shares to the value of £2,000 were given to him as his interest in C. L. Baker and Co. (Limited); but at the date of the winding-up order he did not hold any of them, because he knew too much about the concern. He had realised from £3. 12s. down to 3s. 6d. for a £5 share. He had also purchased other shares in the Company when his faith in it increased, but these had also been disposed of.

By Mr. MUIR MACKENZIE: When the business of C. L. Baker and Co. (Limited) was transferred to the united company he believed it was in a flourishing condition, and capable of realising a large profit. When he joined the United Company he had every reason to believe that with good management it would have been a prosperous company.

In reply to Mr. F. L. Rawson, WITNESS stated that he had never heard it suggested that the latter had ever acted in a manner which was other than straightforward.

By a CREDITOR: At the time C. L. Baker and Co. (Limited) was transferred it was a profitable concern; but it was impossible to say whether that particular branch had been so or not since the amalgamation, as the various businesses had been merged into one, and they could not be separated.

Further examined by Mr. BUTCHER: The Directors of C. L. Baker and Co. (Limited) were never anxious to amalgamate with the other companies; but, in view of the opposition which they would have to face, it was considered advisable to do so. The names of responsible gentlemen appearing on the prospectus inspired him with confidence in the concern.

It was stated at this point of the inquiry that the minute-book of Woodhouse and Rawson (Limited), which it was supposed had been lost or destroyed, had been found, and was at the disposal of the Official Receiver.

Mr. F. W. PIXLEY was next examined, and, in reply to the Official Receiver, stated that he had acted as auditor of Woodhouse and Rawson United (Limited) and of the Woodhouse and Rawson Electric Supply Company (Limited). Being on one occasion unable to obtain the necessary materials for the purpose of auditing the accounts of the latter company, his firm threatened to take further steps in the matter. He could not say whether that particular audit had ever been completed. In the prospectus of the Company it was stated that a profit of £21,000 had been made by Woodhouse and Rawson (Limited) in the previous year, but he did not certify to those profits—that was a matter which rested entirely with the Directors. His certificate as auditor was accompanied by a report to the shareholders, and the certificate and the report ought to have been read together. In a book which he had written on the subject he expressed the opinion that the auditor's report ought to accompany the accounts which were issued to shareholders. He had since had occasion to modify that opinion owing to the difficulty of enforcing what he, as an auditor, might consider to be proper, and the book now quoted from was a very early edition of his work. As auditor for the shareholders he considered it was his function to see that the transactions and accounts were as represented by the Directors, and that there was nothing wrong about them at all; but he was in no sense a "watch-dog." As to the duty of an auditor, he might say that on one occasion he took upon himself to enlighten the shareholders, and the only acknowledgement he got for his trouble was his dismissal, because he was said to have exceeded his powers.

The OFFICIAL RECEIVER: If you thought that it would be better for the shareholders not to know something, do you consider that you are justified in not telling them?—WITNESS: Yes, subject to certain qualifications.

Mr. REGISTRAR HOOD: What are they?

WITNESS said that there were numbers of trading companies now in existence in which it would be very disastrous for the public to know full particulars of their business transactions.

At this point the inquiry was adjourned.

WEDNESDAY, JUNE 20TH.

Mr. F. W. PIXLEY, the auditor, was again examined by the Official Receiver. He said he recollected that large sums were paid by the United Company into the International Okonite Company, in which application was made for shares to a large extent. A profit was stated to have been made of £17,000 on the Kensington Stores transaction, this being the sale of the front part of the Cadby Hall premises to the Kensington Stores, a company promoted by the United Company. He questioned the right to include this as a profit of the year, and counsel's opinion was taken at his request. He had no opportunity of putting his views before counsel, and he could not say that he ever saw the case put.

The OFFICIAL RECEIVER said, as a matter of fact, there was no case in existence, but there was merely a consultation. Counsel was of opinion that the Articles of Association enabled the Directors to form a reserve fund to such an extent as they thought fit, but that such reserve fund should be to provide for future and not for past losses or depreciations. The sum of £35,000 paid by the Kensington Stores was a premium on the lease, without which the rent would have been much greater, and counsel thought this might properly be placed to the profits of the year. He (the Official Receiver) suggested that, although the amount might be included in profits for the year, the

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proper course would have been, as the property was depreciated by the surrendering of a valuable frontage, not to allow the assets to remain at the same figure as previously, £47,000 on account of the Cadby Hall premises.

WITNESS said a new source of income was created by the rental, which was an extraordinary piece of profit for the United Company. He thought it might be said that Mr. Rawson was in favour of the profits being valued at the sums given, whilst witness would have preferred to see them put at a lower figure. Mr. Rawson was entitled to a portion of the profits after 15 per cent. had been paid. Witness wrote to the secretary of the United Company upon learning that an interim dividend had been paid at the rate of 15 per cent., saying that it was unusual for an exceptional dividend of that character to be paid before the accounts were made up and certified by the auditors; but as it had been done the responsibility rested solely upon the Directors, and he could only protest against the course which had been adopted. Witness did not see a prospectus issued at about that period inviting further capital, and stating that an interim dividend of 15 per cent. had been paid, and that the Company was being worked very successfully. He remembered objecting once or twice to his name being put upon these prospectuses. He was persuaded to withdraw his objections to the profits made being set forth as the usual profits of an engineering and trading concern; but he did not now think he was wise in allowing himself to be so persuaded. He was not aware that it was intended to repay the £75,000, held as a guarantee, to the liquidators of Woodhouse and Rawson (Limited); he was not consulted as to the expediency of that course. Coming to the year 1891, the gross profits were given as £74,563. There were several exceptional items of profit again in that year, whilst there was a considerable loss on the industrial business—£8,000 on the Kidsgrove Works alone. There was an item of £14,975 entered as Phœnix Trust profits. He heard afterwards, but did not know at the time, that this was a company founded by Baron Grant and Mr. F. L. Rawson. In that year he wrote to Mr. Rawson, pointing out unsatisfactory features in the accounts, suggesting a rearrangement of the same, and stating that as they stood it would be impossible to certify them without appending a very long explanatory statement. Mr. Rawson replied at some length with regard to these matters, and there were also numerous interviews. Eventually a certificate was drafted, stating that the profits arose almost entirely from financial and not from commercial operations, that investments to the extent of £118,000 were exclusively in shares of allied companies, and suggesting that as the guarantee had been renounced no dividends should be paid until those shares had been realised. That certificate was not appended to the balance-sheet, because it was represented to him that it would damage the Company. That statement would have made the shareholders aware of the real state of affairs. He agreed that the fact that the publication of that statement might affect the financial operations of the Company, or the market value of the shares, would not be a sufficient reason for the withholding of the statement. It was true that the commercial operations of the Company were on a comparatively small scale, and they could not very well be put into a much worse condition. He had stated that he should append the statement to his certificate unless certain pledges were given him by the Directors; but he could not recollect that he did receive any such pledges. He attended a meeting of the Board, there was a long discussion, and he was persuaded to withhold the special report referred to. A letter was written to his firm by the Secretary of the Company, undertaking, on behalf of the Company, that the sum owing by Mr. Rawson should be paid by July 31st, and that appeared to be the only pledge in writing which he received. One cause of complaint was that some of the accounts were made up to the end of May only, whilst others were extended to July 31st. It was true that if the accounts of the financial business had not been extended to July 31st, £35,000 profit through the promotion of the Epstein Company would not have been included. Had he known that several of the patents would expire in the course of a year or so he would have required a much larger sum to be written off than was done. He did not think, however, that anything should be written off goodwill. Where a business was worked at a small profit, or none at all, or even at a loss, the amount of goodwill must still remain; but, on the other hand, if the profits were doubled or quadrupled there should be no appreciation of the amount of goodwill. Nearly the only bit of law on the subject of accounts was to the effect that if the capital of shareholders was applied to purchase an asset which had only five years to run, the Directors were entitled to treat as profit and divide as profits any dividend without writing off one penny as depreciation of that asset.

By Mr. MUIR MACKENZIE: Seeing that the £75,000 was left in the hands of Woodhouse and Rawson United as a dividend guarantee fund, the Directors were bound to pay a dividend, even if there had been no profits. It appeared that divergent views were held by the Directors as to what was the proper method of dealing with some of the profits, especially with regard to the profits on the promotion of the Kensington Stores. Lord Aberdare wrote to Sir Rawson Rawson suggesting that certain things should be done, taking practically the same view as witness; but Sir Rawson Rawson gave reasons why the money should be otherwise applied. Lord Aberdare replied that his views were somewhat modified by the further information given, but he still adhered to the principle that the proceeds of the sale to the Kensington Stores should be applied to capital account and not to profits.

By Mr. JENKINS: No shareholder who attended the meetings of the Company could truthfully say he thought the profits arose out of the industrial business. Lord Aberdare and Mr. Pope both clearly stated that a large proportion of the profits arose out of the fourth branch of the Company's business, but no detailed information as to the proportions of profit was given. He had never had the slightest reason to doubt the honesty of any of the statements made to him, and he believed that the Board was composed of honourable men. He had never since seen any reason to change that opinion. What he complained of was that there were certain parts of the accounts which ought to be amplified.

By Mr. F. L. RAWSON: He could not say that it would be fair, profits having been made for the previous year, for the Directors of the Electric Supply Company to declare an interim dividend in 1887 without waiting for the accounts to be made up and audited. He could not say that the loss which eventually resulted in that year was entirely owing to the Edison-Swan action.

The further examination was adjourned until Wednesday of next week.

National Telephone Company v. Morris Bros.

In the Sheffield County Court, last week, before Judge Ellison, a further hearing was given in this action (see *The Electrician*, June 1, page 138), in which the National Telephone Company sued Messrs. Morris Brothers, chemical manufacturers, of Doncaster, whose works are at West Stockwith. The amount claimed was £50 due for rent of a private wire, and the defendants counter-claimed for £50 damages for alleged ineffective service of the telephone wire put up by the Company between their offices at Doncaster and the works at West Stockwith. When the case was previously before the Court it was stated by the defendants that continuous complaints, extending over a period of three years, were made to the Company; and that 119 letters of complaint were written, and constant verbal complaints were made. The Company, on the other hand, submitted that the telephone wire was repaired whenever necessary, and that they were therefore not liable for the damages claimed. The defendant's case on the counter-claim was reached at the first hearing, and now the plaintiff Company presented their case.

Mr. ELLISON, on behalf of the National Company, said that the claim for rent was admitted at the previous hearing, but the defendants claimed damages for breach of agreement. There was an answer on the face of the agreement on which they were suing, even assuming that all the acts alleged by the defendants were true. The first clause of the agreement was to the effect that "the Company shall erect, and (subject to the performance by the lessee of the condition herein contained) maintain in good working order the wire and telephonic apparatus referred to on front hereof." The Company had erected and maintained the wire and apparatus. The third clause was—"The Company shall not be liable for any loss or damage occasioned by the interruption or disturbance of telephonic communication from any cause whatever." The present claim was for interruption or disturbance of telephonic communication. Clause 2 provided that, "In the event of the said wire or apparatus not being in good working order the Company shall repair and restore the same at its own expense and with all possible despatch; but the Company shall not be held responsible or liable to the lessee, in damages or otherwise howsoever, for any delay, provided it uses every reasonable endeavour to restore the communication as speedily as possible." It was not suggested there had been any delay in restoring the communication when the line became interrupted. Mr. Morris admitted that the moment anything was wrong the Telephone Company did their best to put it in order. Messrs. Morris did not complain of any delay, but they complained that the telephone service was bad, and had to be put right very frequently. It was impossible for a telephone company to carry on its business unless clauses similar to those he had read were inserted in their agreement, and therefore the contention that such clauses were unreasonable was untenable. The line was 22 miles long, and the rent £100 per annum. For this sum the Company had not only to erect but to keep the wire in order. The Company could not guarantee that the line would not break, or would not be short-circuited. Counsel on the other side had referred to two or three letters written at the time the contract was entered into, and which served to suggest the varying of the written contract. These letters could not be used as a contract, because they were not stamped.

Mr. WILKINSON, for the defendants, said they were in the nature of a guarantee prior to the signing of the contract.

Mr. ELLISON, however, contended that the telephone fixed by the Company was perfectly fit for the purposes intended, and was as good an instrument as any of its kind in the country. Mr. Morris pleaded that the Company had given him an inefficient telephone, but he (Mr. Ellison) submitted that, even admitting this allegation, there was a conclusive answer by Clause 7 of the agreement, that "The Company reserve to itself the right to disconnect, without notice and without prejudice to the other clauses of this agreement, any subscriber whose rent is overdue." Mr. Morris had been in arrear with his rent, and it was not until within a few days of the action that he paid a substantial amount. The Company had carried out their part of the contract. As to the correspondence which had passed, he contended that the interruptions which had occurred were such as were necessarily incident to a well-constructed telephone.

Mr. G. F. L. PRESTON, manager of the Sheffield district of the National Telephone Company, said the line in respect of which the action was brought was a properly constructed one. Whenever he was at Doncaster he had invariably tried the line, and found it in good order.

Mr. CHARLES HENRY SIBLEY, local manager at Sheffield, who was also called, was asked by Mr. Wilkinson if he considered a telephone line satisfactory which required a strongly-written complaint to the office at least once a week, and replied that it was not satisfactory if the complaints were justified.

Mr. CHARLES BROWN, electrical engineer to the Metropolitan District Railway, said he had inspected the telephone line in question, and it was well constructed. The "fault" record was an average one.

Linesmen were called with regard to the repairs and inspection of the line, and several attributed the interruptions to corrosion of the wire by chemical fumes from Messrs. Morris's works.

At the conclusion of the plaintiff's case Mr. WILKINSON said he did not for a moment suggest that the interruptions caused by a heavy snowstorm, or anything of that kind, were grounds for damages. With a line

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22 miles in extent, there would be a good deal of interruption due accident; but the complaints covered a great many more times when no such cause as that he had intimated would account for the interruption. The Telephone Company had undertaken to put up a workable line, and the third condition of the contract, he contended, was limited in its interpretation by the two conditions that went before. In the second condition of the contract the Telephone Company recognised liability under certain circumstances. The whole of the complaints of Messrs. Morris came to this, that for a period of three years the Company never had seriously undertaken to put the line in such a condition as to save them from annoyance and interruption which they certainly ought not to have suffered from.

His Honour reserved judgment.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

The 1894 Edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is NOW READY. This valuable book contains 1,000 closely-printed pages, and several new and useful features have been added. The price of the Directory and Handbook is 7s. 6d. Postage in the United Kingdom, 9d.; abroad, 1s. 4d.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," being four Lectures delivered before the Royal Institution in April-May, 1894, by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is in preparation, and will shortly be published.

"ELECTROMAGNETIC THEORY," by Oliver Heaviside, is now ready, price 12s. 6d. (abroad 13s.). Prospectus on application.

TENDERS INVITED.—The City of London Electric Lighting Company require tenders for twelve months' supply of coal, equal to from 20,000 to 25,000 tons. Specifications can be obtained of Mr. David Cook, engineer and manager to the Company; and tenders must be in to Mr. J. Cecil Bull, secretary, at the offices of the Company, 1 and 2, Great Winchester-street, E.C., by 4 o'clock of Wednesday, the 27th inst.

——— The Corporation of Edinburgh invite tenders for work in connection with their electric lighting scheme. The contracts for which tenders are now required include the supply of cast-iron road boxes, copper strip connectors, &c., gun metal grip boxes, cable connectors, and cones. Copies of the specifications and drawings can be obtained from Mr. E. W. Monkhouse, the Corporation's resident electrical engineer, at the City Chambers, Edinburgh, from whom also all other information can be obtained, as well as from Prof. A. B. W. Kennedy, 14, Old Queen-street, Westminster, S.W. Tenders have to be sent in to Mr. W. Skinner, W.S., town clerk, the City Chambers, Edinburgh, by Wednesday, July 4th. Some further particulars will be found in our advertisement columns.

TENDERS ACCEPTED.—The Newport County Council have received four tenders for the supply and erection of an overhead travelling crane for the electric lighting station, as follows:—Stothert and Pitt, £350; Isles (Limited), £290; T. Smith, £285; Carrick and Ritchie, £275. £250 was the sum provided in the contract for this crane, and Mr. Hammond, electrical engineer to the Council, recommended that the offer of Mr. T. Smith of Rodley be accepted, and this course was adopted by the Council.

——— The London County Council have accepted tenders for india-rubber goods sent in by the India-rubber, Gutta-percha and Telegraph Works Company (Limited).

TENDERS RECEIVED.—The Electric Lighting Committee of the Coventry Corporation have received seven tenders for the erection of the buildings for the electric lighting station in Sandy-lane, from plans and specifications by Messrs. G. and I. Steane, and the Corporation have accepted the tender of Mr. C. G. Hill, of Coventry, for the sum of £6,829, including extras of £180. This was the lowest tender. A clerk of the works is to be appointed at four guineas a week. The site selected leaves ample room for future extension. An engine and boiler house is included in the buildings to be erected.

POST OFFICE AND THE NATIONAL TELEPHONE COMPANY.—The Postmaster-General in the House of Commons last night said that negotiations were still going on between the Department and the Telephone Company, and the delay in completing was due to the immense amount of detail work involved. He did not think the delay had enabled the Telephone Company to increase their monopoly, or place themselves in a better position than those municipalities which wished to obtain licences. Hon. gentlemen seemed to forget that the National Company only enjoyed a temporary licence terminating in 1911, and every month that passed must have the effect of reducing the value of their property. The agreement which was being negotiated was simply to give effect to the agreement made by the late Government for the purchase of the trunk lines, and did not involve interference with existing licences.

ENGINES FOR SALE.—The Brush Company have two vertical compound non-condensing Goodfellow engines for sale.

SALE OF PLANT.—On Wednesday, the 27th inst., at Douglas (Isle of Man), by order of the official liquidators, Messrs. W. M. Kernish and Jno. J. Taggart, 21, Athol-street, Douglas, a sale will take place of an immense assemblage of valuable and useful effects, which includes gas engines, Davey-Paxman semi-portable tubular boilers, Brush dynamos and arc lamps, vulcanised and braided cable, &c., &c., particulars of which will be found in our advertisement columns.

DISSOLUTION OF PARTNERSHIP.—The firm of Bennett and Co., carrying on business at the Dynamo Works, Park Cross-street, Leeds, as electrical engineers, has been dissolved. The debts will be paid by Mr. R. F. Winder, who carries on the business.

——— We regret that in our issue of the 8th inst. it was announced that Mr. J. L. Fuller would carry on the business of Messrs. Fuller and Tate, at 20, Bucklersbury, E.C., instead of a *similar* business, as announced in his circular.

APPOINTMENT.—Mr. F. L. Todd, of Glasgow, has been appointed to the post of assistant electrical engineer to the Edinburgh Corporation.

APPOINTMENT VACANT.—The Vestry of St. John, Hampstead, are prepared to appoint an electrical engineer to take charge of their electric lighting station, at a salary of £200 per annum. Applications must be sent in to Mr. Arthur P. Johnson, vestry clerk, Vestry Hall, Hampstead, not later than July 2nd. Some further particulars will be found in our advertisement columns.

BANKRUPTCY.—A meeting of the creditors of John Webster and Joseph Hayes, trading as Webster and Co., at Wheat Sheaf Works, Hall Lane, Bradford, electrical engineers, &c., was held at the office of Messrs. Rawnsley and Peacock, Bradford, last week. A statement of affairs was presented showing liabilities £317. 19s. 8d. and net assets £592. 12s. 1d. It was resolved that a deed of assignment be executed in favour of Mr. John Butterfield, C.A., who as trustee will continue the business with a view of ultimately paying 20s. in the pound. A committee of inspection was appointed, consisting of Messrs. Matthews (Messrs. Rosling and Matthews), Schofield, Payn, and Edmondson.

REMOVAL.—Mr. Albion T. Snell, Assoc. M. Inst. C.E., M.I.E.E., has removed from Brightside, Salusbury-road, N.W., to South View, Brondesbury-road, N.W.

——— Messrs. F. A. Robinson and Co., engineers, merchants, and shippers, have removed from 69, Cornhill, to 54, Old Broad-street, E.C.

OIL-TESTING MACHINE.—Mr. H. F. L. Orcutt, from the London office of Messrs. Ludw. Loewe and Co., sends us an illustrated pamphlet relating to a new oil-testing machine brought out by the firm. The object of the machine is to ascertain by mechanical means the lubricating qualities of oil, and to register the same by means of diagrams. The machine covers a floor space of 41in. by 26¾in., and weighs 920lb.; speed 200 revolutions per minute, or as required.

CARRIAGE LIGHTING.—The new system of carriage lighting by electricity recently brought out by the Bristol Electric Safety Lamp Works, of 63, Queen Victoria-street, can be seen at work at the Coaching Exhibition now being held at the Royal Aquarium, Westminster, S.W., where a drag built by Messrs. Holland and Holland is lighted electrically.

MINERS' LAMPS.—A number of electric lamps made by the Bristol Company have, it is stated, been used with success by the rescuing parties in the great mining disaster at Karwin (Austria).

THE ROYAL ALFRED AGED MERCHANT SEAMEN'S INSTITUTION.—This is a charity with which in the past many telegraph men have been closely associated, and even at the present time considerable aid is rendered by the leading telegraph and cable manufacturing companies. Owing to the recent deaths of several gentlemen who have taken great interest in the Institution, and have been the means of providing considerable funds, it seems likely that telegraph men may overlook the claims of an Institution which does not make so prominent a show as many other charities, but which none the less deserves the cordial support of the telegraphic and general public. At the annual festival held at the Hôtel Métropole on Wednesday last, the Chairman pointed out the claims which the Institution undoubtedly possesses on the support of everyone concerned in our merchant shipping, and regretted to announce that, owing to the reduced condition of the Society's funds, nothing approaching justice could be done to the numerous applicants for the benefits offered by the charity. No less than 250 names are now on the list, and for only about 20 of these can provision be made. An earnest appeal was made for funds in support of a most deserving body of old men. Many gentlemen well known in the electrical world were present at the festival, with which the late Sir James Anderson, Sir George Elliot, and Capt. Halpin were closely identified.

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Cooking by Electricity.—On Friday last the Directors of the City of London Electric Lighting Company invited a number of gentlemen to the Cannon-street Hotel, E.C., to witness the cooking, and to join in the first public dinner cooked throughout by electricity within the Company's supply district. A large gathering supported Sir David Salomons, who presided, the guests including the Lord Mayor, Prof. S. P. Thompson, Mr. W. H. Preece, C.B., Mr. C. Braithwaite, Prof. J. A. Fleming, Dr. Ernest Hart, Col. Martindale, Sir Myles Fenton, Sir Henry Oakley, Mr. Emile Garcke, Mr. David Cook, and Mr. J. Cecil Bull. The Company having done justice to the menu, which was voted a great success, the Chairman, in proposing the toast, "Success to the Development of Electricity," said the City of London Company had become pioneers in a new development of the application of electricity to cooking purposes, and had practically demonstrated its utility by the dinner given that evening. The food those present had eaten was unadulterated by carbonic acid, carbonic oxide gas, or sulphuretted hydrogen. It was distinctly noticeable that the viands they had partaken of were absolutely devoid of any flavour other than that properly appertaining to them, and when, in addition to this most important quality, it was pointed out that the Company had decided to charge only half rates (4d. per unit) for current supplied for cooking and heating purposes, he felt quite sure that in the busy City of London a considerable demand would be created for a method of cooking which, in addition to the advantages pointed out, took up little room, made absolutely no unpleasant smell, and was cleanly to the last degree. The number of ovens, hot-plates, and other apparatus used provided for 120 guests, the number of electrical units used being 60, which gave a cost of 2d per head. This was a result which could not be considered otherwise than as eminently satisfactory to all concerned, and the catering section of the public would, he felt sure, not be slow in adopting this simple and effective means of overcoming all the difficulties of the bad old systems. The field for the electrical system of cooking and heating was a large one, and promised to become an important adjunct to the Company's lighting operations. The greater portion of the apparatus used for cooking the dinner including six large ovens, sauce and frying-pans, was supplied by Messrs. Crompton and Co., of 148, Brompton-road, S.W., the General Electric Company, of Queen Victoria-street, supplying the remainder.

Aberdeen.—The Watch Committee of the Town Council have decided to recommend the adoption of a proposal to light the new police barracks and prison buildings throughout by electricity.

Bank Lighting.—Messrs. Drake and Gorham have secured an order to instal the electric light at the Consolidated Bank, Manchester. About 80 16 c.p. lights will be required, the current being obtained from the Corporation's supply.

Basingstoke.—Mr. Robert Hammond is preparing a report for the Town Council on the electric lighting question at a fee of 25 guineas. An amendment that tenders be invited for the lighting of the town by electricity, and that liberty be given to the Electric Lighting Committee to employ Mr. Hammond to advise the authority on the matter, was also put and negatived.

Bedford.—At the last meeting of the Town Council the Electric Light Committee recommended that application should be made to the Local Government Board for sanction for borrowing £12,000 to provide funds for the necessary buildings, machinery, and plant for supplying electrical energy within the borough for private and public purposes, in accordance with the plans and estimates prepared by Mr. F. H. Medhurst. Mr. Richards, proposing the adoption of the Committee's recommendation, said that a £12,000 loan for 30 years would be met by a rate of 1d. in the pound for each half-year, which the Committee hoped would be returned from the income derived from the supply of electric light and power in the Council's area. The recommendation was adopted unanimously.

Berlin.—A correspondent describes a carriage used by the Emperor William II. Not only are the interior and exterior lighted by electricity, but the harness is also smothered with small electric lamps, the whole presenting a most original appearance.

Brechin.—The Town Council have decided that the Committee recently appointed by the Police Commission to inquire into the details connected with the introduction of the electric light into the city should also act on behalf of the Council.

Brewery Lighting.—The Burton-on-Trent Brewery, owned by Mr. S. Evershed, M.P., is being fitted throughout with the electric light.

Carlisle.—In a discussion which took place on a report of the Gas Committee of the Town Council, Mr. Saint referred to the interest taken in the electric lighting question by the Mayor, and wished to know whether the subject had received the attention of the Gas Committee. Mr. Forster, Chairman of the Committee, in reply, said that "as the Corporation were in possession of an excellent gas plant the Committee did not think it advisable to enter into any discussion on the electric lighting question." The Mayor subsequently said he had mentioned the subject on two or three occasions, but it had been looked upon with great fear and alarm. He himself had no doubt that, if the Committee had the courage to spend a few thousand pounds, electric lighting would pay much better than the gas works; but against the electric light there was prejudice, which, at the present moment, it was difficult to overcome.

Church and Chapel Lighting.—The electric light is being substituted for gas at the Marylebone Presbyterian Church, Upper George-street, W.

City of London.—The City of London Electric Lighting Company announce that they are now prepared to supply electricity for all purposes in every street and lane within the City of London and in the district of St. Saviour's, Southwark, and offer to consumers who undertake to use 75 per cent. of their current between the hours of 10 p.m. and 6 a.m. the special rate of 4d. per Board of Trade unit, which rate is also now charged at all times of the day or night for current used for heating, cooking, and motive power. The Company have opened show rooms at Queen-street, Cheapside, where appliances for heating and cooking can be purchased or hired and information on the subject obtained.

Canterbury.—The Town Council have received a letter from the County of London and Brush Provincial Company intimating that, provided two gentlemen of good financial position and influence in the district will consent to act as Directors of the Canterbury Company, each investing £500 as Director's qualification, and provided that a sum of not less than £6,000, and not more than £7,500 of the first issue of shares be subscribed locally, the Brush Provincial Company will be prepared to find twice the amount of the local subscription, and to proceed with the work within the present year. After discussion it was decided that the suggestion made by the Company that the Mayor should call a meeting to discuss the question, was agreed upon, and a date will shortly be fixed.

Coventry.—The City Council have received the sanction of the Local Government Board for borrowing £20,000 for electric lighting purposes.

Devon.—At the County Council meeting last week estimates were discussed for improving the water supply and for lighting the Devon County Asylum by electricity. The Finance Committee recommend that the amounts required for carrying out the works should be raised by loan, and application is to be made to the Local Government Board for consent to the borrowing of £8,000 for these purposes.

Dundee.—Mr. Brownlee, electrical engineer to the Dundee Corporation, has recommended the extension of the electric lighting works by the putting down of a 200-h.p. engine and dynamo set. This will bring the available horse-power up to 860. It is anticipated that a further extension will be required next year.

Edinburgh.—Arrangements have been made for laying the foundation stone of the electric lighting station on Monday next, at four p.m., by the Lord Provost, Sir J. A. Russell. A popular lecture will be given in the Albert Hall by Prof. A. B. W. Kennedy.

Edmonton.—A notice has been received by the Local Board from the Tottenham and Edmonton Electric Light and Power Company notifying their intention to apply to the Board of Trade for power to light a portion of the Edmonton district by electricity, and asking the support of the Board for the application. It was decided that the engineer and secretary to the Company should attend the next meeting of the Board to explain the exact position.

Electric Traction in Russia.—The municipal authorities of Ekaterinodar are inviting tenders until July 25th for the establishment of a system of electric tramways in the town. Ekaterinodar is an important town in the Government of Kouban in South Russia.—The Allgemeine Electricitats Gesellschaft of Berlin about two years ago introduced a system of electric traction on some of the tramway lines in the town of Kiew. This has proved so successful that electricity has just been adopted on three other lines in the town, making now 13 kilometres of electric tramway in Kiew.

Electrically Propelled Vehicles.—Messrs. Taylor, Cooper and Bednell, of Coventry, have completed the construction of a car-wagonette, propelled by electricity, from the designs of Messrs. Blumfield and Garrad. The vehicle has seats for four, and runs on four pneumatic-tyred wheels, with ball bearings. The frame, which is carried on springs, is constructed of weldless steel tubing, similar to that used in the manufacture of cycles. A battery of 24 storage cells is used, and these are placed beneath the two seats and lasts for about seven hours, the motor being fixed beneath the vehicle. The motor is of 1-h.p. nominal, and will give 2-h.p. for a short time in case of necessity. The switch, steering, speed regulation gear, and brake are controlled from the front seat. The car, which is said to attain a speed of from 3½ to 13 miles per hour, can be propelled either backwards or forwards. The manufacture of such vehicles is particularly suited to cycle works, and, if the novelty is favourably received, will find employment for cycle hands during the slack season of the year.

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FAREHAM.—An adjourned meeting of the Local Board has been held to consider a letter from the Electric Lighting Company on the question of public lighting, to the effect that, unless the Company could obtain a large amount of public and private support they did not feel justified in carrying on the business any longer. The letter suggests that, if the undertaking be abandoned, the Board of Trade would give the Local Board the option of purchasing the plant as it stood; but, as an alternative, asked the Board to put up an additional ten arc lamps at an increased cost of £150 a year. After a long and heated discussion, the offer respecting additional lighting was withdrawn by the Company, on the ground that the shareholders and bondholders could not fairly be asked for more capital to put the electric lighting wires underground. It is satisfactory to learn that the negotiations between the Company and the Local Board are still likely to lead to a satisfactory arrangement, under which the Board will purchase the Company's business. At the meeting on Friday last the Board passed a resolution under which it was decided "to purchase the business of the Company for a sum of not more than £5,000, on condition that the Company undertake to lay underground the portion of the wires so required by the Board of Trade, and to undertake to provide a duplicate engine for a further sum of not exceeding £1,000." A further meeting is to be held at which this decision will be discussed.

FIRE.—A fire which promised to prove of serious dimensions broke out at the South Metropolitan District Schools at Sutton, Surrey, on Sunday last; but the building, which is isolated, is in direct electrical communication with the Sutton Local Board Fire Brigade, the members of which were by this means on the spot promptly after the first outbreak, and saved the building, which would otherwise have been totally destroyed. The schools provide accommodation for 1,700 workhouse children.

GEELONG (AUSTRALIA).—The Town Council of Geelong have agreed that it is desirable to light the town by electricity, and have under consideration a proposal by the Crompton Electric Supply Company to instal the light in the town at an estimated cost of £15,000, with an annual up-keep charge of £1,400.

GLASGOW.—A decision was come to at a meeting of the Watching and Lighting Committee last week by which a proposal to extend the supply of electric light to certain additional streets was negatived on the grounds of the increased cost. It will be remembered that some time back the Glasgow Corporation decided to extend the lighting, and this decision appears to be a departure from the previous resolution of the Council.——A report has been presented to the Corporation, showing the annual expense of the telephones and telephone connections rented by the Corporation, and the several Trusts connected therewith. The total amounts to £497 per annum. The Corporation have agreed to enter into a contract with the National Company to provide telephonic communication between the Water Commissioners' office in John-street, Glasgow, and Strathblane and other positions, at £93 per annum, the offer to take effect upon the expiry of the existing agreements with the Post Office.

HACKNEY (LONDON).—At the last meeting of the Vestry it was agreed that the Special Committee appointed to consider the electric lighting question be requested to bring up a report as to the present position of the Hackney Electric Lighting Order, 1893.

HAMPSTEAD.—The Electric Lighting Committee's recommendation that an electrical engineer be appointed to take charge of the Vestry's electric lighting station at a salary of £200 per annum has been adopted. Some difference of opinion exists between the members of the Vestry and the London County Council as to the terms of and conditions under which a loan is to be granted for the electric lighting works. The Vestry propose £25,000, which has been reduced to £23,500 by the County Council. A proposal that in the thoroughfares where mains for private lighting are now being laid mains for public lighting should be put down contemporaneously, was met by the objection that Mr. W. H. Preece advised that it would be better to await the result of certain experiments now being made in various quarters, in order that considerable savings which were anticipated might be made.

HANLEY (STAFFS.).—Designs for the electric light fittings for the Town Hall and Victoria Hall, submitted to the County Council by Messrs. Spagnoletti and Crookes, have been approved. It has decided to insure the three boilers at the electric lighting station at £3,000.

HOTEL LIGHTING.—The Forsyth Hotel, Aberdeen, is now lighted throughout by electricity by means of 200 16-c.p. incandescents.

IMPORTANT TRADES UNION CASE.—At Clerkenwell Police Court, before Mr. Horace Smith, Edward Stallard, late treasurer of the Bristol Branch of the Electrical Trades' Union, was summoned for unlawfully withholding the sum of £9. 10s. 4d. belonging to the Union. At the commencement of the proceedings a plea of *res judicata* was raised, counsel for the defendant producing a certificate of dismissal signed by the Bristol magistrates, who had previously tried the same matter. Eventually the magistrate said he could not do otherwise than decide the case in favour of the defendant, and dismissed the action.

KENSINGTON (LONDON).—A letter has been received by the Vestry from the Notting Hill Electric Lighting Company notifying the Company's intention of applying for a Provisional Order to empower them to supply electric current in the area recently abandoned by the House-to-House Electric Light Supply Company in the northern part of the parish. The letter was referred to the Electric Lighting Committee.

MOSS SIDE.—Mr. A. Marr, of the Collier-Marr Company submitted a proposal at the last meeting of the Local Board for lighting by electricity several of the principal thoroughfares of this district. He undertook to supply illuminating power of 10,628 candles to replace the present 2,026 candles, at a cost of £535 per annum. The proposal is to be made in writing, and discussed at the next meeting of the Board.

NEWPORT.—The County Council have had under discussion the description of lamp-post to be used for the arc lamps for the lighting of the streets. It has been decided to use bracket lamp-posts, for which designs are now being submitted.

NOTTINGHAM.—The works in connection with the new electric lighting station in Wollaton-street are approaching completion. The various buildings are nearly finished, and the chimney is all but complete.

OFFICE AND WAREHOUSE LIGHTING.—Many of the new sets of warehouses and offices built upon the site of the late extensive fire at St. Mary Axe, London, are being installed throughout by the electric light, and Messrs. Gilbert and Co., of Kensington, have lately received several contracts for wiring the buildings.

PLYMOUTH.—Owing to the opposition of the Plymouth Borough Council, the local gas company have withdrawn the power sought under their Plymouth Gas Bill to obtain a Provisional Electric Lighting Order to supply Plymouth with electric current. The Corporation is therefore now in sole possession of this power. The Council have, in addition, been successful in considerably reducing the amount of capital to be raised by the gas company under its new Bill.

PRESENTATION.—The employés of the firm of Messrs. Peto and Radford have presented Mr. William Peto with a handsome silver salver on the occasion of his marriage.

RAILWAY CARRIAGE LIGHTING.—The Bristol Electric Safety Lamp Works have just completed an order from the Agent-General for the Cape of Good Hope for 40 sets of self-contained electric accumulator lamps, arranged for hanging to the panels of the compartments of railway carriages, and also an order for corresponding fittings for 120 compartments. These lamps weigh about 12lb. each, and consist of a flat accumulator in polished wooden cases, the lamp being fixed in front at an angle of 45deg. It is claimed for these lamps that they can be fixed at a moment's notice, will burn for 15 hours continuously, giving light of about 4 c.p. in front of the reflector. The lamps have been subject to tests for the past two years, and it is stated that this order is the result.

RICHMOND.—The Electric Lighting Committee reported to the Town Council at the last meeting the receipt of a report from Messrs. Urquhart and Small on the electric lighting of the borough and the works of the Richmond Electric Light and Power Company (Limited), and certain recommendations made by the Committee were approved by the Council.

ROYAL AGRICULTURAL SHOW.—This important gathering is now being held at Cambridge, and will remain open up to and including the 29th inst. Messrs. Crossley Brothers have on view a number of their well-known gas and oil engines, including a 25-H.P. latest improved type Otto gas engine, capable of indicating about 65 H.P. at a speed of 160 revolutions per minute. This engine is of the new patent permanent tube type, and is fitted with timing valve, safety starting gear, quiet air suction, and sensitive high-speed governor. There is also on show a horizontal high-speed electric light gas engine of 2½ H.P. on the brake, running at a speed of 300 revolutions per minute. This engine is fitted with two flywheels, and is specially adapted for electric lighting purposes. Other exhibits include a 9-H.P., 3-H.P., and a ½-H.P. single-cylinder vertical gas engine. A number of oil engines are also exhibited from 10 H.P. nominal, to 2 H.P. nominal. One of these—a 4-H.P. engine—is entered for competition in Class I. Another, of 6-H.P. nominal, which has a water-vessel for cylinder-cooling purposes and an oil tank combined, is entered for competition in Class II. The total weight of this 6-H.P. portable engine is, in travelling order, 3¼ tons, and it is equal to a continuous working load of 11 H.P. effective. The engine works on the Otto cycle, and is of similar construction to the stationary oil engine made by the firm. Under the framing of this engine are two tanks—one for oil and one for the cooling water. The oil is pumped up by a small pump into a special measuring apparatus, for which a patent has recently been applied. The feature of this measuring apparatus is that the quantity of oil for working strokes following other working strokes is slightly increased for working strokes not previously followed by a

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working stroke, which is a similar principle to that of the well-known Crossley gas engine, which renders this special measuring apparatus of much importance. Only a small quantity of cooling water is necessary.—Another effective exhibit is that of Messrs. W. H. Willcox and Co., who have on show a large variety of engineers' tools, lubricating and cylinder oils, and general engineers' stores.

SALISBURY.—Mr. E. R. Dale has just opened an electric charging station at 100, Bedwin-street, where cyclists, the police, postmen, &c., have the batteries for their portable lamps recharged. In the neighbourhood of Salisbury and Blandford many cyclists are adopting electric lamps.

SHOREDITCH (LONDON).—The Vestry having, as stated in our last issue, decided to purchase the Pitfield-street site for the electric lighting station, will petition the Board of Trade for an extension of the term of their Provisional Order for 18 months, in order to complete the electric lighting scheme, which is estimated to cost, with the dust destructor and other items, more than £100,000.

SOUTHPORT.—The Gas and Electricity Committee recommend that the price to be charged for electric energy for the first year, from the opening of the works, be 7d. per unit. The recommendation was approved.

TAVISTOCK.—The first annual meeting of the Tavy Iron and Engineering Works at Tavistock was held last week, and after declaring a dividend of 7½ per cent. for the year, Mr. J. Dennis, the chairman, said the Company had under consideration the question of the electric lighting of their works. Statistics were being collected in order to ascertain whether lighting by electricity could be started in Tavistock. They had water power quite sufficient for the purpose.

THEATRE LIGHTING.—A proposed new theatre, to accommodate an audience of nearly 17,000 persons, is to be built at Walsall, at an estimated cost of about £8,000, and is to be lighted throughout by electricity.——At Leeds Mr. Wilson Barrett has decided to build a new theatre capable of accommodating 2,000 persons, which is to be lighted electrically.——The Theatre Royal, Bradford, is now lighted almost entirely by electricity. Two 16-H.P. Crossley gas engines are used. The main switchboard is provided with a mechanical arrangement patented by Messrs. Ullathorne and Hartley for controlling the distribution as between the two engines in a manner stated to effectually guard against all possibility of a breakdown.

TOTTENHAM.—A letter received by the Local Board from the Tottenham and Edmonton Electric Light and Power Company, giving notice of their intention to apply for a Provisional Electric Lighting Order, was at the last meeting of the Board referred to the General Purposes Committee.

WINDERMERE.—It is stated that the Windermere Electric Lighting Company have secured a mill recently used as a woollen manufactory, for the purposes of an electric lighting station at Backbarrow, and that the premises are to be adapted for plant for electric lighting purposes which is to be shortly put down. It is stated that the site has several natural advantages, including a large quantity of water suitable for power purposes, and will form an excellent centre for distribution.

WORCESTER.—It has been decided to obtain an estimate of the cost of wiring and fitting up the Public Hall for the electric light. A new arrangement has just been entered into with the gas company under which, should the Corporation desire to discontinue the lighting of any of the lamps, an allowance of 5s. per lamp is to made to the Corporation.

WORKS LIGHTING.—The extensive iron works at Glengarnock are now lighted electrically.

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

May 21, 1894.

9,862. W. MORISON. New York. Improvements in batteries.*

May 22, 1894.

9,896. G. W. LEECH. London. Improvements in the arrangement of gearing for electrically-propelled vehicles, cars, yachts, and launches.

9,909. E. W. LANCASTER. Birmingham. Improved shade-carrier for gas and electric shades.

9,927. E. J. PIPER. London. Improvements in electrical switches and connecting to the same.

9,934. G. E. ADAMS. London. Self-generating electro-magnetic motor for driving power.

9,949. T. CRANEY. London. Improvements in electrolytic apparatus.*

9,967. C. A. DAY. London. Improvements in electric arc lighting. (The Higham Electric Company, United States.)*

9,968. E. A. SPERRY. London. Improvements in the method of, and apparatus for, arresting motion of electrically-propelled mechanisms.*

9,974. W. P. THOMPSON. Liverpool. Improvements in, or relating to, apparatus for heating metals electrically. (C. L. Coffin, United States.)*

9,975. W. P. THOMPSON. Liverpool. Improvements in the method of, and apparatus for, heating, welding, or working metals by electricity. (C. L. Coffin. United States.)*

May 23, 1894.

9,999. W. MCGEOCH, jun., and A. W. STEWART. Glasgow. Improved holder for incandescent lamps.

10,021. S. W. MAQUAY. London. Improvements in connection with primary batteries and portable electric lamps.

10,044. A. THEODOLI. London. An improved system of producing luminous electric changeable writing, and in apparatus therefor.*

10,045. J. B. ORMSBY and G. H. BANISTER. London. An improved method of and apparatus for controlling the action of electric motors and other prime movers.*

May 24, 1894.

10,114. B. PELL. London. An improvement in incandescence electric lamps.

10,115. A. C. COSSOR. London. Improvements in electric lamps for surgical purposes.

May 25, 1894.

10,132. J. EDMONDSON. Halifax. Automatic zero reading electric instruments.

10,140. W. HARTNELL. Leeds. Improvements in regulators for electric currents.

10,149. J. ORME. London. Improved apparatus for supporting electrical conductors, and the like.

10,169. G. R. BLOT. London. Improvements in plates for secondary voltaic batteries.*

10,171. P. A. NEWTON. London. Improvements relating to writing telegraphs. (E. Gray, United States.)*

10,172. E. HOPKINSON. London. Improvements in or connected with vehicles for electric railways or tramways.

10,186. E. NASHOLD. London. Self-locking cleats for electric wires.*

10,199. J. W. NAUGHTON. London. An improvement in the art and process of electrotyping.*

May 28, 1894.

10,228. W. H. HILL-HARTLAND. Sheffield. Improvements in deodorising and purifying sewage or other waste liquors containing organic matters, in combination with generating and storing electricity, and in means or apparatus therefor.

10,242. W. HEARN and C. R. GATEHOUSE. London. An electric switch.

10,292. J. MANGER and E. MAJON. London. A novel mode of illuminating watches, clocks, compasses, barometers, and similar instruments boxed up in metal cases, by means of electricity.

10,293. J. MANGER and E. MAJON. London. A portable electric lamp.

10,331. F. B. BEHR. London. Improvements in conductors for electrically propelled tramway and railway vehicles.

10,332. S. J. SUTER. London. An improvement in regulating apparatus for electric arc lamps.

10,353. J. MORRIS, jun. London. Improvements in pendant fittings for electric lamps.

10,364. E. DRAGOUMIS. London. Improvements in electrical devices suitable as meters, motors, dynamometers, and the like.

May 29, 1894.

10,384. G. S. ORSON. Belfast. Improved carbon for electric lighting and other electrical purposes.

10,386. F. FRITZ. Manchester. Improvements in or applicable to clocks for operating electrical alarms.*

10,425. J. A. KINGDON. London. Improvements in electrical transformers.

10,426. J. A. KINGDON. London. Improvements in dynamo-electric machines.

May 30, 1894.

10,463. J. M. MOFFAT. London. Improvements in cells or boxes of electric batteries.

10,487. H. W. SULLIVAN. London. Improvements in electrical measuring and signalling instruments.

10,490. J. PLATT. Cleckheaton. Improvements in the method of and apparatus employed for heating steel wire by electric currents.

10,515. W. H. FLEMING. London. Improvements in dynamo brushes. [Date applied for under Patents, &c., Act, 1883, Sec. 103, November 13, 1893, being date of application in United States.]

May 31, 1894.

10,565. S. P. THOMPSON. London. Phase transformers for electric currents.

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10,586. G. C. LUNDBERG. London. Improvements in wall-sockets for electric lighting.

10,590. THE EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY (LIMITED) and C. F. PROCTOR. London. A combined switch and holder for an electric glow-lamp.*

10,594. M. FRANK. London. Improvements in or in connection with magneto-electrical telephones.*

June 1, 1894.

10,634. J. W. ROGERS. London. Improvements on arc lamps.

10,658. F. W. GOLBY. London. Improvements in electric chimes. (A. Neumann, Germany.)*

10,659. F. W. GOLBY. London. Improved apparatus for the suspension of incandescent electric lamps. (A. Neumann, Germany.)*

10,660. F. W. GOLBY. London. Improvements in or relating to incandescent electric lamps. (A. Neumann, Germany.)*

10,672. C. HAMPEL. Liverpool. An improved device for casting electric accumulator plates.

10,687. L. BOREL. London. An improved electric fire alarm apparatus.

10,701. C. S. SNELL. Saltash. Improvements in electrical connections for marine purposes.

June 2, 1894.

10,745. J. CARRUTHERS. Brighton. A continuous magnetic motor.

June 4, 1894.

10,798. W. W. MCLAUCHLAN. Manchester. Improvements in the lighting, and in lamps used in coal mines, and the like, by electricity.

10,803. W. THOMSON and A. E. MAVOR. Manchester. Improved means for waterproofing fabrics, paper, and the like, and for insulating electrical conductors.

10,823. A. F. B. GOMESS. London. A new or improved process for the extraction of aluminium from certain clays by electrolysis.

10,851. H. H. LAKE. London. Improvements in electric railway signals. (F. Beattie, United States.)*

10,853. J. Y. JOHNSON. London. Improvements in electrical accumulators or storage batteries. (La Société L'Accumulateur Fulmen, France.)*

June 5, 1894.

10,917. S. Z. DE FERRANTI. London. Improvements in electric safety fuses or cut-outs.

10,952. C. HOEPFNER. London. Improvements in electrodes.

June 6, 1894.

10,967. J. H. TUCKER. Birmingham. Improvements in electrical switches.

10,978. W. T. GOOLDEN and S. EVERSHED. London. Improvements in electric measuring instruments.

11,022. S. Z. DE FERRANTI. London. Improvements in alternate-current rectifiers and apparatus connected therewith.

June 7, 1894.

11,059. H. A. ROWLAND. London. Methods of, and apparatus for, varying the frequency and number of phases in a polyphase electric current, and for converting alternating electric currents into continuous currents, and for other purposes.

SPECIFICATIONS PUBLISHED.

NOTE.—All Specifications can now be obtained at the uniform price of 8d. each.

1893.

9,397. GARRARD and BLUMFIELD. Electro-motors, &c.
9,906. FITZGERALD. Voltaic batteries, &c.
10,129. EDMUNDS. Electrical conductor.
10,218. WOOD. Distribution of electricity, &c.
10,298. SAYERS. Dynamo-electric machines.
10,788. PARSONS. Generation of electricity.
10,993. SCIAMA. Electric search light.
11,184. SIEMENS BROS. AND CO. (LIMITED). (Morgan and another). Electrical communication.
11,749. WOAKES. Heating liquids by electricity.
12,139. HUTIN and LEBLANC. Electric machines and transformers.
12,314. FRICKER. Electrically illuminated signs.
12,702 HARDINGHAM (Felten and Guilleaume). Electric cables.
12,786. NEW and MAYNE. Electric arc lamps.
12,850. BROCQ. Counter of electricity.
13,064. THOMPSON. Electric cables.
13,218. LITHANODE AND GENERAL ELECTRIC COMPANY (LIMITED) and NIBLETT. Secondary electric batteries.
13,274. ROUSSEAU. Plates for electric accumulators.
13,339. LAKE (Girard and another). Carbon.
13,340. LAKE (Girard and another). Electric furnaces.
13,469. ASPINALL. Electrical railway signals.
13,647. MENGES. Galvanometers.
13,792. CLARIOT. Electric switches.
23,902. HALL. Electric motors.

1894.

2,048. VOIGTLÄNDER. Dynamometers.
2,866. WISE (Lewis). Dynamo-electric machines.
3,108. LEFFLER and CORRIGAN. Electric railways.
4,244. DICKINSON. Overhead electric tramways.
5,474. DAVY. Electric arc lamps.
5,816. LAKE (Weston). Electrical measuring instruments.
5,971. ADAMSON. Using electric light for photography.
6,491. PITT. (Blondel and others.) Converting electric currents.
6,606. ALLISON. (Electrical Specialty Company.) Controlling electric lights.
7,215. MAGNIN. Electric printing telegraph apparatus.
7,307. BALBIANI. Electrical alarm.
7,617. COX. Thermo electric generators.

NEW COMPANIES. STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1894, pages 274-300, *&c., &c.*]

CENTRAL CHILI COPPER COMPANY (LIMITED).—This Company was registered on June 15th with a capital of £255,000 divided into 30,000 £6 per cent. Priority and 225,000 Ordinary shares of £1 each, to carry into effect an agreement made between the Panulcillo Copper Company (Limited), Sir John Pender, G.C.M.G., M.P., Francis J. Johnston, and Frank W. Bond, the liquidators thereof, and the present Company, for the sale to this Company of the goodwill of the business and all the assets of the said Panulcillo Copper Company (Limited), and to carry on the business of raising, crushing, smelting, washing, reducing, amalgamating, working and winning ores, metals, minerals, and mineral substances of all kinds. The first Directors are: Sir John Pender, G.C.M.G., M.P., Eugene A. J. Goldschmid, and J. H. Collins, F.R.S.

GOWERTON FOUNDRY COMPANY (LIMITED).—This Company was registered on June 14th with a capital of £10,000 in 200 shares of £50 each, to acquire the business of engineers carried on at the Gowerton Foundry and Engineering Works, Gowerton, near Swansea, South Wales, under the style or firm of "Henry Marker and Son," and to carry on the business of mechanical, electrical, and general engineers, manufacturers of and dealers in electric light fittings, art metal workers, fitters of electric bells, telephones, signalling apparatus and appliances, &c.

HEMMING AND COMPANY (LIMITED).—This Company was registered on June 12th with a capital of £25,000 in £5 shares to acquire and take over on and from January 31st the business of T. L. Hemming and Company (Limited), of 88, Snow-hill, Birmingham, and to carry into effect an agreement dated May 14, 1894, between T. L. Hemming and Co. (Limited), Thomas L. Hemming, and Stephen Wright, and to carry on the business of mechanical, chemical, electric, scientific, and general engineers, electricians, designers, and constructors, illuminating contractors, manufacturers of and dealers in iron, steel, brass, and other metals, manufacturers of all kinds of machinery, engines, motors, dynamos, electric appliances, &c. The first Directors are John Thornton, Thomas L. Hemming, Samuel Tonks, Charles T. Bishop, and Thomas R. Canning.

LLANDUDNO ELECTRIC SUPPLY COMPANY (LIMITED).—This Company was registered on June 18th, with a capital of £15,000, in £10 shares, to carry on within the district of the Llandudno Improvement Commissioners the business of an electric supply company in all its branches; and to carry on the business of electricians, mechanical engineers, suppliers of electricity for the purposes of light, heat, motive power, or otherwise, and dealers in electrical apparatus, &c. The subscribers (with two shares each) are:—Richard Conway, John Bellis, John Smith, James Nicol, William E. Jones, W. R. Nicol, and W. Arnold (all of Llandudno).

ARTHUR LEE AND SONS (LIMITED).—This Company has been registered with a capital of £30,000, in £10 shares, to acquire the business hitherto carried on by James Fairbrother and Co. (Limited), steel converters and refiners, wire drawers, &c., and to develop and extend the same.

F. H. ROYCE AND CO. (LIMITED).—This Company was registered o June 14th, with a capital of £30,500, divided into 30,000 Ordinary and 500 Deferred shares of £1 each, to acquire and take over as a going concern the business carried on by Frederick H. Royce and Ernest A. Claremont, under the style or firm of F. H. Royce and Co., at Cooke-street, Hulme, Manchester, and generally to carry on the business of manufacturing electricians and mechanical engineers. The subscribers, with one share each, are:—Frederick H. Royce, Ernest A. Claremont, A. W. Claremont, John de Looze, Mrs. Edith Claremont, Mrs. M. G. Royce, and F. Himus. The first Directors are Frederick H. Royce and Ernest A. Claremont, who are also managing Directors, and who may remain in office so long as they are willing to act.

RONALD A. SCOTT (LIMITED).—This Company was registered on June 15th, with a capital of £10,000, in shares of £1 each, to acquire the goodwill, machinery, rights, privileges and other property of Ronald A. Scott, of Acton Hill, in the county of Middlesex, and to carry on the business of electricians, mechanical engineers, electrical engineers and general contractors, and such other business as the Company may from time to time determine. The subscribers (with one share each) are:—Ronald A. Scott, Mrs. Annie Scott, Godfrey Wolley, George Heaver, James H. Garratt, T. H. J. Watts, and James Darner. The business of the concern is to be carried on by a manager or managers, the first of whom is Ronald A. Scott.

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KERBEY BOWEN (LIMITED).—The statutory return of this Company, made up to January 30th, was recently filed. 956 shares, out of a nominal capital of £20,000, in £10 shares, have been taken up, and of these 800 have been issued as fully paid to Kerbey D. Bowen, electrical engineer and electric launch manufacturer, of 55, Regent-street, London, W., whose business has been acquired by the Company. Upon the remaining 156 shares the full amount has been called, resulting in the payment of £1,500, and leaving £60 in arrears.

LANCASHIRE AND YORKSHIRE ELECTRIC LIGHTING COMPANY (LIMITED).—The annual return of this concern, made up to July 12, 1893, was recently filed. Out of a nominal capital of £100,000, in £5 shares, 127 have been taken up. Upon each of these calls amounting to £2. 10s. per share have been made, resulting in the payment of £315, and leaving £2. 10s. in arrears.

NATIONAL ELECTRIC SUPPLY COMPANY (LIMITED).—The annual return of this Company, made up to March 14, 1894, has just been filed. The nominal capital is £100,000, divided into 100 Founders' and 19,900 Ordinary shares of £5 each. All the Founders' and 10,505 Ordinary have been taken up, and the full amount called, resulting in the payment of £53,010, and leaving £15 in arrears.

OGMORE VALLEY ELECTRIC LIGHT AND POWER SUPPLY COMPANY (LIMITED).—The annual return of this Company for 1893, made up to March 25, 1893, was recently filed. Out of a nominal capital of £10,000 in £5 shares, 634 shares have been taken up, and the full amount called on each, resulting in the payment of £2,287. 10s., and leaving £882. 10s. in arrears. The annual return for 1894, made up to March 27, 1894, was filed with the foregoing; 710 shares have been taken up, and the full amount called. The calls paid amount to £3,313, leaving £237 unpaid.

ORME'S ELECTRIC SIGNAL SYNDICATE (LIMITED).—The statutory return of this Company, made up to November 16, 1893, was filed on April 6, 1894. Out of a nominal capital of £7,500, in £1 shares, 6,350 have been taken up, of which 6,000 were issued as fully-paid to John Orme, in consideration for Patent No. 20,742 of 1891, and Provisional Patent No. 3,518 of 1893, granted to him for inventions relating to "electric and automatic signals." Upon the remaining 350 shares the full amount has been called and paid.

OSWESTRY ELECTRIC LIGHTING AND POWER COMPANY (LIMITED).—In explanation of their failure to file the required return, a letter from W. W. Coulson, of Oswestry, writing on behalf of the Company on June 9, 1894, states that pending the granting of the Provisional Order no allotment has been made.

OXFORD ELECTRIC COMPANY (LIMITED).—The annual return of this Company, made up to March 24, 1894, has just been filed; 6,586 shares have been taken up, out of a nominal capital of £100,000 in £5 shares. Upon each of these shares the full amount has been called, resulting in the payment of £32,930. The Electric Construction Company (Limited), of Queen-street-chambers, Queen-street, London, E.C., hold 6,401 shares, while 25 shares are held by residents of Oxford.

WATERHOUSE ELECTRO-METRIC SYNDICATE (LIMITED).—The statutory return of this Company, made up to December, 15, 1893, was filed on June 13th. The Company has a nominal capital of £20,000, divided into 1,000 Vendors' and 1,000 Ordinary shares of £10 each, of which 1,000 Vendors' and 260 Ordinary have been taken up. All the Vendors' shares were issued as fully-paid to Addison G. Waterhouse, electrician, of 127, Cromwell-road, London, S.W., and A. T. Salisbury-Jones, of 33, Old Broad-street, London, E.C., as part payment for certain patented inventions relating to the controlling and measuring of electricity sold to the Company. Upon the 260 Ordinary shares the full amount has been called, resulting in the receipt of £1,600, leaving £1,000 unpaid.

WILLANS AND ROBINSON (LIMITED).—An agreement dated May 7, 1894 (filed the following day) between Willans and Robinson (Limited), incorporated in 1888 (referred to as "the old Company"), and John Baker, of Billiter House, Billiter-street, London, E.C., the liquidator of the old Company, and the new Company, provides for the allotment as fully paid of 14,462 Ordinary shares of £5 each, Nos. 8 to 14,469 inclusive, and 14,463 £6 per cent. Cumulative Preference shares of £5 each, Nos. 30,001 to 44,463 inclusive, to the members of the old Company, in accordance with the Reconstruction Agreement dated March 9, 1894.

CITY NOTES.

AFRICAN DIRECT TELEGRAPH COMPANY (LIMITED).—The coupons on this Company's Four per Cent. Mortgage Debentures to bearer, due July 1st, will be paid on and after July 2nd, at Parr's Banking Company and the Alliance Bank (Limited), Bartholomew-lane, London, E.C. Coupons must be left three days for examination. The debenture register will be closed from the 25th to the 30th inst. inclusive.

ANGLO-PORTUGUESE TELEPHONE COMPANY (LIMITED).—This Company notifies that Coupons No. 13 of the First Mortgage and No. 8 of the Second Mortgage Debentures will be paid, less income-tax, by Parrs' Banking Company and the Alliance Bank (Limited) on and after 2nd prox.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).—The coupons on this Company's second issue of Five per Cent. Debentures, due on the 30th inst., will be paid on and after that date at Parr's Banking Company and the Alliance Bank (Limited), Bartholomew-lane, London, E.C. Coupon must be left three days for examination.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended June 17th were £831, as against £782 in the corresponding period of 1893, being an increase of £49. The total receipts for the half-year amount to £21,754, as against £21,035 for the corresponding period of 1893, an increase of £719.

CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).—The transfer books of the 5 per cent. redeemable debenture stock of this Company will be closed from the 23rd to the 30th inclusive, for the purpose of preparing interest warrants.

EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY (LIMITED).—Notice is given that an extraordinary general meeting of this Company is to be held at the Cannon-street Hotel, E.C., on Tuesday, July 3rd, at 12:15 o'clock, to consider and pass the resolution adopted at the meeting of the Swan United Company last week.

GREAT NORTHERN TELEGRAPH COMPANY.—The coupons of this Company's shares falling due on July 2nd will be paid by Messrs. C. J. Hambro and Son, of 70, Old Broad-street, London, E.C., on and after that date. Coupons should be left three days for examination.

GULCHER (NEW) ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—An extraordinary general meeting of this Company was held on Tuesday last at Winchester House, Old Broad-street, E.C., Mr. D. De Castro presiding. The Secretary (Mr. T. C. Morgan) having read the notice calling the meeting and the minutes of the previous meeting, the Chairman said that the shareholders had been brought together to confirm the resolutions passed at the extraordinary general meeting of the Company held on June 4th for the purpose of winding up the Company voluntarily and of appointing Mr. Charles Fitch Kemp liquidator. He, therefore, without further comment, proposed that those resolutions should be confirmed. A shareholder seconded the motion, which was agreed to unanimously, and the proceedings ended.

HOBART ELECTRIC TRAMWAY COMPANY (LIMITED).—The first annual general meeting of this Company is to be held at the offices, College-hill Chambers, Cannon-street, E.C., on Wednesday, the 27th inst., at 2:30 p.m.

HUMPHREYS (LIMITED).—The Directors of this Company have declared a half-yearly dividend of 7 per cent. per annum on the Preference shares, and 10 per cent. on the Ordinary shares, carrying forward £2,000. The reserve fund now amounts to £10,000.

MEDICAL BATTERY COMPANY (LIMITED).—The creditors, shareholders, and debenture-holders of this Company have held a meeting at the Inns of Court Hotel, London, W.C., to consider a scheme of arrangement whereby the business is to be carried on in future. Mr. Warley (the Assistant-Receiver in the liquidation proceedings) presided, and Mr. Jerome gave details of the scheme, from which it appeared that a new company is to be formed under the style of the Medical Electrical Institute (Limited), or similar name, with a capital of £75,000 in 25,000 £1 Preference shares and 20,000 Ordinary shares of £2. 10s. each, with power to increase or reduce this number. The Preference shares are 7 per cent., and are to be issued to creditors of the Medical Battery Company in payment of their claims. The new Company is to take over all assets and such sum of money as may be in the hands of the Receiver for the debenture-holders, after deducting certain costs and expenses. Six Directors are to be appointed—two to be creditors' representatives. In the event of another winding up being necessary the creditors are to have a first charge on the assets. Mr. Jerome stated that the business had been carried on recently, and had just paid expenses. But it had only been continued for the purposes of realisation, and in order to complete existing contracts. No attempt had been made to carry on the business in the ordinary sense of the term, and the wares had not been advertised in any way. If the scheme were approved the business could be resuscitated, and carried on in a manner that would defy further attacks. On the methods by which these attacks are to be defied, and on the style of business to be carried on in future the scheme was, so far as we can discover, silent; and it will be a gross scandal if the Harness quackery is to be continued under a scheme which has, presumably, the sanction of the authorities of the Bankruptcy Court. A creditor wished to move a vote of confidence in, and sympathy with, Mr. Harness, but was ruled out of order, and no such resolution was put. Resolutions were, however, passed at each meeting unanimously accepting the scheme; and it therefore appears likely that another crusade will be necessary before electrical science will be rid of this attempt to associate its name with the "electropathic" belt business. Unless some radical change in the method of doing business is contemplated by the new Directorate, it should not be difficult for, say, the Institution of Electrical Engineers or the British Medical Association to obtain an injunction against the use of the name selected for the reconstructed company, which will undoubtedly be more misleading to the general public than the original company was proved to have been.

PACIFIC AND EUROPEAN TELEGRAPH COMPANY (LIMITED).—The coupons in this Company's Four per Cent. Guaranteed Debentures, due 30th inst., will be paid on and after that date at Parr's Banking Company and the Alliance Bank (Limited), Bartholomew-lane, London, E.C. Coupons must be left three days for examination.

WEST COAST OF AMERICA TELEGRAPH COMPANY (LIMITED).—The coupons due on June 30th on the debentures of this Company will be paid by Messrs. Barclay and Co., Lombard-street, E.C. Coupons should be left two clear days for examination.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended June 15th (after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited), were £2,379.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the two weeks ending June 15th were £2,181, as compared with £2,719 for the corresponding period of last year. The receipts for February, estimated at £4,946, realised £4,942.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share	Last Dividend.	Name.	Previous Week's Price, June 13.		Price Wednesday, June 20.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending June 20.	
			TELEGRAPHS.					£ s. d.		Highest	Lowest
£1,012,880	Stock	9 0	Anglo-American	43	45	40	42	5 13 1	Jan., Apr., July, Oct.	..	..
£2,933,560	Stock	18/0	Do. Preferred	82½	83½	76	77	6 3 5	" "	81¾	77
£2,933,560	Stock	5/0	Do. Deferred	7½	8	7	7⅛	..	.. ..	7 1/16	..
£184,500	100	4%	African Direct Telegraph 4% Deb. (Reg. & Bearer)	102	105	102	105	3 16 2	January and July	..	..
130,000	£10	3/0	Brazilian Submarine	12	12½	12¼	12¾	5 2 0	Mar., June, Oct., Dec.	12½	12⅜
£18,700	£100	5%	Do. 5 per Cent. Bonds	101	104	101	104	4 16 2	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	109	113	109	113	4 8 6	June and December	.	..
10,000,000	$100	$1¾	Commercial Cable Capital Stock xd	140	145	139	143	4 17 11	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	12	13	12	13	6 3 1	February and August	12⅜	..
6,000	10	10%	Do. Preference 10 per Cent.	18	19	18½	19½	5 2 7	.. ..	..	..
12,931	5	1/7½	Direct Spanish (fully paid)	4	4½	4	4½	4 8 11	April and October	..	–
6,000	5	10%	Do. Preference 10 per Cent.	9	9½	9	9½	5 5 3	" "	..	–
60,710	20	2/0	Direct United States Cable, 1877	9¼	10¼	9¼	9¾	6 3 1	Jan., Apr., July, Oct.	..	..
400,000	10	2/6	Eastern	15	15½	15	15½	4 5 3	" "	15¼	15
70,000	10	6%	Do. 6 per Cent. Preference	15¾	16½	15¾	16¼	3 13 10	" "	16 1/16	16
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	113	116	113	116	3 9 0	May and November	114	..
£102,100	100	5%	Do. 5 per Cent. Debentures, 1899	107	110	107	110	4 10 11	February & August	..	..
250,000	10	6/6	Eastern Extension	15⅝	15⅞	15⅝	15⅞	4 8 2	Jan., Apr., July, Oct.	15⅞	15⅝
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	114	118	114	118	3 7 10	February & August	–	..
£62,700	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	105	108	105	108	4 12 7	January and July	–	..
£95,100	100	5%	Eastern and S. African 5 per Cent. Mor. Deb., 1900	105	108	105	108	4 12 7	" "	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures, 1909 (regd.)	105	108	105	108	3 14 1	February & August	106½	..
£200,000	£25	4%	Do. 4% Mauritius Sub. Debs.	107%	110%	107%	110%	3 12 9	May and November	..	..
180,227	10	2/6	Globe Telegraph and Trust	9	9½	8⅝	8⅞	4 10 2	Jan., Apr., July, Oct.	9 3/16	8¾
180,042	10	6%	Do. 6 per Cent. Preference	15⅓	15⅝	15⅓	15¾	3 18 1	" "	15⅝	15½
150,000	10	7/2	Great Northern	21	21½	21	21½	3 19 1	Jan., April, and July	21¼	..
£190,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	105	108	105	108	4 12 7	March & September	106	..
17,000	25	37/6	Indo-European	43	45	43	45	5 11 1	May and November	..	..
37,548	10	5/0	London Platino-Brazilian	5	7	5	7	..	.. ..	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	107	110	107	110	5 9 1	March & September	..	..
£100,000	£100	4%	Pacific European Tel. 4% Guar. Debs. "Red" 1942	103	103	103	106	3 15 6	.	..	..
11,839	8	4/0	Reuter's	5	6	5	6	..	April and October	..	..
3,381	£100 Cert.	35/0	Submarine Cables Trust 6 per Cent.	112	117	110	115	5 4 4	" "	112	..
15,609	10	5/0	West African Telegraph	3	5	3	5	..	January and July	..	..
£249,900	100	5%	Do. 5 per Cent. Debentures	102	105	102	105	4 15 3	March & September	..	..
30,000	10	2/0	West Coast of America	2½	3	2½	3	.	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	100	105	100	105	7 12 5	June and December	..	..
88,321	10	9d.	West India and Panama	1⅓	1¾	1⅓	1⅝	..		1½	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10½	10¾	10	10½	5 14 3	May and November	10½	10½
4,669	10	6%	Do. 6 per Cent. 2nd Preference	9	10	9	10	6 0 0	" "	..	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	109	112	109	112	4 9 3	June and December	..	–
64,242	15	7/6	Western and Brazilian	6¾	7½	6¾	7½	..	May and November	6¾	..
33,129	7½	7/6	Do. 5 per Cent. Cumulative Preferred	6	6½	6	6½	..	..	..	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	2	2½	2	2½	..	..	..	..
£171,900	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	107	110	107	110	5 9 1	February & August	..	..
£214,800	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	107	110	107	110	5 9 1	" "	..	..
$1,211,000	$1,000	7%	Western Union 7% 1st Mort. (Building) Bonds	111	115	111	115	6 1 9	May and November	..	..
£166,900	£100	6%	Do. 6 per Cent. Sterling Bonds	100	104	100	104	5 15 5	March & September	..	..
			TELEPHONES.								
44,000	5	10/0	Chili Telephone (fully paid)	1½	2½	1½	2½	..	..	..	..
224,850	10/0	2⅝d.	Consolidated Telephone Const. & Maintenance xd	1/16	3/16	1/16	3/16	..	May and November	..	..
171,504	£1	6d.	Oriental Telephone and Electric (fully paid)	½	⅝	½	⅝	..	Yearly	..	..
484,597	5	2/6	National	4⅞	5⅜	5	5½	4 15 3	June and December	5 3/16	5
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	15	16	15	16	3 15 0	" "	15¼	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	14½	15½	14½	15½	3 17 5	" "	..	..
119,234	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	5½	5¾	5⅝	5⅞	4 5 1		5¾	5 11/16
1,000,000	Stock	4½%	Do. Debenture Stock, 4½%	115	117	112	115	3 18 3	January and July	114¾	113
58,000	5	1/0	United River Plate	1½	2	1½	2		" "	..	..
£146,733	Stock	5%	Do. 5 per Cent. Debenture Stock	90	100	90	100	5 0 0	" "	..	–
			ELECTRICITY SUPPLY COMPANIES.								
40,000	£10	..	City of London Electric Lighting (fully paid)	12	13	12	13	..		12⅝	..
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	13½	14	13½	14	4 5 9	..	14	13⅜
19,900	£5	..	Electricity Supply Co. for Spain	..		..		..	..	..	..
£30,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	4½	5½	4½	5½	..	..	..	..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	..		..		–	..	..	..
8,322	£5	..	House-to-House Electric	..		..		..	..	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	..		..		–	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..		..		–	..	..	..
5,523	£5	1/9	Liverpool Electric Supply (£4. 10s. paid)	..		..		–	January and July	..	–
39,477	£5	2/6	Do. (fully paid)	6¾	6¼	6¾	6¼	–	..	..	..
111,000	5	..	London Electric Supply	¾	¾	¾	¾	–	..	..	..
149,900	£10	5/0	Metropolitan Electric Supply (fully paid)	8½	8¾	8½	9	2 15 7	..	8⅞	8⅝
£100,000	Stock	5%	Do. 5% Debs. (Bonds of £10, £20, and £40)	107	110	107	110	4 10 11	June and December	–	..
6,452	£10	..	Notting Hill Electric	4½	5½	4½	5½	–	.	–	..
19,980	£5	4/6	St. James and Pall Mall	7	7½	7	7½	..	..	7⅝	–
20,000	£5	7%	Do. 7 per Cent. Preference	8¼	8¾	8¼	8¾	4 0 0	..	8⅝	..
59,900	5	2/6	Westminster Electric Supply (fully paid)	6¼	6¾	6¼	6¾	2 19 3	..	6⅝	6 1/16
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
90,000		1/6	Brush Electrical Engineering	2¾	3	2¾	3	6 0 0		2¾	..
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	2⅛	2⅝	2⅛	2⅝	5 1 1	..	2⅛	2 1/16
£125,000	Stock	4½%	Do. 4½ per Cent Debentures	108	111	109	112	4 0 4	March & September	110	..
20,000	5	2/6	Crompton and Co., 7 per Cent. Cumulative Pref.	3	3½	2¼	3½	–	January and July	..	..
12,139	5	..	Edison and Swan United	–		–		..	..	–	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	..		–		..	..	–	–
120,000	2	..	Electric Construction	¾	¾	¾	¾	..	–	–	–
12,845	2	..	Do. 7 per Cent. Cumulative Pref.	1½	1¾	1½	1¾	..	–	..	–
91,195	2	10/0	Elmore's Patent Copper Depositing	1⅛	1⅜	1⅛	1⅜	..	–	1 1/16	..
20,000	5	..	Fowler-Waring Cables (fully paid)	¾	1½	¾	1½	–	..	..	..
50,000	10	15/0	India Rubber, Gutta Percha, &c., Works	23	24	23½	24½	5 2 9	February & August	24	23¾
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103	105	103	105	4 5 9	March & September	104¾	–
15,995	£10	6/4	International Okonite Ordinary	..		..		..	–	–	–
16,000	£10	..	Do. 8 per Cent. Preference	–		–		–	December and June	–	–
20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	–	⅞	–	⅞	..	..	–	..
78,949	5	3/6	Swan United (£3 10s. paid)	2	2¼	2	2¼	7 0 0	May and November	2⅓	2
37,350	12	36/0	Telegraph Construction and Maintenance	39	41	39	41	5 17 1	March and July	41	39¾
£150,000	100	5%	Do. 5 per Cent. Bonds	104	107	104	107	4 13 6	January and July	–	–
37,514	£5	–	Woodhouse and Rawson Ordinary (£3 15s. paid)	–		–		..	..	–	–
41,098	£5	–	Do. Preference (fully paid)	–		–		..	–	–	–
			RAILWAYS AND TRAMWAYS.								
£630,000	Stock	5%	City and South London Railway	36	38	36	38	1 16 2	May and November	37	36½
£67,130	Stock	4%	Do. 4% Perpetual Debenture	119	121	119	121	3 6 2	May and November	119	..
7,000	10	5%	Do. 5% Perpetual Preference	12	12½	12½	13	3 16 11	..	12¾	12½
37,500	£10	1%	Liverpool Overhead Railway	8½	8½	8 1/16	8 7/16	..	..	–	–
6,29	10	5%	Do. 5% Preference	12¾	13½	12¾	13½	3 15 6	..	..	..
£125,000	Stock	4%	Do. 4% Debenture	112	114	112	114	3 10 2	January and July	–	–

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

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NOTES.

In a leading article in our issue of March 9th we adverted to the then recent decision of the London County Council, that all loans made to the London vestries for electric lighting purposes should be repaid within a period of 25 years; and we pointed out that there were one or two sound reasons for, and advantages in, adopting this course. The stand made against this policy by the would-be parochial borrowers has, however, already induced the County Council to throw over its own Finance Committee, and adopt the 42-year period of repayment in the case of the Hampstead Vestry loan. The immediate result of this step ought certainly to be an appreciable reduction of the price of the metropolitan municipal unit; that is to say, if parochial management be really all that it is claimed to be.

One of our leading articles this week discusses some modern views on the theory of electro-chemistry, in relation to an interesting Paper by Prof. Ostwald, which we also publish. We cannot refrain from noticing one or two practical matters in this Paper, which, though aside from theory, are worthy of attention. Prof. Ostwald, while throwing new light upon the phenomena of primary batteries, has pointed out the direction from which the successful commercial primary battery must be expected to come. It must be a battery developing electrical energy from carbon without the intervention or aid of any heat transformations. Prof. Ostwald's advice amounts to a recommendation to renounce the heat engine and all its works. Advocates of primary batteries, as they exist at the present time, sometimes argue that, although these batteries consume zinc, they really consume carbon or coal, since coal is used in the manufacture or recovery of the zinc. They therefore claim that a zinc battery is in reality a carbon engine. Such a battery, however, is not a carbon engine in Ostwald's sense, for it involves a relation between the zinc and the fuel which is not independent of heat, and which must therefore suffer from those defects and that inefficiency from which heat-energy operations are inseparable.

On the other hand, those who are inclined to disparage the claims of the primary battery, *per se*, as an electric engine should look to the ground beneath their feet to make sure that it is not too thin. The absence of the carbon engine, in the Ostwald sense, rests entirely upon the accident of certain chemical relationships remaining yet undiscovered. No one believes that their discovery is a physical impossibility. At the same time, Prof. Ostwald himself admits that he has no presage of the practical solution. It is far easier to say what Jablochkoff should not have done than to indicate what he ought to have done. The best that can be done is to indicate a parallel. But parallels, where the first term is a Bunsen cell and the third term a hypothetical carbon engine, do not advance the practical side of the question very much. Nevertheless, the question is one the solution of which involves great issues, industrial and social; and we quite agree with Prof. Ostwald in thinking that "had we a cell in which electrical energy was produced by the direct oxidation of carbon with an output approaching the theoretical, we should be on the brink of an industrial revolution, compared with which the invention of the steam engine sinks into insignificance." Such a cell should yield nearly six H.P. hours, or four electrical supply units per pound of carbon which opens up a potentiality of cheapness beyond the dreams even of Mr. Preece.

The article by Mr. Kennelly which we publish this week is a useful contribution to the methods of calculation at present available for alternate-current problems. The treatment of vector quantities in the manner described has been long known to mathematicians, but Mr. Kennelly has been the first to show the applicability of the method to such problems as the one here considered. Fortunately, the majority of alternate-current problems, when mathematically considered, are not found to involve the hyperbolic functions or a number of vector qualities. As a rule, it is quite sufficient to consider the two components of these vectors in phase and in quadrature with the current, and in such cases the complication introduced by having to consider not only the magnitude of the vector but its phase angle can be avoided. But when, as in the present problem, a large number of vectors is involved, the method of Mr. Kennelly is very useful, and the signs which he has introduced to denote the phase angle of any vector are most convenient. As regards the result in the present problem, it is interesting to see that, as nearly always happens when alternate-current problems are attacked numerically, it is possible to reduce the formulæ to a comparatively simple form, owing to the fact that when the complicated functions are examined, and their relative values are considered, it is seen that they can, for the most part, be neglected.

It may be objected to the synchronising method invented by Mr. J. W. Jones, and described by him in another column

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that the Aron meters to which it has been successfully applied are almost out of date. A new Aron meter with short pendulums and an automatic starting and driving-gear has been introduced, but a large number of the old instruments are in daily use, and form a serious item in the plant of the supply companies, though one which earns a steady and handsome revenue. Pending the long-delayed pronouncement of the Board of Trade as to the types of meter which will succeed in obtaining certificates, the supply companies are at liberty to put any kind they please into the consumers' houses, and the longer the official decision is postponed the more difficulties are likely to arise as to the use of meters which have failed to meet with approval. Whether the old type of Aron is likely to be approved or no is of small importance compared with the efficient maintenance of a stock of many hundreds. The objection to the periodic winding is not so great as inventors of motor meters would have us believe. The range is pretty good, and the serious fault is the slow movement, which is not infrequently produced by slight want of synchronism of the pendulums, resulting in a false registration on the dials. That a meter should be liable to record a few pennyworths of current per quarter, when no current whatever had been passed, has been regarded as a more serious fault than an error of 5 or 10 per cent. on an average load. Mr. Jones's remedy is an extremely simple one, and possesses several points of interest which have not been touched upon in his article. Two pendulums slightly out of synchronism, if thus magnetically yoked together, vibrate with a continually altering difference of phase gradually attaining a maximum, and then reversing, never exceeding a certain amount. The mean period of each pendulum taken over a considerable number of beats is identical. If not thus yoked, the phase would continuously and progressively alter.

The claim which is advanced, that the most unique and striking feature of the "S.K.C." motor system—which we describe this week—is the use of condensers, may be justifiable enough in regard to American practice; but it certainly is not true that the use of the condenser in this system has any novelty when European as well as American practice is considered. Continental and British manufacturers long ago used electrostatic condensers in conjunction with alternate-current motors; and some of these makers have advanced a step further — they have abandoned them. The necessity for a condenser, or some other device to prevent the "false currents" or "wattless amperes," as they are variously called, from surging in and out of the line and making everybody's lights pump, is rather a confession of an inherent weakness in this type of motor. People, of course, do not want their lights to pump whenever a motor is started on the mains; but neither do the users of small motive power care to be bothered by all the trouble and inconvenience, and the extra cost of getting and maintaining this form of starting gear. What is required, and what would suit every party, is a type of motor which has not this electrical defect of what Artemus Ward would call "slopping over." Perhaps, if the motor must "slop over," electrically speaking, it is better that it should do so into a convenient condenser than into the neighbouring lamp leads.

A representative of the *Pall Mall Gazette* has been interviewing Prof. George Forbes on the subject of the Niagara power scheme. The Professor is thoroughly sanguine about the success of the scheme and the revolutionary influence it will exert upon the industrial features of the locality. Already the requests for the supply of power "come in from places as far distant as Albany, 350 miles away on the Hudson river." Perhaps this affords an explanation of the anxiety of some American mathematicians to find out how far the power of Niagara may be commercially transmitted, they want to see if they can reach that customer in Albany. Prof. Forbes and his colleagues have determined to make a solid job of their engineering works. "The massiveness of the masonry would stagger you." But, recognising that the old order changeth, giving place to the new, they have refrained from "building for eternity," as the Americans say we do with our railways. They have not designed their structures "to last much longer than 2,000 years." The "much longer" is delightful. In about that time—3,894 A.D., to wit—Nature will have done her little solid job, and will have eaten away the foundations of all that staggeringly massive masonry. For our own part we shall be relieved when the period of talk and interviewing is past, and glad when the two-phase alternators are generating energy to be delivered at Buffalo and elsewhere at a rate appreciably less than it can be obtained in the usual way. Then, and not before, engineers all over the world will be ready to recognise the commercial and engineering greatness of the Niagara scheme.

Royal Institution.—The general monthly meeting will be held on Monday next, at 5 p.m.

"Our Postal Telegraphs."—Mr. W. H. Preece is contributing a series of papers to *You and I* under the title of "Our Postal Telegraphs: The Wonderful Story of their Development."

Legalising Electrical Units.—The American House of Representatives has passed the Bill legalising the Chicago "international" ohm, volt, ampere, coulomb, farad, joule, watt, and henry.

Obituary.—The death is announced of M. Edmond Carré, who was the first to manufacture the hydraulically squirted electric light carbons invented by his brother, M. Ferdinand Carré.

Lux in Tenebris.—A German police regulation is said to read as follows:—"From the beginning of darkness every vehicle must have a lighted lantern. Darkness begins when the street lamps are lighted."

Electric Traction in Brussels.—The electric tramway in Brussels, which has been constructed by the Union Company in Berlin on the Thomson-Houston overhead-conductor system, was opened for traffic a few days ago.

British Association.—At a recent meeting of representatives of the principal educational bodies and other institutions in Toronto, it was unanimously decided to invite the British Association to hold a meeting there in 1897.

The Union of European Incandescent Lamp Manufacturers.—Representatives of the various glow lamp manufacturing firms held another meeting in Berlin last week, when further points as to the working of the Union were discussed.

The Telegraph in Kashmir.—The telegraphic party in Kashmir under Mr. Olphert's superintendence have crossed the passes and recommenced work, says the *Indian Engineer*, but the whole party suffered severely from snow blindness.

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Cable Interruptions: Date of Interruption.

Bissao-Bolama	Nov. 24th, 1893.
Tarifa-Tangier	June 12th, 1894.

A Central Station on the Spree.—The Allgemeine Electricitäts Gesellschaft intends to commence during the present summer the erection of a central station on the Upper Spree, to supply current for lighting and power purposes to the Berlin suburbs.

The Canadian Pacific Railway.—According to *Engineering*, the Canadian Pacific Railway propose to use electricity for moving its trains over the Rocky Mountain division of the line. The method is to be tried first at the Kicking Horse Pass, where there is ample water-power.

Electric Treatment of Leather.—According to *L'Electricien*, an electrical process of colouring leather is being tried. The hide is stretched on a sheet of metal and covered with a layer of the colouring liquid. A current is passed, opening the pores of the hide, and allowing the colouring material to soak well in.

Scarborough.—The line connecting Scarborough with York by telephone was completed last Thursday week, but it is expected that a month will pass before it will be thrown open to the subscribers. Some delay has been occasioned by a fractious landowner, who refused to permit the line to cross his property.

Electric Traction in Panama.—The electric tramway which was laid down at Panama early in 1892 continues, according to the last report of the British Consul there, in successful operation. The line is on the overhead-conductor system, and traverses the entire length of the city along the principal thoroughfares.

The Berlin-Vienna Telephone Trunk Line.—It is stated that the Austrian Postal and Telegraph Department is now busy preparing the plans for the establishment of direct telephonic communication between Vienna and Berlin. The line, which it is expected will be completed by the autumn, will run *viâ* Prague, Bodenbach, and Dresden, the total distance being about 400 miles.

Society of Arts.—According to the treasurer's statement of receipts and expenditure for the year ending May 31, 1894, the income of the Society of Arts from all sources amounted to £9,748, subscriptions and life compositions accounting for £5,847. The expenses for the same period amounted to £8,428; the principal items being office £2,818, *Journal* £2,142, conversazione £640.

Electricity and Gas in Massachusetts.—According to the report of the Gas Commissioners of Massachusetts for the year ended June 30, 1893, there are 134 concerns under the supervision of the Board. Of these, 24 supply gas and electricity, 62 only the electric light, and 48 only gas. The aggregate receipts of the gas business amounted to £1,226,466, and those of electric lighting to £687,673.

Hastings and St. Leonards.—To-morrow evening at 10 o'clock, the Mayor of Hastings will formally switch on the arc lights on the sea front, extending from the Fish Market to the end of the Marina. The ceremony is to be performed at the Hastings pier head. Up to the present only 15 arc lamps have been in use on the sea front; but the extensions which are about to be inaugurated will include some 52 lamps.

Accident to Mr. Edison.—Mr. Edison met with an accident at his residence at Ogden, New Jersey, on Thursday last week. He was sitting in the porch of his house when the back of his chair broke and he fell down four steps. His injuries were thought at the time to be trivial, but on Saturday Mr. Edison felt pains in the side and back. A medical man who was consulted said the pains were probably due to an internal injury.

The Paris 1900 Exhibition.—The Paris correspondent of *The Times* reports that at the first meeting of the 1900 Exhibition Commission a scheme of classification was read. Group IV., which is devoted to "the *Matériel* and General Processes of Mechanics," comprises steam-engines, motors, various apparatus in general mechanism and implements. Group V. deals with electricity, including the production and mechanical application of electricity, electro-chemistry, electric lighting, telegraphy and telephony.

Unconscious Newspaper Humour.—Having found that more than once since the establishment of street arc lighting in Portsmouth the thoroughfares have been left in darkness, a local newspaper observes that this is all very well as showing the advantage of the arcs over no light at all, but that constant repetition of the phenomenon is irritating. The local contemporary recommends that the matter should be "rectified."

Farewell Dinner to Mr. Kapp.—We are glad to learn that it is proposed to give a farewell dinner to Mr. Kapp, who, as we have already chronicled, has been offered, and has accepted, an important position in Germany, and will, in consequence, be leaving England in August. It is the wish of many of Mr. Kapp's friends to mark, in some suitable way, their appreciation of his services to electrical engineering, and their regret at his departure. With this object it is proposed to invite him to a farewell dinner, on Monday, July 23rd, at 7:30 p.m, to be held at the Whitehall Club, and to present him with a souvenir.

Lamp Shades.—M. Dupré returns to the charge in *The Times* this week. He is of opinion that if Messrs. Crompton had as much experience in matters relating to so-called spontaneous combustion as he has they would not be astonished at their failure to bring about the necessary conditions in what was, probably, their first attempt at experimental research. The exact conditions to bring about the spontaneous ignition of such lamp shades may be difficult to bring about experimentally, but he, M. Dupré, thinks that there can be no doubt that the case recorded in his former letter was one of spontaneous combustion.

A Self-contained Car.—According to the *Electrical Review* of New York, a "Mr. W. H. Patton is again trying to boom his car, and has formed a corporation known as the Independent Electric Traction Company. Each car is supposed to be self-contained; that is, a gas engine is placed in the centre of the car, fed with gasoline from a tank overhead, and in turn drives a dynamo that charges a set of storage cells, from which current is supplied to a motor supported on the car axles. With the addition of a compressed air motor the car would only need a compartment to hold a team of horses to be of practical, if not commercial, utility."

The Electric Light and Overtime.—At the Westminster Police Court on Monday there was a batch of prosecutions against West End dressmakers and other employers for Factory Act offences, and substantial fines were inflicted in every case. In one instance, where the summons was for having a number of women at work after eight o'clock in a room of very insufficient cubic space, the defendant, who was from Sloane-street, maintained that he ought to be exempt from the regulations as he had been to the expense of putting in the electric light, which did not vitiate the air like gas. Mr. de Rutzen would not entertain this as an excuse, and imposed a fine of 40s. and the costs.

Edinburgh.—Prof. B. W. Kennedy lectured in the Albert Hall, Edinburgh, on Monday night, on "The Electric Light in Edinburgh." The lecture was of a popular nature, and was illustrated by limelight views. Prof. Kennedy, in explaining the Edinburgh system, said there would be ten trunk mains, each one ending in fifteen branching or feeding points, from which distributing mains would run under the pavement and afford a domestic supply by means of connections. After describing the central station at Torphichen-street, he stated that four miles of the city would be lighted by arc lamps, 175 of which the Council had sanctioned. The pillars, he said, showed an artistic design which had been supplied by the School of Applied Art, and adopted by the Council.

Wood-Fibre as an Insulator.—One of the best materials yet tried for underground conduits for electric wires, says Mr. Franklin L. Pope in the *Engineering Magazine*, is wood-fibre treated with an insulating and preservative compound, so as to form a dense, hard substance. The fibre is formed into tubes of 5ft. in length, and of any diameter from 1in. to 24in. by an ingenious machine recently invented for the purpose. Couplings, fittings, and section-boxes are made of the material. The

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prepared wood is a perfect non-conductor of electricity and heat, and, when laid in the ground, is much more durable than iron, being unaffected by either acids or alkalies. One advantage, which will be appreciated by electricians, is that the material is easily cut by ordinary tools, so that joints or fittings can be inserted at any point where it is desired to connect a branch.

The City Lighting.—In a report on the works executed by the City Commissioners of Sewers, furnished by Mr. D. T. Ross, the recently-appointed chief engineer to the Commission, it is stated that the number of arc lamps now lighting in London is 479, and the total length of the thoroughfares lighted is 13 miles. There has been a proportionate reduction in the number of gas lamps lit, which is 1,315; it follows, therefore, that 2·74 gas lamps are extinguished for each arc lamp. The question as to the propriety of lighting the minor streets by the incandescent or glow lamps, and as to the relative cost of gas and electricity for that purpose, is still under the consideration of the Commission. This subject was reported upon by the late engineer at the beginning of last year. The City of London Electric Lighting Company has lighted experimentally the thoroughfares of Basinghall-street and Aldermanbury with incandescent lamps as an illustration.

Gas and Electric Light.—Mr. John West, in his Presidential Address to the Incorporated Gas Institute last week, was good enough to make some flattering remarks about electrical engineers and their influence on the standard of light required by the public. After considering some of the technical matters connected with gas lighting, the address goes on to discuss the altered circumstances of gas undertakings since the dawn of the era of cheap oil and electric lighting. There can be no doubt, says the *Journal of Gas Lighting* in its report of the address, that the influx of the able, keen, pushing engineers connected with the latter industry into the business of artificial lighting has had a marked influence upon the public with which they have had to deal. Without going so far as to say that the average electric light engineer is a smarter man than the average gas manager, it may be held that the former is the greater novelty. He has all the advantage that freshness confers upon a new cause; and he deals with the problems of lighting in a different style from that of a man who has hitherto regarded it as his sole duty to make gas. The electrician knows that electricity in itself has no interest for the consumer, so he sets himself to make it interesting in its applications. The gas manager has expected his public to be content with gas, and has troubled himself little with its applications.

Science and Popular Opinion.—The following cogent remarks on this interesting subject are from a speech made by Mr. A. J. Balfour on Wednesday evening last, at a meeting of the British Economic Association:—

The public have never yet mixed themselves up in scientific investigations without spoiling the investigations and doing themselves a good deal of harm. Take medicine. Perhaps it is flattering medicine to describe it as a science; at all events those who pursue it do their best to pursue it on scientific principles. But directly the public mix themselves in it, directly party feeling, which is an essential element in all popular feeling, arises, you have the most paradoxical, and in some cases the most disastrous results. . . . Science has often been proved wrong; instinctive, uneducated public feeling has in many cases been proved right. But I have no doubt that if you are going to allow questions of scientific interest to be decided by universal suffrage, you will not do much good to universal suffrage, and you will absolutely ruin science. For though science is often wrong, it can only get right and develop itself in the direction of truth by being allowed free play, outside the influence of those popular forces which tend to divert it out of a scientific direction. Fortunately for us, the other branches of science, closely as they are connected with the development of civilisation, are so far beyond popular interest or knowledge that the public are ready to leave them alone. I suppose if we could make a true diagnosis of the causes which have produced the great social improvement and development of the last 100 or 150 years, we should put at the very head of these causes, first, the growth of scientific knowledge in mathematical, in physical, and in other directions. But the public who have profited by these labours hardly realise themselves how much they have profited by them. At all events, they never venture to put their finger in the pie or to suggest to the mathematical physicist or chemist what view he ought to take of the properties of matter, or the mode in which energy can most usefully be applied. The public have left the scientific man alone. They have but vaguely understood the character of his labours; they have been content to profit by them without apprehending them.

The First Monopoly Patent.—The absence of reliable information concerning the history of patents for invention under the common law, says *Engineering*, has been noted with regret by several writers. The Statute of Monopolies in 1624 is known to have been based on the law declared in the case of "Darcy *v.* Allin" in 1602; but as this case in its turn appeals to decisions of a still earlier date, no definite conclusion can be drawn therefrom as to the period in which the first monopoly grants were made. The alchemical patent of Edward III., quoted by Hindmarch, proves on examination to be either a warrant for the arrest of two alchemists, or one of a series of dispensations from the law of Henry IV., by which the practice of multiplication was forbidden. The Commission appointed by Henry VI. to inquire into the feasibility of the philosopher's stone issued no report, and the alum patent cited by Farcy before the Parliamentary Committee of 1829 resolves itself into a permission to an Italian merchant to import a fixed quantity of that commodity. In default of facts, therefore, English and American writers have been driven to accept as genuine the theory of Collier, who, in his essay on "The Law of Patents," published in 1893, traced the origin of patent law to the charters of the Trading Companies and City Guilds. But these charters, which gave legal recognition to certain voluntary associations on the ground that they had existed from time immemorial, conferred no new rights. The patent, on the other hand, creates a right not otherwise recognised by law, the validity of which is practically decided on the question of the novelty of the manufacture therein claimed. The assumed connection, therefore, rests on no historical basis, and no apology will be made for an attempt to substitute a theory, the truth or falsity of which, at any rate, can be easily tested by the records themselves. As the result of a search, believed to be exhaustive, through the voluminous patent rolls of Elizabeth, it may be stated with some degree of confidence that the practice of granting monopoly patents was inaugurated in 1561. The subject of this first monopoly, we are delighted to hear, was a substance called "sope."

The Post Office and the Telephones.—Several questions on this subject were asked last week in the House of Commons. Captain Bagot asked the Postmaster-General whether an agreement between the Post Office and the National Telephone Company had been in preparation for two years; and whether, in view of the fact that he had stated on various occasions during the last year that the agreement would be shortly laid before the House of Commons, he could now state definitely before what date the agreement would be produced. The hon. member further asked the right hon. gentleman whether he was aware that the effect of the long delay in concluding the agreement, and the refusal of the Post Office in the meantime to grant licences to municipalities, had been to enable the National Telephone Company to increase their monopoly and place themselves in a better position than those municipalities which wish to obtain licences; and whether he would state how many applications for local licences from municipalities had been received since it was decided to purchase the trunk lines. Mr. A. C. Morton had a similar question on the Paper. Mr. Henniker Heaton asked whether the Postmaster-General would take care that any agreement between himself and the National Telephone Company should provide that, in the event of the purchase by the State of the Company's property, only the market value of the stock and plant actually belonging to the Company should be paid as consideration money, without taking into account prospective profits or any claim for goodwill, or any similar claim. Mr. A. Morley stated that since he answered a question on the subject on April 30th last further points of considerable complexity had arisen in connection with the settlement of the details of the agreement. He did not think that the delay had enabled the National Telephone Company either to increase their monopoly or to place themselves in a better position. With reference to the question of the member for Canterbury the Postmaster-General pointed out that the agreement now being negotiated was simply intended to give effect to the arrangement made by the late Government for the purchase of the Company's trunk wires—an arrangement which did not contemplate any interference with the general conditions of the existing licence.

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ON IMPULSIVE CURRENT-RUSHES IN INDUCTIVE CIRCUITS.

BY ALFRED HAY, B SC. (EDIN.).

Introductory.

The object of the present series of articles is to give an account of experiments recently carried out (and still being continued) in the Engineering Laboratory of University College, Nottingham, on the abnormal rushes of current which sometimes occur when a transformer is suddenly switched on to live mains. The subject is one of great interest, from a practical as well as a theoretical standpoint, and it is hoped that the experiments about to be described will prove of interest as definitely establishing the nature of the action which takes place.

In carrying out the experiments I have been assisted throughout by Mr. W. B. Burnie, a senior student of the College, who not only constructed the greater part of the apparatus used, but spent much time and trouble in perfecting the arrangements and getting the apparatus into proper working order. The success of the experiments is largely due to his zeal and perseverance, and I here desire to acknowledge my indebtedness to him for his able and willing assistance.

§ 1. Since the publication of Dr. Fleming's paper on "Experimental Researches on Alternate-Current Transformers," read before the Institution of Electrical Engineers in November, 1892, it has become generally known that under certain conditions there is an abnormal rush of current into the primary coil of a transformer at the instant of connecting it to the supply mains. That such a rush of current might sometimes be expected was shown by Dr. Sumpner in a paper contributed to the *Philosophical Magazine* for June, 1887, and partially reproduced in Dr. Fleming's "Alternate-Current Transformer," Vol. I., pp. 263-268. The exact conditions determining a rush, as well as the nature of the effect produced, appeared, however, to be somewhat obscure. It therefore occurred to the writer that the most satisfactory way of settling the points at issue would be to devise some method of experimenting which would enable one to study the action in detail and trace the various stages through which it passes before a steady periodic state has set in. For this purpose a special form of switching apparatus was designed, which fulfils the following conditions:—

(1) The "make" or "break" of the switch are completed in an interval of time which is but a very small fraction of the whole period. By this means any such effect as a gradual "tailing-off" of the current at the instant of breaking, spread over a number of periods, is entirely avoided.

(2) The exact phase of the E.M.F. is known, both at the instant of switching on and off.

(3) The points on the E.M.F. curve at which the switch is closed and opened are capable of being varied independently.

(4) By combining this switching apparatus with an ordinary revolving contact-maker, the actual shape of the E.M.F. and current curves, both normal and those corresponding to a "rush," may be obtained.

§ 2. The description of the special switching arrangement referred to above will be deferred for the present; but the method of taking readings and the instruments employed will be briefly described. The alternator used in the experiments was a Ferranti alternator of the old type, with zigzag-wound armature. As constancy of excitation was of great importance in the experiments, the field of the alternator was excited by a number of small E.P.S. cells, the current being measured by a Siemens electro-dynamometer. Fig. 1 shows the arrangement of the apparatus. For measuring the instantaneous values of the potential difference at the transformer terminals, and the current through the primary coil, a quadrant electrometer of the Ayrton-Perry-Sumpner type was used. The magnetic control in this instrument was, however, abandoned for several reasons. The needle supplied by the makers was removed and replaced by another with a delicate phosphor-bronze strip suspension. The leaden vessel which is designed to contain the sulphuric acid was filled with a heavy mineral oil, and a disc of brass hung from the needle so as to be completely immersed in the oil. It was found that this arrangement rendered the instrument almost aperiodic, so that readings could be taken in quick succession, and the zero of the instrument obtained at any instant without much loss of time. In taking readings for the potential difference curve, the instrument was, of course, used idiostatically, and the arrangement of connections was as shown in dotted lines in Fig. 1. The full lines show the arrangement for taking current readings. A small non-inductive resistance, R, was placed in series with the primary coil of the transformer, and the potential difference at the terminals of R was measured by the electrometer, which in this case was used heterostatically.

The alternator was driven by a "Priestman" oil engine, the speed of which was remarkably constant (in spite of the fact that the engine was running light), the maximum deviation from the mean speed not exceeding 2 per cent.

§ 3. We shall begin our study of current-rushes by considering the comparatively simple case of a circuit of constant permeability, and shall then pass on to the more complicated case of a circuit containing iron. At first sight, it might be supposed that there is no analogy whatever between the two cases; it appears, in fact, by most people to be assumed that such a phenomenon as a sudden rush of current at the instant of closing the switch is only characteristic of circuits containing iron, and does not take place in the case of circuits whose

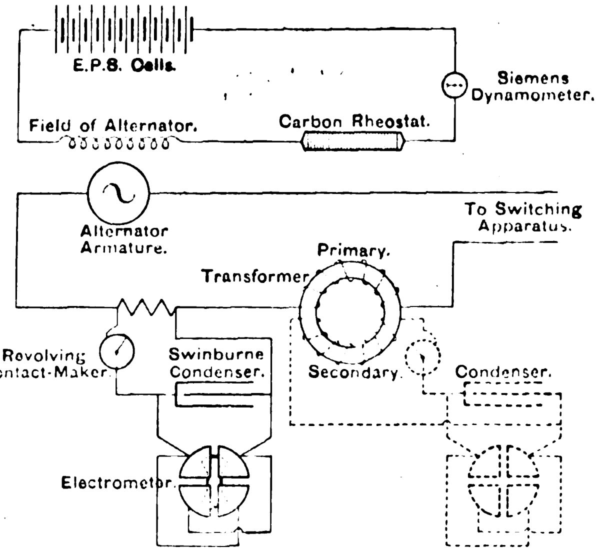

FIG. 1.

permeability is constant. The fallacy of this view will presently be made apparent. It will also be shown that what under certain initial conditions happens in the case of an inductive circuit not containing iron, is precisely of the same nature as the abnormal current-rushes in transformers, with the difference that the latter are considerably more complicated on account of the variable inductance and hysteresis of the material, and take place on a very much larger scale.

It will conduce to brevity and clearness in what follows if we define a "current-rush" as a definite numerical quantity; viz., the ratio of the maximum value reached by the current during any half-wave to the normal maximum when a steady periodic state has been reached. Thus, if by measurement we find that during its first half-wave the current reaches a maximum value of 3 amperes, and that its normal maximum is one ampere, we may say that the "current-rush" during the first half-wave is 3.

§ 4. Let r and L stand for the resistance and (constant) inductance of a circuit, and let a simple harmonic electromotive force $E \sin (pt + \alpha)$ be suddenly applied to the circuit. Taking the well-known differential equation

$$r i + L \frac{di}{dt} = E \sin (pt + \alpha), \quad . \quad . \quad . \quad . \quad (1)$$

and solving, we find

$$i = \frac{E}{\sqrt{r^2 + p^2 L^2}} \left\{ \sin [pt - (\theta - \alpha)] + e^{-\frac{rt}{L}} \sin (\theta - \alpha) \right\}, \quad (2)$$

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the time being reckoned from the instant of closing the circuit; p stands for 2π times the periodicity, and $\theta = \text{arc} \tan \frac{pL}{r}$.

From (2) we see that the current is the sum of two terms, one of which is a pure harmonic function of the time, while the other is an exponential function, which becomes vanishingly small after a certain number of waves.

If $a = \theta$, the exponential term vanishes, and nothing abnormal happens at the instant of switching on. If a is greater or less than θ, the first few waves are not simple harmonic waves, but harmonic waves distorted by the addition of an exponential term. Since the simple harmonic component of the current alternates in sign, and the exponential component is always of the same sign, it is obvious that if $\theta > a$; *i.e.*, if the exponential function is positive, the effect is to increase the ordinates of the positive half-waves, and to reduce the ordinates of the positive half-waves, and to diminish the ordinates of the negative half-waves. The reverse of this happens if $a > \theta$.

We thus see that the sudden application of a simple harmonic E.M.F. to an inductive circuit of constant permeability will in general result in the phenomenon of "current-rushes." These current-rushes will be as great as possible when the distorting term is as great as possible, and this happens when $a = 0$; *i.e.*, when the switch is closed at the instant when the E.M.F. is passing through its zero value. The equation (2) then takes the form

$$i = \frac{E}{\sqrt{r^2 + p^2 L^2}} (\sin \overline{pt - \theta} + e^{-\frac{rt}{L}} \sin \theta). \quad (3)$$

§ 5. Any function which is capable of being represented as the sum of two simpler functions is most conveniently plotted by drawing the graphs of the component functions, and adding their ordinates. Now, if the resultant function has turning-values, it is obvious that the greatest maximum reached by the function can never exceed the sum of the greatest maxima of the component functions. In the case under consideration the current is the sum of two terms, a simple harmonic and an exponential term. Now the greatest value of the former is $\frac{E}{\sqrt{r^2+p^2L^2}}$, and the greatest value of the latter is $\frac{E}{\sqrt{r^2+p^2L^2}} \sin (\theta - a)$, or $\frac{E}{\sqrt{r^2+p^2L^2}} \sin \theta$ if $a = 0$. The current can therefore never exceed the value

$$\frac{E}{\sqrt{r^2+p^2L^2}} (1 + \sin \theta),$$

which is tantamount to saying that the "current-rush" as defined in § 3 must always be less than 2.

§ 6. It was thought desirable to confirm these theoretical conclusions by experiment. So far as the writer is aware, no attempt has hitherto been made to furnish direct experimental evidence of the existence of these current-rushes. But by means of the special switching arrangement mentioned above, and the apparatus shown in Fig. 1 and described in § 2, it is easy to obtain the actual shape of the current-curves, both normal and abnormal. In order to convince any non-mathematical reader of these articles that the exponential term occurring in the current equation is not a pleasant mathematical fiction, but a solid physical reality, we shall first work out and plot the theoretical curve for a special case, and then give the actual curve as determined by experiment.

(To be continued.)

SYNCHRONISING CLOCKS FOR ELECTRIC METERS.

BY J. W. JONES.

In electric meters of the Aron type, in which the current to be measured produces a difference in rate between two clocks (this difference being proportional to the amount of energy passed through), it is necessary that when no current is flowing the clocks should maintain the same rate, otherwise the difference will be registered as though caused by a current. This has always been a source of difficulty, and its importance may be gathered from the fact that, in a 100-ampere meter, having a constant of 0·5 for units, *i.e.*, each division on the top dial being equivalent to half a unit, an error in synchronism of one division per day would make a difference of 45 units in the quarter's account.

The writer, while in charge of the meter-testing department of the Westminster Electric Supply Corporation (Limited), has, during the last three years, experimented on various forms of synchronisers, and as provision had to be made for a large number of existing meters, it was a necessary condition that

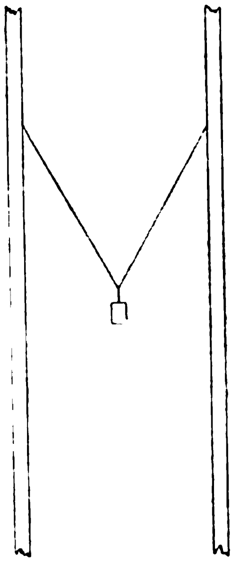

Fig. 1.

any improvement in this direction should not be made at the expense of much alteration; for this reason some types, which would probably have worked well, were not considered.

The first arrangement tried was that shown in Fig. 1, the pendulums being connected together by a loop of silk having a small weight at its centre; the result of this is that as one tends to go faster it is retarded, while the other is accelerated by an equal amount, they will therefore swing together unless the tendency to differ exceeds the amount for which the apparatus is adjusted.

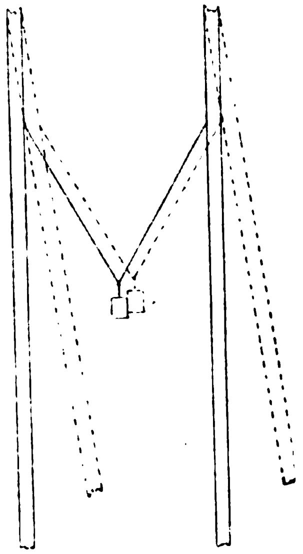

Fig. 2.

One evident objection to this form of synchroniser is that the clocks have to carry the extra weight at a point where there is least power, and as the pendulums approach the end of their swing, their momentum gradually falling off, they become more susceptible to any retarding influence; but as the weight is at the same time approaching its highest point (Fig. 2), and consequently increasing its effect, the pallet is sometimes found to miss one of the escapement teeth, and when this happens the pendulum seldom recovers, especially when

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it is due to the sudden check experienced when a comparatively large current is switched off. Several modifications were made with the object of reducing the effect of the weights at end of swing, but all were found more or less uncertain.

The type at present in use, as will be seen from Fig. 3, consists of two very light magnets, A, B, fixed to the pendulums C, D, and then set so that their free ends lie behind one another at a distance of about ¼in. (Fig. 4). The attraction between the

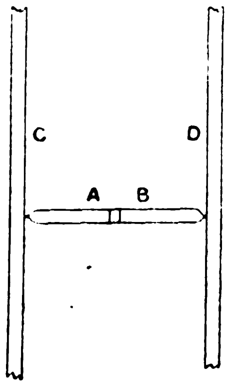

Fig. 3.

magnets has somewhat the same effect as the weights, but their weight, being so small, can have little or no influence on the clocks, while the increased pull at the end of swing is considerably diminished, as the free poles commence receding from one another soon after passing the centre, at, or near, which point lies the maximum effect (Figs. 3, 5, 6, 7); the action of the magnets being very smooth, the jerk noticed in the case of weights is hardly perceptible.

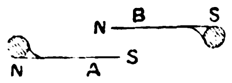

Fig. 4.

The objection to the magnets losing their power is not likely to be serious, if they are kept for some time before sending out.

The constant (*i.e.*, the figure by which the reading on the dials is multiplied to convert it into units) being found by passing a given number of units through the meter and

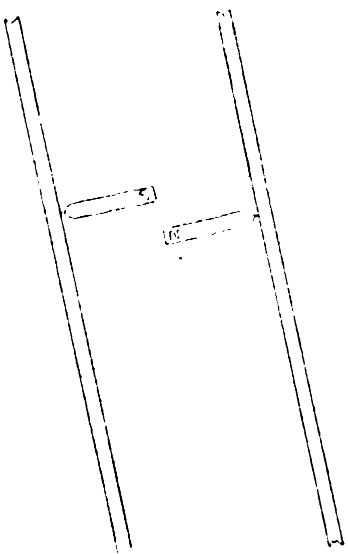

Fig. 5.

dividing by the number of divisions advanced, it is evident that if from any cause the advance for the same number of units falls off the constant will rise. The effect of any auxiliary system of synchronism would probably tend to raise the constant more as the load falls (the curves of Aron meters with permanent magnets on the pendulums generally have a slight tendency to rise at low loads independently of the state of synchronism); in this case, however, as will be seen from

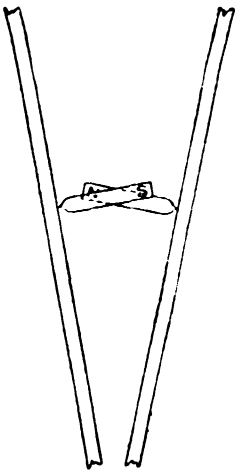

Fig. 6.

curves (Fig. 8) which are plotted from actual tests, and are representative of results now frequently met with in ordinary work,

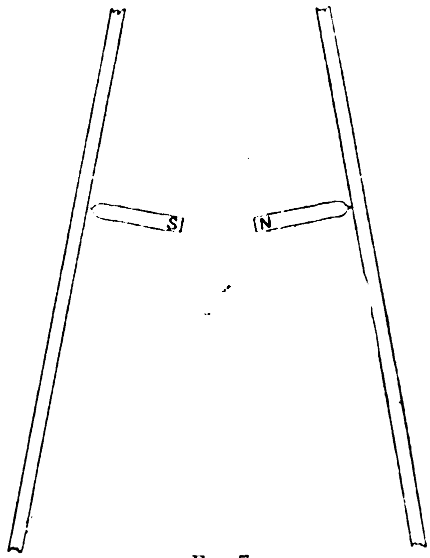

Fig. 7.

the constant seems to keep well to the horizontal until the load drops to between 1 and 3 per cent. of the maximum—in

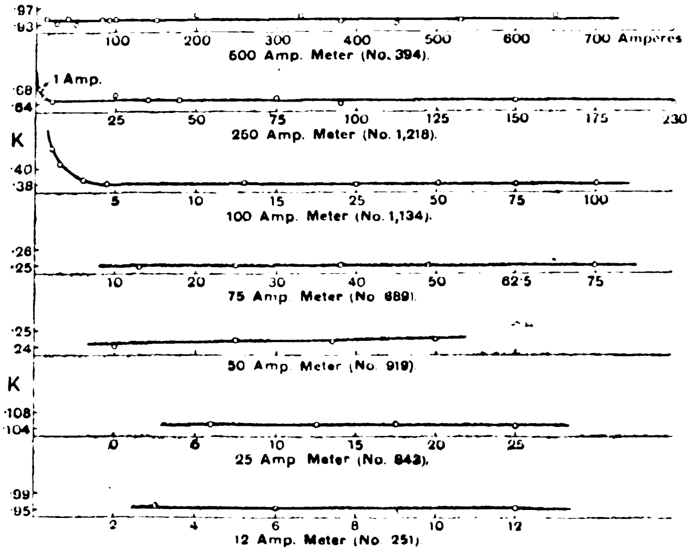

Fig. 8.

these tests (Fig. 8) the range of synchronism was not ascertained, but would probably have been about three divisions per day, which is found to be a convenient amount for usual working

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conditions—at which point it rises somewhat abruptly. This is, of course, a loss to the Supply Company; but if the capacity of meter is selected with due regard to the probable average load, the amount of energy it should register at this point will be comparatively small, and an error of 5 or even 10 per cent. will not be a serious matter.

As it is impossible to tell beforehand in which direction the clocks are likely to change, it is obvious that the best position for the regulating nut on the standard pendulum will be mid-way between the extreme points, to which it would have to be moved to make the clocks go backward or forward against the effect of the synchroniser; should it be at a point between the true zero and one limit, the range of synchroniser in that direction would be less, while for the other direction it would be correspondingly greater.

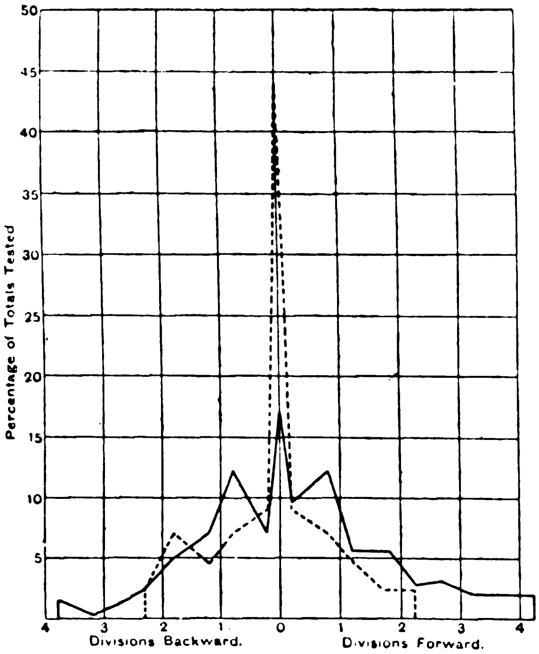

FIG. 9.—Dotted lines, Meters with Magnets. Total 43. Thick lines, Meters without Synchronisers. Total 250.

Within the last 18 months certain meters were for various reasons suspected of being out of time, of these 43 had magnets fitted, while 250 had no synchronisers of any kind. The results of these tests shown in the curves (Fig. 9) cannot of course be considered as representative of the true state of all meters on circuit, and are only given to show the results as far as the experiments have gone. The number at present fitted is about 700.

A CONTRIBUTION TO THE THEORY OF TELEPHONY.

BY A. E. KENNELLY.

The theory of the transmission of telephonic current-waves is complex to the degree that the wave character of their generated E.M.F. must be, in order to follow, and even partly conserve, the highly composite character of vocal vibrations in air. Nevertheless, the theory of transmitting sinusoidal current waves of any single frequency within telephonic range is simple, and with judiciously selected values of frequency and amplitude the application of this elementary theory may, with due reservation, be of practical value.

It is the object of this article to develop the theory of simple harmonic telephony in its simplest form, and to point out a few of the consequences.

A B in Fig. 1 represents a single line of copper wire, L miles or kilometres in length, with an induction coil transmitter at A, a receiving telephone at B, and ground return circuit.

If we assume that a pure musical note of some standard frequency is sung steadily before the transmitter at A, producing a steady sinusoidal current in the primary circuit of the coil, a sinusoidal E.M.F. will be generated in the secondary winding. The E.M.F. delivered at the terminal A will, however, depend upon the load, namely; the impedance of the line and receiving instrument.

The manner in which the voltage of delivery varies with the load may be observed by experimentally substituting for the line an adjustable non-inductive resistance, and measuring the E.M.F. at terminals with a delicate electrostatic volt-

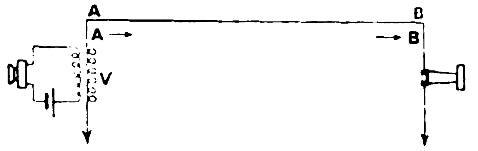

FIG. 1.

meter as this resistance is changed. The following table and curve (Fig. 2) gives the result of a series of observations made with a small telephone induction coil of European construction, having a primary of 1·21 Ω and 0·0091 H, a secondary of 393 Ω and 1·13 H, and a mutual inductance of 0·12 H, with two storage cells in the primary circuit, and the note "middle c" of 256∿ sustained in a moderately loud voice before the transmitter. The readings were too variable to admit of a high

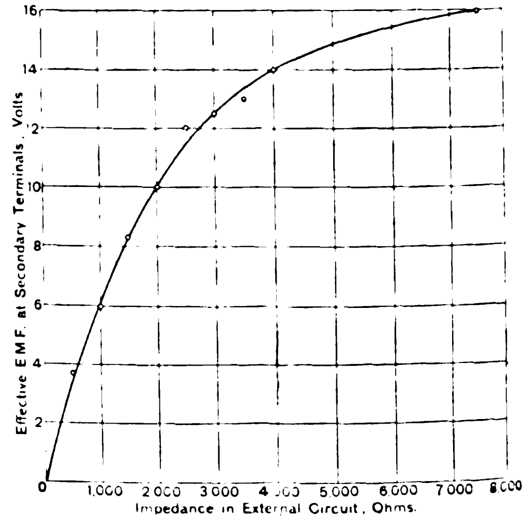

FIG. 2.—Curves Representing the Observed Relation of Effective Terminal E.M.F. to Load in a Telephone Induction Coil.

degree of accuracy, but the curve fairly represents the terminal E.M.F. produced by the transmitting apparatus under those conditions for any external impedance up to 7,500 ohms:

Ext Res.	Effective volts at terminals.
500	3·75
1,000	6·0
1,500	8·25
2,000	10·0
2,500	12·0
3,000	12·5
3,500	13·0
4,000	14·0
7,500	16·0

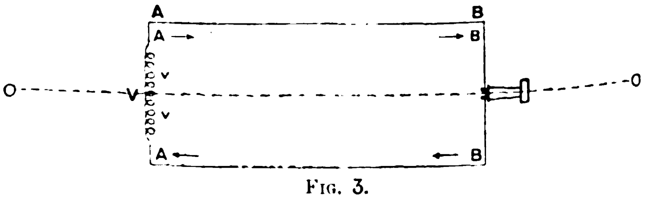

FIG. 3.

Returning, then, to Fig. 1, the effective voltage at the terminal A is experimentally determinable when the impedance of the line and receiving instrument can be assigned.

The distance at which simple harmonic sound waves will be recognisable with sufficient clearness for the purposes of intelligent communication will then depend upon the strength of the current reaching the telephone at B, the usual amount of "cross-talk" and other disturbances being taken into consideration.

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The problem may therefore be stated as follows:—For any given homogeneous line of known resistance, inductance, leakage, and capacity, grounding through apparatus of known impedance, to find the total impedance as presented at A; and thence, having determined the effective pressure at A, to find the current strength that will reach B. Simple harmonic telephony will then be practicable or not according as this current strength exceeds or falls short of some experimentally determined value at the standard frequency adopted.

Let L be the length of the line in miles or kilometres.
- r „ its conductor resistance in ohms per mile or kilo.
- l „ its inductance in henrys per mile or kilometre.
- c „ its capacity in farads per mile or kilometre.
- g „ its leakage conductance in mhos per mile or kilo.
- ω „ $2\pi\times$ the frequency.
- j „ $\sqrt{-1}$.
- e „ the effective terminal voltage at A.
- i „ the current strength through B, effective amperes.
- I „ the effective current strength at A in amperes.
- J „ the vector impedance of the apparatus at B.

But long distance telephony employs metallic circuits, such as is represented in Fig. 3, with an effective E.M.F. E. The line O O divides this circuit into two symmetrical halves, each as though employing ground return, and with half the E.M.F. at A, half the impedance in the apparatus at B, and twice the capacity allowed to each wire that is measured between them when insulated from the ground and from each other. In equation (1) we therefore insert half the vector quantity J, and the quotient e/I then gives the impedance of either half of the complete circuit. Twice this result, being the impedance of the loop at A, E, is obtained from the data, and e, or half of E inserted in (2) or (5), supplies the strength of received current i.

We may now consider some examples of these formulæ.

First Case.—Two parallel overhead wires, each 950 miles long, of hard-drawn copper 0·165″ (0·419 cm.) in diameter, are supported on poles at an interaxial distance of 9″ (22·9 cms.), no other wires being in their vicinity. Then each will have per mile a resistance of 2·2 ohms, a capacity of $0{\cdot}009525\times10^{-6}$ farad, an inductance of 0·00159 henry, and a leakage con-

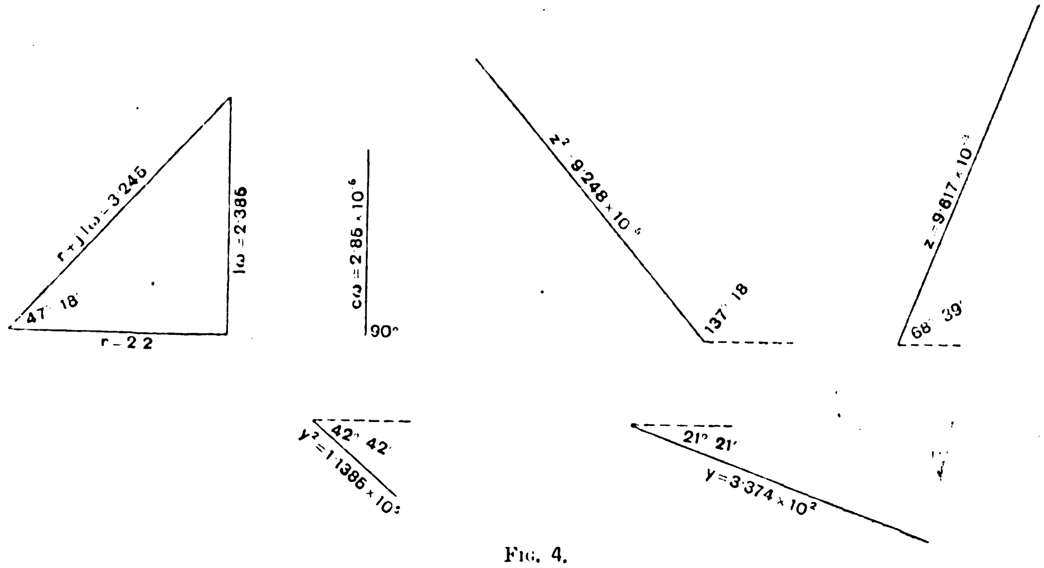

Fig. 4.

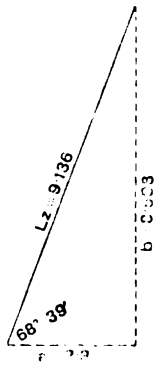

Fig. 5.

J will usually have the form $(\mathrm{R_T}+j\,\mathrm{L_T}\,\omega)$, where $\mathrm{R_T}$ and $\mathrm{L_T}$ are the resistance and inductance of the apparatus.

Then it can be readily shown that

$$\mathrm{I}=\frac{e}{y\sinh \mathrm{L}z}\left(\cosh \mathrm{L}z-\frac{\mathrm{J}}{y\sinh \mathrm{L}z+\mathrm{J}\cosh \mathrm{L}z}\right), \quad . \quad (1)$$

and

$$i=\frac{e}{y\sinh \mathrm{L}z+\mathrm{J}\cosh \mathrm{L}z}, \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where $z=\sqrt{(r+jl\omega)(g+jc\omega)}$ and $y=\sqrt{\dfrac{r+jl\omega}{g+jc\omega}}$. . (3)

These equations give the magnitude and phase of the currents at the receiving and transmitting ends of the line, the quotient e/I in (1) being, of course, the impedance of the line at A, which, being computed, gives both e and I, whence equation (2) determines the serviceability of the line.

These equations involve plane vectors, of which the rules for treatment are given in the *Electrical World* for January 6, 1894, Vol. XXIII., No. 1, p. 18. The equations may, however, be further simplified when dealing with electrically long lines—that is to say, lines approaching the limitations of transmission—for in such cases the influence of impedance in the receiving apparatus usually ceases to be significant upon the circuit, and we may make $\mathrm{J}=0$; while, since the vector L z is then sure to be more than two units in length, its hyperbolic tangent in (1) will be practically unity, so that for long lines here considered our equations become:—

$$\mathrm{I}=\frac{e}{y\tanh \mathrm{L}z}=\frac{e}{y}, \quad . \quad . \quad . \quad . \quad . \quad (4)$$

$$\text{and } i=\frac{e}{y\sinh \mathrm{L}z}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

ductance quite negligible. Then if the simple harmonic standard frequency is 238·7 ∾ making $\omega=1{,}500$, we have

$$\mathrm{L}=950$$
$$r=2{\cdot}2$$
$$l=1{\cdot}59\times10^{-3}=\therefore l\omega\ 2{\cdot}385$$
$$\text{(doubled) } c=1{\cdot}9\ \times10^{-8}\therefore c\omega=2\cdot85\times10^{-5}$$
$$g=0$$

Therefore, as shown in Fig. 4, $z^2=9{\cdot}248\times10^{-5}\diagdown 137^\circ.18'$

$z=9{\cdot}617\times10^{-3}\ \angle 68^\circ.39'$, $y^2=1{\cdot}1385\times10^{5}\ \diagdown 42^\circ.42'$,

$y=3{\cdot}374\times10^{2}\diagdown 21^\circ.21'$

It is to be observed that twice the actual value of c has to be allowed owing to considering the lines as being operated independently with ground return. Similar remarks apply to the case on page 19, *Electrical World*, Vol. XXIII. The impedance y of one line is thus 337 ohms, and 674 ohms is the impedance of the loop at A. By reference to Fig. 1, it appears that the terminal pressure which the transmitter would support on this circuit would be 4·6 volts, or 2·3 volts on each wire. Fig. 5 shows L z, which is L times the length of the vector z, and with components a and jb of 3·326 and 8·508 respectively. The hyperbolic sine may be fully worked out as indicated on page 18, *Electrical World*, Vol. XXIII.; but whenever, as in this instance, the horizontal component a is greater than 2, the maximum possible error in the numerical value of sinh L z made by ignoring the vertical component and the phase is 3·5 per cent., and when a is greater than 2·5, 1·25 per cent., rapidly dwindling. We may, therefore, when considering long lines, write equation (5) as

$$i=\frac{e}{y\sinh a} \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

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Here $\sinh a = 13{\cdot}9$, and $i = \dfrac{2 \cdot 3}{337 \times 13 \cdot 9} = 0{\cdot}0004905$ ampere.

This is the current strength we should expect at B.

Second Case.—The same wires separated to an interaxial distance of 72″ (183 cms.), the inductance per mile of each is now 0·002259H, and the capacity of each to each insulated $0{\cdot}01321 \times 10^{-6}$ farad. Thus, $l\omega = 3{\cdot}389$, and doubled $c\omega$ $1{\cdot}981 \times 10^{-5}$. Fig. 6 represents the corresponding steps in computation $z^2 = 8{\cdot}00 \times 10^{-5} \backslash 147^\circ.1'$, $z = 8{\cdot}944 \times 10^{-3}$ $/73^\circ.30'.30''$, $Lz = 8{\cdot}498 / 73^\circ.30'.30''$, $y^2 = 2{\cdot}041 \times 10^5 \backslash 32^\circ.59'$ $y = 4{\cdot}518 \times 10^2 \backslash 16^\circ.29'.30''$.

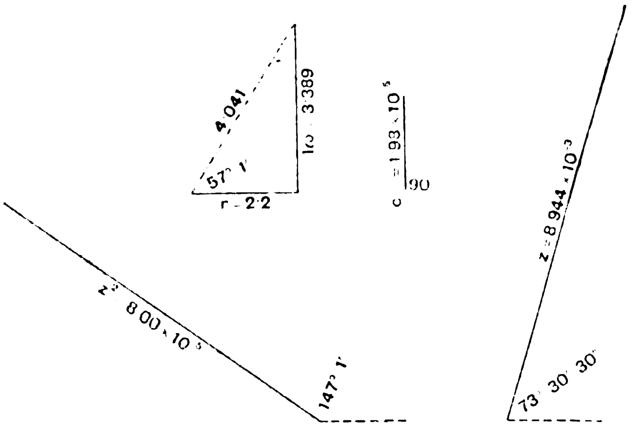

Fig. 6.

The impedance of the loop at A or $2y$ is now 904 ohms, at which the terminal pressure is E = 6 volts, or three to each wire. Entering equation (6) with this value of e, Fig. 7 shows that the horizontal component of Lz is now 2·412, whose hyperbolic sine is 5·53. The received current is consequently $\dfrac{3}{452 \times 5{\cdot}53} = 0{\cdot}0012$ ampere.

Increasing the distance between the wires from 9 to 72in. has more than doubled the strength of the current at B.

By watching the geometrical development of the computation, the utility of inductance in telephonic transmission is symbolically apparent in two ways. First by making the length $(r + jl\omega)$ greater, it adds to the length of y, and thus augments the impedance at A and the effective voltage delivered to the line. Secondly, it increases the angle of z and Lz, thus reducing the horizontal component a upon which the value of $\sinh a$ so sensitively depends. On the other hand, it will be evident that beyond a certain value the beneficial influence of inductance will cease.

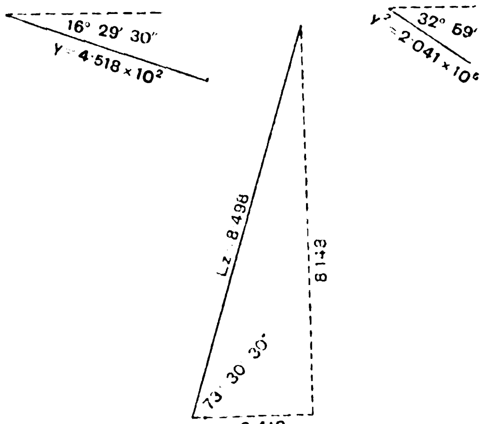

Fig. 7.

Equations (1) and (4) indicate that when the circuit is sufficiently long to make the horizontal component of Lz more than 2, the factor $\tanh Lz$ is practically unity, and the impedance of the circuit as apparent at the transmitter becomes constant, no matter how far the line be then extended. The effective voltage of delivery therefore remains constant, and the received current, as the length of line increases, depends entirely upon the reciprocal of $\sinh a$. In other words, with a moderately long line of fixed and uniform electrical constants, the strength of the received current varies inversely as the hyperbolic sine of a fraction of its length and not inversely as the square of its length. Fig. 8 gives the curve of hyberbolic sines, which may be employed when a table of this function is not available. The dotted line represents a particular curve of squares. The agreement between the two curves is very fair until the variable exceeds 3·5, and, to a first approximation, therefore, the law that assigns the amplitude of received current to the inverse square le of the length is correct. This does not, of course, contravene Lord Kelvin's law of signal transmission, which asserts that the interval of time required to bring the amplitude of continuous current strength received at the distant end of a cable (having small inductance in relation to its capacity), to a given fraction of the ultimate full maximum, varies as the square of the cable's length. In the case of harmonic telephony before us, we consider only the amplitude of harmonic current waves that have already practically reached their full development; and the progress of that development towards maturity, at the start, and in the initial stages of transmission, is removed from present consideration.

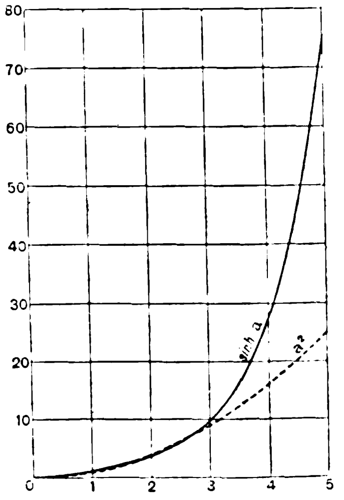

Fig. 8.—Curves of sinh a and a^2.

Third Case.—Two No. 10 A.W.G. copper wires, 0·1019″ (0·2588cm.) in diameter, are suspended parallel and alone upon poles, at an interaxial distance of 1ft. (30·48cm.). Assuming that their capacity when insulated from each other and from ground is 0·007 microfarads per mile, their separate inductances 2·138 millihenrys per mile, their resistances each 5·28 ohms, and their insulation each 250,000 ohms per mile, required the distance at which harmonic telephony will be possible with the special transmitter above referred to, when the limiting current strength at $\omega = 1{,}500$ is 0·00025 ampere.

Here $r = 5{\cdot}28$, $l = 2{\cdot}138 \times 10^{-3}$, doubled $c = 1{\cdot}4 \times 10^{-8}$, $g = 4 \times 10^{-6}$, $l\omega = 3{\cdot}207$, $c\omega = 2{\cdot}1 \times 10^{-5}$.

Constructing triangles as before, we find $(r + jl\omega) = 6{\cdot}178 \backslash 31^\circ.16'.30''$ and $(g + jc\omega) = 2{\cdot}138 \times 10^{-5} / 79^\circ.1'$. Whence $z = 0{\cdot}01149 / 55^\circ.8'.45''$., and $y = 537{\cdot}6$ with neglected phase. The loop impedance at A is 1,075 ohms, to which the transmitter will respond with a terminal E.M.F. of 6·7 volts by Fig. 1, or 3·35 volts to each wire. We have then the relation $e/(y \sinh a) = 0{\cdot}00025$, or $\sinh a = 24{\cdot}93$, so that $a = 3{\cdot}91$. Lz is $3{\cdot}91/\cos.55^\circ.8'.45''$, or 6·842, and $L = 6{\cdot}842 / 0{\cdot}01149 = 595$ miles. The harmonic sound reproduction would have the limiting amplitude at about 600 miles.

In conclusion, it may be pointed out that all the preceding formulæ apply immediately to continuous-current *leaky* circuits by suppressing the influence of their inductance and capacity; that is, by equating l and c to zero.

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MODERN ELECTRO-CHEMICAL THEORY AND ITS BEARING UPON THE PRACTICE OF THE FUTURE.*

BY DR. OSTWALD.

The bulk of the benzol produced in England, amounting to many thousand gallons, is annually exported from the land of its origin to Germany. The significance of this fact is best grasped when it is considered that there is but little use for benzol as such, but that it serves for the preparation of other commodities such as colours, perfumes, and drugs. Benzol itself is indeed a semi-raw material, and its export in a partially-manufactured condition is clear proof that the oldest industrial country in the world is compelled to abandon the manufacture of merchantable products from coal tar at a point far short of that which is ultimately attained, thus foregoing the more remunerative part of their utilisation, and allowing the greater share of the profit which accrues to be secured by another nation. Seeing that the production of coal tar colours on a commercial scale was first achieved in England, the question naturally arises: How can the present industrial decadence, indicated by the shifting of trade adverted to above, have occurred? The answer is best to be found in the impressions conveyed to the author by a sojourn in this country.

He visited an industrial town of considerable importance and called upon the Professor of Chemistry at the local college. The laboratory, which was excellently fitted, was shown to him with obvious pride, but enquiry as to the number of students attending elicited the fact that there were but few. As a saving clause it was stated that the teacher of dyeing and calico-printing attached to the same institution, had five times as many students as the Professor of Chemistry. Far from being impressed by this fact the author immediately put his finger on the evil of the system thus exposed. The English student has too great a belief in the value of "practical" subjects to waste time in learning pure chemistry, and when wishing to become a technically trained dyer, learns dyeing instead of the chemical principles upon which dyeing depends. The natural result is that at the first notable departure from the art of dyeing as he learnt it, he is utterly at a loss, and has to begin learning new empirical methods instead of applying that general knowledge which the technical man who has studied chemistry before dyeing has fully acquired. The secret of German industrial success is this: Germans have grasped the fact that science is the best practice.

Electro-chemistry has been somewhat behindhand in the general development of technical knowledge, chiefly because electricians have been hitherto chiefly concerned in the evolution of purely mechanical appliances; a meeting place of science and electrical technology is provided by those electrolytic problems which are now of especial interest. The present time is well fitted for investigation of this kind. The century-old problem of the voltaic couple is in process of solution. We are now in the possession of sufficient knowledge to calculate the E.M.F. of a given couple with a high degree of approximation, and our information concerning electrical conduction is also considerable. The modern dissociation theory of solution must be invoked to provide a satisfactory explanation, and in this particular instance its electrical rather than its chemical aspect may be profitably considered. Taking the case of a dilute solution of sodium chloride in water—*e.g.*, 0·5grm. per litre—it is found that such a solution is a good conductor. Adopting the view that conduction depends on the translation of electrical charges by ions, it is clear that with sodium chloride of the strength given, sodium ions act as carriers of positive electricity and chlorine ions of negative electricity. This solution being dilute, the distance separating any given ion from another of the same kind is comparatively great, whence it follows that the period during which an ion—*e.g.*, of sodium—exists alone in the watery solution, is greater than that passed by it in the combined state. On grounds of the kind thus indicated, it becomes possible to calculate what fraction of a given electrolyte is split up into ions. The conditions determining the electrical conductivity of a solution admit of simple definition. In every electrolyte the conductivity is proportional to the number of ions per unit volume, and also to two constants—the velocities of migration of the ions differing in kind. This velocity is greatest in the case of hydrogen, whence it follows that acids are the best conductors in solution. The question of the conditions governing E.M.F. is, however, of still greater moment than that relating to conductivity, and may be dealt with in a similar manner.

The starting point for reasoning on this subject consists in a full appreciation of the nature of osmotic pressure, which may be stated thus: When a concentrated aqueous solution is covered by a layer of water, diffusion takes place until the concentration is uniform. The cause of movement from one layer to the other has the character of a pressure, and is termed osmotic pressure. To prove the existence of this pressure it is only necessary to oppose the movement of the dissolved substance, which can be done by interposing a septum between the two layers which is pervious to water but not to the substance in solution. A septum of this kind has been devised by Pfeffer,* and by its means osmotic pressure has been shown actually to exist, and to be of considerable magnitude. Thus a solution such as sea-water gives a pressure of about 20 atmospheres. The origin of this pressure is still unknown, but its existence is certain, and obtains for all soluble substances. By surrounding a solution with an osmotic septum strong enough to resist the pressure, a maximum osmotic pressure is obtained, which is dependent on the solubility of the substance in solution, and cannot be exceeded. This pressure is perfectly analogous to steam pressure, and just as steam pressure may be used to drive an engine, so can osmotic pressure be caused to drive a corresponding machine. *A galvanic cell is nothing more than a machine driven by osmotic pressure.*

In order to understand this fully, the process of solution which a metal undergoes when used in a galvanic cell must be studied somewhat closely. In an ordinary Daniell cell, zinc dissolves to form zinc sulphate; this, stated in dissociation language, means that zinc ions electrically charged are formed from the metal in the massive unelectrical condition. A corresponding number of copper ions are translated from their electrically-charged condition to that of the ordinary metal. At the zinc electrode positive electricity is continually received, and at the copper electrode it is given up. The conductive connection of the two electrodes determines the simultaneous occurrence of a chemical and an electrical change, neither of which takes place without the other. The analogy between pressure and E.M.F. is now complete. Just as an engine can be driven by means of two fluids of different pressure, so can an electrical cell be operated by two sources of different electrical pressure. The zinc and copper of a Daniell cell are two such sources, and the difference of their electrical pressure depends on the difference of osmotic pressure due to the zinc on one side and the copper on the other. The higher the pressure arising from the zinc and the lower that to be overcome at the copper electrode, the better the cell works and the greater is its E.M.F.

The pressure measuring the endeavour of a metal to go into solution, or the "solution-pressure," as it may be termed, is of perfectly definite magnitude for every metal, and it appears at first sight as if it simply depends on the nature of the metal in the cell and on no other factor. That there is another factor becomes apparent from the following considerations: When the zinc electrode is in contact with the solution, the effective solution pressure depends not only on the zinc but also on the zinc ions present in the solution which exercise a counter pressure. The excess of the first above the second is the effective solution-pressure. The E.M.F. due to the zinc is therefore the greater the smaller the counter-pressure of the ions, *i.e.*, the lower the concentration of the solution in respect of its content of zinc ions. As a matter of fact the E.M.F. of a Daniell cell is greater when sulphuric acid is in contact with the zinc than when zinc sulphate is used. The converse holds in the case of the copper electrode where it is desirable that the concentration of the liquid in respect of copper ions should be at its maximum, in order that the pressure exerted by those

* Zweite Jahres Versammlung des Verbandes der Electrotechniker Deutschlands in Leipzig am 7-9 Juin, 1894. *Electrotechnische Zeitschrift*, 1894, 24, pp. 329—331.

* The septum consists of the colloid cupric ferrocyanide.

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ions may aid the deposition of copper in the ordinary metallic state. This, then, is a simple exposition, quantitative in character, comparable with the Newtonian law of gravitation of the theory of the galvanic cell. The theory gives definite conclusions for definite cases, and those instances in which complete calculation of results from data has not been effected probably arise not from imperfection of the theory, but rather from known mathematical difficulties. Certain constants have also yet to be determined.

The conditions under which the best output from a given cell may be obtained can now be ascertained. On the zinc side a minimum ion pressure must prevail. This is best secured by using a solution in which but few zinc ions are present, even when more or less zinc has been dissolved in it. This is not an impossible requirement, because the whole of a dissolved metal is not necessarily in the form of ions. From this point of view the use of *alkaline* liquids for the zinc (now frequently adopted) has especial significance. The next step consists in combining the use of an alkaline liquid for the zinc electrode with that of an acid liquid at the cathode, in order to obtain the greatest possible E.M.F. It is a consequence of the theory already expounded that the oxidising agent will act better in an acid liquid, and the reducing agent in an alkaline liquid. Thus, a cell consisting of zinc in caustic potash and carbon in strong nitric acid has an E.M.F. of more than 2·5 volts. Whether it is possible to make such a cell practically available is a question to which it would be premature to reply.

The matters touched upon above become of insignificant importance when compared with a much larger problem, the solution of which must be looked for from the electro-chemist. The low efficiency of the steam engine, as a means for the conversion of the chemical energy of fuel is not sufficiently widely recognised. In the best cases not more than 10 per cent. appears as mechanical work. Now, it may be admitted that the complete conversion of heat into mechanical work cannot be attained; but it is possible to calculate the fraction which can be obtained from a given quantity of heat at a given temperature on allowing the temperature to fall through a known range, and on taking this as a basis it is found that only about one-seventh of the total convertible amount is utilised. The steam engine, regarded as a machine, is not responsible for this state of things, which depends far more on the fact that of the high temperature of the burning fuel (much understated at 1,000°C.) only a small portion is used, namely, that represented by the difference in temperature between the boiler and the condenser. The very large difference of temperature between the furnace and the boiler is not rendered available, and an improvement of the thermo-dynamic machine can only be rendered possible by the use of a higher initial temperature.

But the thermo-dynamic machine is not the only apparatus for the conversion of chemical energy into mechanical work. Should it be possible to obtain the energy of fuel in such a manner that heat as an intermediary was abolished, the difficulty of having to deal with high temperatures would be overcome and the whole quantity of energy obtained without encountering that inconvenience. The way in which this, the most weighty of all technical questions, can be decided, must be shown by electro-chemistry. Had we a cell in which electrical energy was produced by the direct oxidation of carbon with an output approaching the theoretical, we should be on the brink of an industrial revolution compared with which the invention of the steam engine sinks into insignificance. It is not practicable to foretell the arrangement of a cell of this order, but one point may be insisted on which has been constantly ignored. The energy of a galvanic cell indubitably results from the chemical energy of its components, but complete conversion never occurs. What, then, are the conditions which permit of the maximum efficiency of conversion? The answer is that only *indirect* chemical reactions are electrically useful. The following experiment, therefore, acquires much significance. Two beakers connected by a filled syphon, contain a solution of potassium sulphate. In one is a rod of zinc, in the other one of platinum. On connecting these electrodes with a galvanometer a momentary current passes, and then the needle quickly comes to rest. This, of course, is due to polarisation, and in order to obtain a continued current, an acid liquid must be substituted for the original neutral solutions. The question now arises: To which beaker shall an acid (*e.g.*, sulphuric acid) be added? When this is put to most people, the reply is: "To the beaker containing the zinc." Actual trial shows, however, that no effect is thus produced, whereas when the acid is added to the liquid in the beaker containing the platinum the galvanometer needle flies to the stop. The apparently paradoxical result is obtained, that the acid must be placed in contact with the metal on which it has no action. This principle is perfectly general in character, and has been demonstrated to hold good in numerous cases. Its necessity is obvious on closer inspection. In order that the zinc may dissolve, ions must be formed, and receive their charge of positive electricity. That this may be possible it is requisite that the solution should give up a corresponding amount of positive electricity, *i.e.*, that an equivalent quantity of hydrogen must cease to be in the ion state, and must become converted into hydrogen gas. This giving up of positive electricity from the liquid cannot take place at the point where the zinc dissolves, because the contrary electrical change occurs there. It is therefore only possible for the hydrogen to come off at the cathode, as is actually the case.

It now becomes clear how fallacious was the method by which Jablochkoff sought to obtain electrical energy direct from carbon. He placed the carbon in fused nitre, and by its vigorous oxidation obtained a current so feeble that its utilisation was not to be thought of. The reason for this failure is as follows: The nitre should not be in contact with the oxidisable electrode, but with the electrode which is not attacked by oxidising substances. A parallel is found in the Bunsen cell where the oxidising substance (nitric acid) is not placed in contact with the substance to be oxidised (zinc), but with that upon which it has no action (carbon, which is unattacked under these conditions). Similarly the cell of the future (in which carbon is oxidised for the conversion of chemical into electrical energy) will have the oxidising material *at the point where the carbon to be oxidised is not.* Such a cell will exhibit exactly the same chemical processes as an ordinary furnace. On one side the carbon will be shovelled in, and on the other oxygen will be admitted, and the product of their indirect interaction will be CO_2. The one essential is a suitable electrolyte to interpose between the carbon and the oxygen, and permit of the occurrence of the electrical interactions, itself suffering no permanent change.

Another problem which will be grappled with in the future by the electro-chemist, is that of the storage of electrical energy by means of secondary cells. The energy stored in a cell is proportional to the quantity that remains in it and to the E.M.F. of the cell. The first is, in its turn, proportional to the electro-chemical equivalent of the material used. This, in the case of a lead accumulator is undesirably great, viz., 103·5. If aluminium, with an electro-chemical equivalent of 9, were available, the weight of the electrodes would be at once reduced to less than $\frac{1}{11}$ of their present amount. It is unlikely that aluminium will prove a practicable substitute, but it is not the only metal with a low electro-chemical equivalent, and something may be achieved by keeping this fact in view.

In conclusion the nature of electrolytic changes may be profitably considered. A conventional distinction between primary and secondary electrolytic changes has sprung up; but it is of little value and, indeed, scarcely tenable. On electrolysing a solution of potassium sulphate the products are not the ions K and SO_4, but hydrogen and caustic potash at the cathode, and oxygen and sulphuric acid at the anode, and these are often called secondary products on the assumption that K and SO_4 are first separated, and immediately act upon the water present, with the result that the substances mentioned above are obtained. But on measuring the E.M.F., which is necessary for this electrolysis, it is found to be smaller than that which would be necessary were it true that the change takes place in the manner conventionally received. The E.M.F. is, in actual fact, of the magnitude demanded by the production of the substances appearing at the anode and the cathode, on the assumption that they are not secondary, but are primary products. The principle is perfectly general; the E.M.F. is constantly dependent only on those reactions

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which actually take place, and is in no way influenced by those arbitrarily termed primary. The distinction between primary and secondary products is therefore of little utility. There is, however, a distinction which is not commonly insisted upon as clearly as is desirable. It is that existing between the substances which are the intermediaries of conduction, and those which separate at the electrodes. They are not necessarily identical and can, indeed, be identical only in a few instances, for only a few ions are capable of passing over into the non-electrical condition without chemical change, as they must if the electrolysis should yield only primary products (using the phrase in its conventional sense).

The distinction which can properly be drawn between primary and secondary products of electrolytic decomposition is foreshadowed by the inquiry: What conducts the current, and what appears at the electrodes? In a few cases the two classes of substances are identical; as, for example, in the electrolysis of fused magnesium chloride, where chlorine and magnesium are evolved; in most instances, on the other hand, wholly different substances appear, and there is no necessity that they should be identical. When such choice of electrolytic products is possible, those substances are always produced whose separation requires a minimum E.M.F. It is wholly indifferent whether they are "primary" or "secondary," *i.e.*, whether they are concerned with the chief part of the conductivity of the electrolyte or not. All the ions present in an electrolyte, each acting according to its number (concentration), and its velocity of migration, come into play in the conduction of the current; for the polarisation at the electrodes only the final products of electrolysis have to be regarded. The two things are wholly independent. The matter, though but little regarded, is not of merely theoretical interest, for many errors of practical importance can be traced to want of appreciation of its cogency. In spite of the clearness with which many technical questions can be regarded in the light of scientific investigation, it must not be supposed that the labour of the technical inventor is rendered superfluous. Technical questions must be propounded before they can be answered, and even then the answer may not be forthcoming. The stimulus supplied by such problems is a "valuable consideration" for the help given in response to questions which admit of immediate solution.

MEETING OF THE ASSOCIATION OF MUNICIPAL ENGINEERS.

At the meeting of the Incorporated Association of Municipal and Country Engineers at the Institution of Civil Engineers, Westminster, on Friday last, Mr. J. N. Shoolbred, of London, read a Paper on the Bradford Corporation Electricity Supply, with the results of four years' works. The author pointed out the successful working of the installation at Bradford, the profits which have been made by the Corporation in addition to the provision of interest on capital and sinking fund, and the low working cost of the system, which compares favourably with any other in the kingdom. Mr. Robert Hammond contributed a paper on Electric Street Tramways. He gave a detailed description of the electric tramways at Buda-Pesth, which he inspected last year, and pointed out that there are at the present time in Europe 47 electric lines in operation, the total length being 194½ miles, and the horse-power employed 14,579. In the United States, however, where electric traction had reached its greatest development, 12,369 miles and 39,178 cars were in operation.

Having briefly reviewed the distinguishing characteristics of the accumulator, overhead and conduit systems, Mr. Hammond said the combination of electric traction and electric lighting appeared to be a most beneficial one. At the opening of the day, when the trams started operation, there was no load upon the electricity works, and this absence of load practically continued until sunset. Here, then, was a most convenient use for plant other wise lying idle. In the case of electricity works specially confined to traction, the whole of the standing charges were debited to the cost of the car mile run; whereas, if worked in connection with electric lighting, only a portion of those charges would be debited. It must, however, be borne in mind that at one period of each evening the electric lighting load and the tram load would clash, and this had hitherto been considered a bar to the combination of the two works. The author fully admitted that the overlapping of the loads was a matter of great moment, but he was convinced that an economical arrangement could be arrived at. The accumulator system was that which lent itself most readily to the combined plan. Up till the moment of reaching the top load there was a margin of capacity in the plant for doing the work of charging the batteries, and from the moment the load began to fall off this margin of capacity was released. In the case of systems of direct supply it might still be possible to tide over the period of maximum electric lighting load by secondary batteries fixed in the station; which, charged during the day, could be used at the critical period to give out the electrical energy necessary to feed the motors on the cars. There was a third plan, which he had lately been considering, and which, indeed, might prove the most economical method of dealing with the over-lapping difficulty, viz., the horsing of the tramcars during the time of the top lighting load. By whatever means, however, the over-lapping load was coped with, it by no means presented an insuperable difficulty, and even though, comparatively speaking, it might not be dealt with economically, the advantages of the combination of traction and lighting in one works completely outweighed the disadvantages connected with the less economical running of the trams for a short time daily.

Mr. CROMPTON said the battle which had raged over the low pressure continuous system and the high pressure alternating system between the two bodies of electricians had been very puzzling to Corporation Committees who had investigated the electric lighting of towns. The Bradford Committee had been strongly attacked for not having adopted the high-pressure system, but the returns showed that if they had done so their working costs would have been considerably higher, and their works would not have been the financial success they were at present. He knew what he was saying was slightly controversial and might be contradicted, but in saying it he was one of a very strong army, which included Lord Kelvin, the late Dr. Werner von Siemens, Prof. Von Hefner Alteneck, of Berlin, and Prof. Kennedy, who probably advised more Corporations than any other man in England. Those who advocated the high-pressure system were able to show a smaller cost for plant; but this was more than counterbalanced by the higher working costs. He was in a peculiar position. He advised three of the largest companies in London on the low-pressure system, and he held three-fourths of the capital of a high-pressure system at Chelmsford. That installation was just turning the corner, whereas in other towns the turning of the corner had taken place some years ago. The four low-pressure companies in London were paying an average of 5 per cent. on their capital. On the other side there were only two Companies—those at Newcastle—which were paying any interest on their capital when invested in high-pressure plant. The case of Newcastle was easily explained from the exceptionally low cost of coal. With regard to Mr. Hammond's Paper he considered he had put a very moderate case before them in favour of municipalities taking up the driving of trams by electricity.

Mr. R. HAMMOND regretted that from the point of view of the Association Mr. Crompton could not deal with the subject of Municipal electricity works generally rather than lay before them a plea for any particular system. With regard to electric trams he was very pleased to hear from so close an observer as Mr. Crompton that he had not put his case as strong as he might have put it. The great argument he wanted to drive home was that in electricity supply works there were perforce a great many idle hours, and that there was a capacity in those works which might very well be used for tramway traction. He need hardly point out how markedly the cost would be decreased by an increase of output, and this was especially so when they increased the output by doubling the number of hours for duration of work.

PROPAGATION OF MAGNETISATION OF IRON AS EFFECTED BY THE ELECTRIC CURRENTS IN THE IRON.*

BY J. HOPKINSON AND E. WILSON.

Consider a solid, cylindrical electromagnet; it is well known that, in reversing the magnetising current, the induction does not instantly reverse, but a certain time elapses before it again attains its full value, that it reverses at a later time at the centre of the core than near its surface, and that the delay in reversal near the centre is due to the electric currents induced in the iron. The object of the present Paper is to investigate these effects.

The magnet experimented upon had a diameter of 4in., and formed a closed magnetic circuit. Through a part of its length the cylinder of 4in. diameter was formed of an iron core surrounded by two concentric closely-fitting tubes. Exploring coils of fine copper wire were bedded in the iron between the surfaces of the tubes. The currents induced in these exploring coils were observed when the current in the main coil of the magnet was reversed. These currents in some cases last for over half a minute.

Inferences can be drawn from these results as to the behaviour of other diameters than 4in. Comparing two cylinders of different diameters, similar events occur, but at times proportional to the squares of the diameters of the cylinders. From this consideration and the experiments, a judgment is formed as to the effects of local currents in the cores of transformers and of the armatures of dynamo machines.

* Abstract of a Paper read before the Royal Society.

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THE LONDON COUNTY COUNCIL CONFERENCES ON TRADE CLASSES.

Whatever may be the shortcomings of the London County Council in other directions, it must be admitted that its policy in regard to technical or, as we prefer to call it, trade education, a subject over which so many local authorities appear to have gone hopelessly astray, has been marked by both tact and good sense. In the first place, instead of proceeding on the orthodox lines, and handing over the duty of supervising the industrial education of the metropolis to a committee composed solely of its own members, it decided in February, 1893, to delegate its functions to a body tolerably representative of the various interests concerned, and containing 15 outside members out of a total of 35. And within the past few months the Technical Education Board so constituted has taken a step which is even more conducive to the furtherance of genuine technical education than the original departure of the County Council. "Who is he that darkeneth counsel without knowledge?" is a question to which the present-day reply might well be, "The average advocate of so-called technical education;" a state of things for which there could be no better remedy than the series of trade conferences organised by the Board, the second of which, attended by representatives of the engineering, shipbuilding and metal trades, was held in Spring-gardens on Wednesday last week. Technical education is an expression that has been dinned into our ears for the last 12 years, and has almost as vague a meaning as socialism or polarisation. The refined scientific lectures at the Guilds Central Technical Institute, and the research work carried on by third-year students in its laboratories, is called technical education; but, of course, it differs widely from the system of instruction under discussion. "Trade Classes" is the simple name given at Finsbury to this very valuable branch, and, unlike "secondary education," has the peculiar merit of saying what it means.

The remarks of the speakers at this Conference, a full report of which will be found in another column, were characterised, as is generally the case where the speakers are in

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daily contact with hard facts, by a keen appreciation of the limitations and possible evils of technical training. To a London foreman engineer "it mattered little that a man had learned the differential calculus if he could file a key into a wheel only indifferently well. . . . Until the commercial element of time was introduced, technical education would be a snare." The main discussion, however, centred around the desirability of trade apprentices being afforded by law or general custom opportunities of attending day classes, of the instructors being practical workmen, of every technical class being in some manner in touch with "the union or trade it represented," of confining instruction to those actually engaged in the trade taught; the now academic question of the relative merits of the old apprentice system and the modern method of school or college training being quite rightly only lightly touched upon. As regards the first point it would certainly seem right that just in proportion as the fine old system of indentured methodically-taught apprentices falls into desuetude employers should afford reasonable opportunities to the rising generation to learn the fundamental principles underlying their craft, not in stuffy lecture-rooms at the end of a day's work, but whilst the mind is fresh and receptive. Of course, if this desirable end cannot be attained by other means, the inevitable short Act would probably effect what humanity and enlightened self-interest had failed to accomplish. The demand that technical instructors should be practical workmen is a natural and extremely plausible one. Nothing can be more baneful than that a teacher should be set to teach the principles of a trade of which he has no real practical experience. At the same time, apart from the fact that, as one speaker pointed out, the best teacher is not necessarily the best workman, it must be remembered a life-long absorption in minute detail is not altogether the best preparation for one who is required to have a broad view. The third point, about which there was absolute unanimity, is, like the second, extremely specious on first consideration. Trade classes, if they are to serve any useful purpose must obviously be in close touch with the trade concerned; but that they should be controlled by the trade-unions is a demand of a very different nature, and the pliant deference paid to this behest at the Conference last week emphasises one of the dangers to which the existing order of things is exposed. If the plenary inspiration of the greater number is to be tamely accepted as a democratic dogma, improvements in machinery and manufacturing processes will be restrained by a well-nigh irresistible force.

Up to the present industrial education, in as far as it is concerned with the turning-out of more talented and versatile workmen, has to a large extent missed its mark; and the demand which speaker after speaker put forward at the Conference, that trade classes should be restricted to men actually in the trade, is but just and reasonable, if those excluded are to be the amateurs, dabblers, and well-to-do youths who are so prominent, not only at the day, but at the evening classes of many of our technical colleges. But to press the point, as did Mr. Walker, of the Electrical Trades Union, to the extent of excluding *bonâ-fide* working men merely because they happen to nominally belong to a slightly different trade, is both selfish and short-sighted. Mr. Walker is wrath with the authorities of the Battersea Polytechnic because gas-fitters are allowed to attend the electrical classes. Only a few minutes previously another representative of the electrical trade was crying out like a sensible man against excessive "sectionising." Specialism, carried to the degree to which it is in most modern processes, is a decided evil; though under existing conditions it is, so far as one can see, a necessary evil. All those who wish well to society in general, and the working man in particular, should surely welcome every opportunity that is offered of combating this tendency to narrow each man's labour to some small mechanical day stint. For our own part, we should anticipate that an experienced house-carpenter or gas-fitter would, with a modicum of electrical knowledge, make an excellent wireman. The work would be better done, and the worker, with two strings to his bow instead of one, would be far more independent of the vicissitudes of trade than before—two results which contravene no known principles except those of the narrowest-minded trade-unionism.

MODERN VIEWS OF ELECTRO-CHEMISTRY.

A very remarkable paper, by Prof. Ostwald, slightly condensed from published reports in foreign journals, appears in another column. It is so full of suggestive matter that we would rather recommend its study as a whole than endeavour to give an account of its salient features—a task of much difficulty and of doubtful utility in a case where each noteworthy statement depends for its power of instruction on a lengthy chain of reasoning, leading gradually to a logical conclusion. Nevertheless, there are a few points at once of much moment and sufficient isolation to serve as texts for debate and, possibly, for criticism. The preamble of the paper is worthy of the closest attention, for it shows that our greatest commercial rivals—the Germans—are fully alive to the advantages which they possess on account of their greater technical knowledge as a nation, and are also perfectly aware of what gives them those advantages. It is lawful to learn of the enemy, and when he, in the person of a spokesman of the calibre of Prof. Ostwald, deliberately states it as his opinion that the way in which to acquire a knowledge of the technical part of any industry is to thoroughly learn the science on which the practice of the industry ultimately rests, and to avoid the futile attempt to acquire mere "technical training," regardless of previous true education, it would be fatuous on our part to ignore or belittle the pronouncement. The view that a sound education in a science should precede the attempt to learn the details of the corresponding art, is one which we thoroughly endorse; but we would add to it the rider that the right man to receive the double training should be first secured. It is only because we have, as a nation, been fortunate in possessing a sufficiency of the right men, men of some originality, purposeful and able to face difficulties due to novel conditions as they arise, that we have won and retained our present industrial place. A little extra knowledge and discipline, however, would not harm us.

The audience to which the paper was primarily addressed consisted of electricians rather than chemists, and was accordingly restricted as far as possible to the electrical aspect of the questions touched upon. The chemical side is so completely complementary that its discussion could scarcely be avoided, and in several places might have been profitably extended. The reference to osmotic pressure in general carried with it allusion to the obscurity of the origin of that pressure—a matter still craving settlement. Comparison with steam pressure is valid if a source of renewal of the pressure as work is done by its means be postulated; pressure alone is only one factor of energy. Thus the definition of a galvanic cell as a machine driven by osmotic pressure should be amended in the sense that "it is a machine driven by energy, of which osmotic pressure is one factor." The comparison of the osmotic theory of the galvanic cell and the Newtonian theory of gravitation is, perhaps, scarcely to be maintained as yet, in face of the many

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difficulties in the way of explaining all cases from the osmotic standpoint. Prof. OSTWALD is inclined to lay stress on the mathematical obstacles in the way of solution of some points admittedly obscure; the mathematician should at least be heard in his own defence, when, perchance, he would complain of inadequate data.

The ingenious and significant experiment of exciting a zinc-platinum couple by putting the solvent for the zinc on the platinum side of the cell, involves a principle so obvious that those to whom Prof. OSTWALD propounded his conundrum must surely have been taken unawares when they failed to answer it. But it is well worth repetition if only to show the principle upon which the construction of a cell producing electrical energy by the direct oxidation of carbon should be based. All efforts in this direction, in addition to that cited in the Paper, have, we believe, failed to take account of the *modus operandi* of the ordinary aqueous cell.

The mention of an instance in which the nature of the ions conducting a current and that of the products appearing at each electrode is identical—as, for example, in the electrolysis of a fused halogen salt—is interesting; but it would have been of yet further interest if Prof. OSTWALD had formulated his views concerning the electrolysis of a *pure* fused salt. The combination of two bodies appears not to take place in the absence of a third, which should be an electrolyte. Conversely, the dissociation of a binary compound will not occur under the same conditions. But the existence of ions of a binary compound involves its partial dissociation. Whence it follows that if no third substance be present which allows of dissociation, no portion of the binary compound will exist in the ion state, and consequently electrolysis cannot be effected. A binary compound should, therefore, either conduct as a metal or be an insulator. A pure fused halogen salt fulfils the requirements of a substance of this character, and should not suffer electrolysis until a third substance—*e.g.*, some impurity—has been introduced. The extreme electrical resistance of pure water tends to support this view of the behaviour of a binary compound exposed to electrolysis.

THE "S.K.C." TWO-PHASE SYSTEM.*

For the past three years the Stanley Electric Manufacturing Company, of Pittsfield, Mass., has been perfecting a two-phased alternating current system for the distribution of light and power indiscriminately from the same generator and circuit at the highest commercial frequency. The objects kept in view by the inventors were, first, the production of a system which would permit of an economical and satisfactory service of both light and power from the same alternating generator and circuit, and one of such a character that existing light companies could operate it without discarding their present apparatus; second, a system which would make it possible for those just starting in the business to equip a station with one class of apparatus for all purposes, thus avoiding the multiplication of both circuits and apparatus necessary in the past when a company desired to furnish not only incandescent and arc lights, but power; third, to make possible the commercial transmission of water power over long distances and the distribution of the same for lighting and power by a simple system not requiring the duplication of apparatus and many conversions.

The various apparatus included in the system are the joint invention of Mr. William Stanley, Mr. John F. Kelly, and Mr. C. C. Chesney, and so closely have their labours been intertwined that the Company has adopted the three initials "S. K. C." as the distinguishing mark of the various devices included in the system. A great disadvantage of the alternating-current system of distribution as heretofore applied has resulted from its not being able to furnish power service from the same mains, and thus necessitating, where there is a demand for power service, the installation of direct-current machinery and a separate system of distribution. With the system here described a lighting company may very largely increase its earning capital by being able to instal motors on its lighting circuit. It is considered a safe statement to make, that in the majority of towns of any size more can be made by furnishing power than light, as the demands of the former are fairly steady for from eight to ten hours, whereas the maximum lighting service averages only three to four hours.

The inventors call attention to the fact that their two-phased generators can be used interchangeably with the present single-phased machines, and, in fact, fit in with existing systems just as well as new single-phased generators. By adding one of these generators to its present equipment, and by combining the two existing circuits at the station switchboard, or, at the worst, by adding one or two more small line wires, a station can be equipped for furnishing light and power indiscriminately, and when the hours of power service are heavy the two-phased machine can be

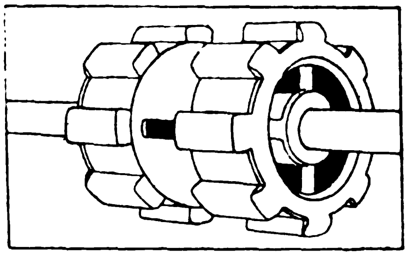

FIG. 1.—Two-Phase Inductor.

run on two or more ordinary two-wire single-phased circuits just as well as one or two of the old single-phased machines can be run on them. It is not necessary to throw anything away, as the present transformers and generators are just as good and useful with the proposed system as with the original ones.

Stress is laid upon the important element in this system, that as motors are started and stopped, or their loads increased or decreased, lights on the same circuit are not perceptibly influenced; also upon the fact that this system can be used with the highest frequencies, thus securing the great advantages possessed by high over low frequencies in first cost, superior regulation, and economy of operation of transformers.

The generators are all of the same electrical design; but have, however, a somewhat different mechanical structure in the larger and smaller types. The revolving part of this machine, which is shown in Fig. 1, is really the field; but is more properly termed

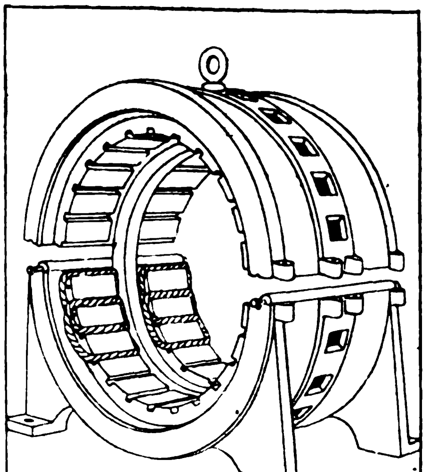

FIG. 2.—Armature of Two-Phase Generator.

the inductor. This is made of a steel casting, upon the periphery of which polar projections of iron laminæ are securely fastened. There is no wire whatever on this inductor, and consequently trouble is obviated from band wires, insulation and collectors, it being simply a mass of metal which can be put in place and revolved with a feeling of perfert certainty that nothing can happen to it.

The armature shown in Fig. 2 is made up of laminæ of iron, and is stationary, constituting, in fact, the body of the machine. The individual coils are very small, are wound separately on forms, and then secured in grooves provided for them in the laminations. Being so small and stationary, it is a comparatively simple matter to insulate them to safely withstand E.M.F.'s which would not be at all safe to generate in the older types of alternating machines. If a coil should be destroyed by lightning or any other cause, it can be readily replaced by the ordinary men employed about a

* Abstract from the *Electrical World* of New York.

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station, as can be seen by reference to the cut. In the small machines it is only necessary to take off the top half of the bearings, lift off the top part of the armature and raise the inductor, when all the coils are easily accessible. In the machine of 240 kilowatt capacity and larger the great weight of the parts would make this plan very inconvenient in many stations, so removable side tables are furnished with this type and, by turning hand screws on each side, the machine can be drawn apart and all the armature coils exposed and made easily accessible. This does not require disturbing the inductor at all, which when the machine is opened simply hangs in its place in the bearings. The side tables need not be kept in place except when needed, as they are removable.

The armature and field wires are brought out from the machine to a terminal board, from which the leads are taken out. The terminal board consists of two heavy slabs of marble, one secured to the machine and the other forming a removable cover. This cover on its inner face is divided into partitions, so that when in place each terminal is in a compartment by itself. It is so arranged that fuses may be inserted in the leads, if desired, as an extra precaution against short circuits. This convenient form of leading the wires out of a dynamo is made possible by the absence of collectors or commutators. By simply changing the connections on the board the armature coils may be connected either in series or parallel, so that the standard machines may be connected for either 1,000 or 2,000 volts, as desired.

The field or exciting coil is circular and wound on a copper spool, which rests in the centre of the machine, surrounding the inductor. It is thus easily insulated to a very high degree, and, being enclosed on three sides by the heavy copper spool, danger of breaking down the insulation due to a discharge caused by breaking the field circuit when it is fully charged is practically removed.

The following efficiencies are given for the several types of machines:—

—	60 kw. Per cent.	120 kw. Per cent.	240 kw. Per cent.
Efficiency at full load	94	95	96
" " half load	91	93	94
" " quarter load	85	88	90

There being no moving wire, it is safe to run this type with a closer clearance than is advisable with other machines, even of toothed armature construction. The design also permits of abundant ventilation, so that it runs unusually cool. The maximum rise in temperature above the surrounding atmosphere is not more than 50°F. in any part of the machine after a continuous run of 24 hours at full load.

One of the most important properties of the machines is their inherent regulation. The designers have proceeded on the theory that compounding in itself is an unquestioned disadvantage, as it complicates the generator, and makes commutation necessary; while it has been necessary, however, in the older types of alternating-current generators not regulating otherwise within 30 or 40 per cent., the new type of generator has an inherent regulation of from 6 per cent. to 9 per cent., depending on the size of the machine and the margin of E.M.F. desired. With one of these machines the full load, excepting one lamp, can be thrown off instantly, it is claimed, without materially increasing the brilliancy of the one remaining lamp (provided, of course, the speed of the machine is constant), and this is accomplished without any extraneous regulating device whatever. It is claimed that there is no possible advantage in compounding when two or more circuits (with 10 per cent. or more loss when fully loaded) are often supplied by a single generator at times when one of them may be fully loaded and the others half or quarter loaded. The vexing problems of distribution are solved by using a closely-regulating machine, and by being more liberal in the use of copper in the line. This liberality will pay for itself many times over by saving in operating expenses, by saving the first cost of all sorts of devices, and by saving in repairs.

As has been pointed out by the inventors of this system, by Kennelly and others, the shape of the current wave generated by a machine is of great importance in order to obtain the best economy in transformers and in the operation of motors by alternating currents. Some of the original types of alternators used in this country, with the surface-wound armature, produced a very good form of wave; but the so-called toothed armature machines distort the wave so that instead of being in the form of a sine curve it is jagged and irregular. In the generator described, the poles, both on the armature and inductor, being stamped out of sheet iron by dies, are all exactly true and perfectly formed, and as the armature is stationary there is no need of overlapping teeth to hold the coils in place, consequently the form of the current wave produced is what it ought to be theoretically, that is, a sine curve. In operating motors commercially this is of great importance, as it permits of the more complete elimination of the false currents. In the ordinary operation of lights it is also important, because with a current of this character the energy lost in the iron of transformers (core loss in watts) is about 10 per cent. less than with the usual form of current supplied by other types of alternators.

If it is desirable to run alternators coupled in multiple it can be accomplished with this generator, from the fact that the poles on any two or more machines, both on armature and inductor, being necessarily exactly alike, the form of current wave must be the same from all the machines and coincide at all times. The close regulation of the machines is also an important factor in this connection.

The alternating current motor that shall fulfil the conditions imposed by commercial service must possess the following characteristics:—It must start from any position of rest with a torque considerably greater than its running torque; it must maintain constant speed under maximum variations of load and its operation

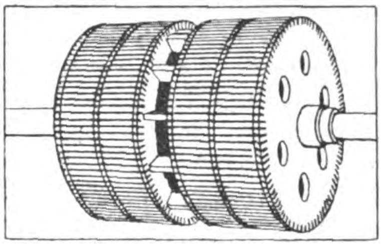

Fig. 3.—Two-Phased Armature (Unwound).

must not unduly disturb the potential of the system. The further qualities of simplicity of construction and operation, and of efficiency in converting electrical energy into motive-power are, of course, necessary.

It is thus evident that synchronous motors cannot fulfil these commercial requirements, for they cannot start from rest with sufficient torque. Alternating current motors of the induction type, either for single or multiphase circuits, have the disadvantages due to the false currents developed by such motors; the difficulty of making them with good starting torque without producing very excessive false currents, and the impossibility, because of these false currents, of producing a comprehensive system for both light and power fed by the same dynamo and circuits. These false currents react on and abnormally demagnetise the generator and transformers, thus introducing difficulties in regulation. They also would make necessary the use of generators, lines and transformers disproportionately large for the work to be done. In a

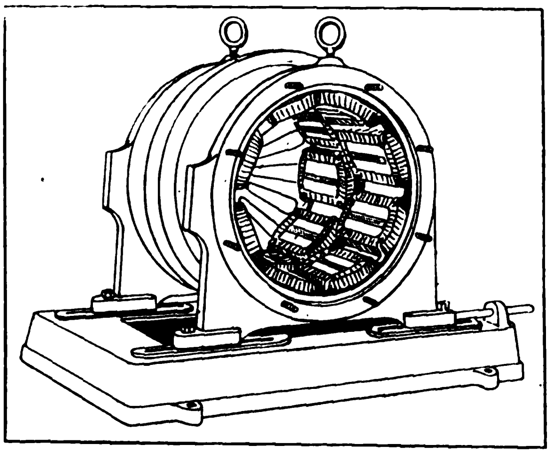

Fig. 4.—Two-Phase Motor Field.

commercial system for distribution of light and power widely throughout the city, motors which take current about in proportion to their load are essential.

Another reason why alternating motors have not been introduced in this country has been because of the high frequency here adopted, at which the false currents are much greater than with lower frequencies, and their disturbing features more difficult to overcome. One object of the Stanley Company has been to produce a motor which would be commercial on the standard frequencies used in this country in order to, in a great many places, simplify the problem of adopting multiphase apparatus because of the vast amount of money already invested in generators and transformers only adapted for this high frequency.

The "S. K. C." motor is novel, and its principle of operation may be best described as consisting of two parts, a motor proper and a rotating transformer, the two parts alternately exchanging

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their functions. It consists electrically of two fields, which are fed by currents differing 90deg. in phase, and two armatures, though mechanically there is but one. The winding is so connected that the wire which lies directly under poles on one armature is in series with the wire lying between poles on the other. It is clear that in this position one-half the machine acts as transformer and the other half as motor. The motor armature is shown unwound in Fig. 3. The armature winding is not connected with the circuit, and consequently the only current flowing in it is an induced current.

The field construction is shown in Fig. 4. The coils are wound separately, and then secured in place. These coils are the only part of the motor connected with the circuit. Being stationary, they are easily insulated to a high degree. The applied E.M.F. on the coils is 500 volts.

The most unique and striking feature of this motor system is the use of the condenser, the function of which is to make the motor take current in proportion to its load substantially as direct-current motors do. The condensers are connected in multiple with the fields of the motor; and when so placed they supply the lagging component of the current, or, in other words, the false current. Thus, with this arrangement, the false currents, instead of flowing back through the transformer line and generator, thereby disturbing the whole system, simply flow in a local circuit through the condensers. This enables alternating current motors and lights to be operated successfully from the same generator and circuit. Without condensers it is claimed that alternating-current motors cannot be operated on the same circuit with lights on currents of high enough frequencies to meet other commercial conditions. The condenser in use is no trouble and does not complicate the system. When once set up in place there is nothing to do to it, being like a transformer in this respect. Much study has been given for the past two years by the Stanley Company to the manufacture of condensers for commercial use with its motors, with the result that they are now guaranteed thoroughly reliable and inexpensive.

THE LONDON TECHNICAL EDUCATION BOARD.*

ENGINEERING, SHIPBUILDING AND METAL TRADES CONFERENCE.

The second of the series of Trades Conferences, called by the Technical Education Board of the London County Council, was held at the County Hall, Spring-gardens, on Wednesday, 20th inst., at 8 p.m., Mr. Sidney Webb, L.C.C., presiding. The following points were suggested for the consideration of delegates and others taking part in the conference :—

(1.) Training in public elementary and continuation schools.

Whether greater facilities than now exist should be offered to children to continue at school for two years after passing the sixth standard, and the nature of the instruction to be provided.

(2.) Continuation of education after entering the trade.

(*a*) The desirability of having technical schools for members of the engineering and metal trades open in the day time, and the steps, if any, to be taken to make it possible for young apprentices to attend these schools for, say, two half-days in the week.

(*b*) The modifications, if any, required in the organisation and teaching of evening classes in such subjects as geometry, elementary mathematics, applied mechanics, steam, mechanical engineering, pattern making, metal-working tools, machine design, naval architecture, electricity, electrical engineering, and the corresponding laboratory work, &c., and the desirability of teaching the principles of these subjects to members of particular trades, apart from other students, so as more definitely to direct the teaching into useful channels.

(*c*) The best methods of combining sound instruction in principles with practical training in mechanical processes, and generally the best way of associating the theoretical class teaching with the school workshops.

(3.) Special training for those who desire to equip themselves for appointments as foremen or managers—

(*a*) The desirability of providing day teaching of an advanced character in a technical institute provided with an experimental laboratory, and the nature of the aid which would be necessary to enable workmen to take advantage of such teaching.

(*b*) The character of the teaching to be provided, whether in day or evening classes, for foremen or managers, particularly with reference to machine drawing and design, the setting-out of work, principles of the steam engine, the management of machinery, &c., and, for electrical engineers, the methods of electric testing.

(4.) The manner in which the Technical Education Board can best render aid in connection with any of the branches of teaching work indicated.

(5.) The means available for making known to members of the trades, especially to apprentices, the educational facilities provided.

The CHAIRMAN briefly introduced Sir John Hutton, Chairman of the L.C.C., to the delegates.

Sir JOHN HUTTON said he need scarcely say how pleased he was to have an opportunity, through the courtesy of his esteemed friend and colleague, the Chairman of the Technical Education Board, of welcoming them that evening. He regarded it as a most interesting occasion; in the first place, because that was a picked audience, consisting of delegates from various trades and associations, and an audience not only competent to express their views upon the subjects which would be brought before them, but also views that would be of practical value in the administration of the Technical Education Board. In addition to that, they were present for the purpose of helping the younger men who were coming on. No one could say that the object of their presence was their own immediate financial or trade advantage, and he rejoiced to know that that spirit animated them. That he said in no patronising sense, but as a very humble co-worker for the public good. Might that spirit grow and multiply, and still grow on. It was his profound belief that workmen had advantages to their hand of which they had not taken the full benefit up to the present, and that there were opportunities in London which from past neglect had remained absolutely unrealised. It was an old grievance that London was far behind foreign countries in technical education; and when they said that they often with a sigh passed on to consider, not how to remedy that state of things, but how grievous it was, and then the subject dropped. Happily, they lived in better days, and the Technical Education Board of the London County Council had set itself, during the last eighteen months or two years, to seriously consider the question. He ventured to think that the neglect of the subject in the past had been largely due to the fact that it was of very slow growth, and perhaps the spirit of the age was "small profits and quick returns." It reminded him of walking in an avenue of oak trees, realising the pleasant shade of those trees, and forgetting that they were once acorns. Now, that evening they were implanting in the soil of the London technical education schools those acorns which, if properly planted, would germinate and fructify until they produced a giant forest, under the shade of which many a worker yet to come would find refreshment and encouragement. The first conference had been devoted to trades which might be considered as affecting the comfort of home life, but on the present occasion they had to consider trades of greater magnitude and importance, and which in a very distinct sense affected the safety and the welfare of every resident in the country. To engineering they owed those so-called wonders of the world, the pyramids of Egypt, the Roman aqueducts and magnificent roads, in construction scarcely equalled, certainly not surpassed, by modern science. Then they had the civil engineering of the present day, their railways, docks, harbours, bridges; and the desire of the Technical Education Board was that men—the men who were coming on—should have a grasp of the theoretical and the practical parts of the work, without which perfection could never be attained. The Board desired that there should be worthy successors of such men as Smeaton and Brindley and the two Stevensons, father and son, and many others. It was related than an eminent man had been accustomed to raise his hat when going through any of the public schools, because a future Lord Chancellor of England might be in that school; but he (the speaker) did not know but that they could better do without a future Lord Chancellor than without eminence in the engineering art, and, if reverence was due from them to those who in the future might be excelling in a particular walk of life, they might well raise their hats to those boys and girls who were being employed in their technical schools. With regard to shipbuilding, if, unhappily, it was a matter that did not practically interest them in London, they were consoled by the fact that 70 per cent. of the commerce of the world was in English ships, and, although it was true that London in this respect was not the London of thirty or forty years ago, when from Northfleet to the Pool could be seen signs of the shipbuilding industry, still, they were rich enough in wealth, and, he hoped, in talent also, to be able to instruct their young men in this art, so that they might carry their knowledge of it to other centres of industry. With regard to the metal trades, they perhaps offered a special induce-

* From the *Technical World*.

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ment to educated youths, because they might always feel themselves to be on the verge of a discovery in science which would mean a fortune to themselves and, what was infinitely better, a benefit to mankind. Who 20 or 30 years ago would have thought of steel rails for railways? and science had still secrets not yet divulged in regard to the combination and treatment of metals, which offered a wide and interesting field for the intelligence of the young men who were rising around them. He hoped the spirit of mutual goodwill might prevail and grow and multiply, and the dignity of labour be a reality, and not a sham, to be known and felt of all men.

The CHAIRMAN, after the eloquent words of welcome they had just listened to, would not trouble them with any remarks of his own, beyond two or three connected with the business before them. The Education Board had no views or fads of their own; they were in the position of learners. They desired that whatever work was done in London in the direction of technical education might be turned towards the turning-out of perfect workmen, and not wasted in increasing the number of smatterers. He would ask the delegates to address themselves to the agenda on the paper before them, not dealing with the subjects one after the other, but generally, and, perhaps, they would get on better without moving any formal resolutions.

Mr. STEWARD (London Trades Council and Silversmiths' Association), addressing himself more particularly to the subject of gold and silversmiths' work, said there was a sad lack of education in technical drawing, such as young lads and men would adopt in their particular branch of the trade. In no school were lads taught how to adapt design to work in metals like chasing and *repoussé* work. He hoped the Board would see that the education given included technical and artistic drawing. Then, with regard to confining the education to boys intending to engage in the trade as a livelihood, he instanced the New Cross Institute as one where the education was extended to any and everyone who cared to avail themselves of it; a carpenter it might be, or an engineer, or a joiner, and so on. It would be well if the minds of the delegates could be made clear as to whether the Board intended to give assistance to those schools in London in which everyone was free to come in. Again, some principles would have to be laid down in separating the men engaged in the various branches of a trade in the workshops; for instance, the pattern-maker from the engineer, and the zinc-worker from the tin-worker, &c. In the silversmiths there was a clear distinction made between the silversmith and the spoon-maker; the latter was looked upon as the silversmith proper. If enamelling and engraving were distinct branches of the trade, and if plate-working and goldsmith's work were distinct branches of it, so must chasing and repoussé work be also. He might suggest, also, that if it was decided to teach the lads modelling, it could be done simply and effectively by allowing them to model in clay and wax. That would be a great help to the stonemason, the carver, and even to the architect, as well as to the gold and silversmith. If they set them to work to learn to manipulate metal, they must first teach them a good deal about the technique of the metal, and that, the speaker thought, involved a waste of time. Then there was a great need of good teachers. Men were engaged not so much for their abilities as because they were willing. That might be attributable to the inability to offer decent wages. Thus they might find a metal graver teaching repoussé work and so on, whereas the teachers ought to be specialists. It might not be essential for every teacher in a school to be a practical man, but he did urge, and the whole of his fellow workers urged, that the teachers in the special classes should be specialists in their class. As regards the lads, it was a frequent complaint that they would not be got to attend the classes. If the masters could be induced to allow their apprentices at least one half-day in the week in which to attend the schools, it would be a great gain. He thought the falling-off in attendance might be due to the boys being set to do hard-and-fast things after being at work all day in the workshops. Discipline was a very good thing; but encouragement was desirable also, at any rate in making a start. The whole of the metal trades were agreed that the classes should be held in the centres where the workers reside.

The CHAIRMAN explained, with regard to evening classes, it was laid down in the regulations that instruction was to be given in the subjects mentioned only to those students who were actually engaged in some branch of the trade to which the subject of the class had reference. The rule had not been found so easy in application as might have been expected, and the Board would be glad to receive suggestions on this point.

Mr. ROBINSON (United Pattern-makers' Association) said he knew something about pattern-making, having been engaged in the trade for some 33 years. He understood the object of the Conference to be to elicit such information as would best enable them to educate the young workman in the principles and sciences of his craft, so that he might be a better and more efficient workman and of more commercial value to his employer. Taking an average pattern-maker in a well-appointed engineering firm, in addition to the elementary rules of arithmetic, he should be well up in vulgar fractions and decimals, and he must have a fair acquaintance with plane and practical geometry, not as geometry was taught in the schools, but as applicable to his work. He had known young men, well educated in the sense of having been to school under the ordinary schoolmaster, who, if called upon to apply the most elementary principles of geometry, such as to construct a perpendicular line on a particular base, were utterly at fault. A pattern-maker must also have a good knowledge of mechanical drawing, not that kind of drawing which consisted in being given a subject to copy, which the schoolmaster himself did not understand. Those present who had copied a screw would know what a trying and tedious work it was, and especially to a young man who had been at work all day. But, by explaining at the same time how the setting-out of that screw would have to be applied, they would get greater interest thrown into the work, and the instruction would be of more value to the boy when he went into the workshop. In the small engineering shop technical education was of the utmost value to the pattern-worker, because, if in the large engineering shop draughtsmen were employed to work out details, in the small shop the pattern-worker had to rely on his technical training received in the school. Therefore his knowledge of mathematics must be extended, and he must possess a knowledge of the mechanical details of his craft. He must know, for instance, the relative stress of metals, the contraction and internal strain of iron and light castings, &c. So far as the Board aimed at imparting technical training to *bonâ-fide* apprentices in pattern-making, they would have the sympathy of every workman in the trade. He was not one of those who were frightened by the German bogey. From his 30 years' experience he was quite convinced that the British workman was able to hold his own. The Board should establish its schools in convenient centres, and boys who showed special aptitude should be given opportunity for extending their studies after receiving a general technical training. The boy himself, the master, the workmen, and the trade were all interested in his turning out an efficient workmen. The nation also had an interest in it, and the expense should be borne by the parties who would benefit by it; and if the workmen were to be called upon to bear a portion of the expense, they must also have a voice in deciding how many, and what boys, should be brought into the trade. So far as the technical education was confined to the boys, *bonâ-fide* apprentices in the trade, the Board would have the sympathy of every workman engaged in the trade.

Mr. SENIOR (Electrical Trades) wished to draw attention to a very serious question so far as employés in the electrical trades were concerned. The electrical industry was as yet in its infancy, and, he regretted to say, in a very crushed condition. He welcomed any measure that tended to improve its condition. It was a trade that technical education had much to do with. One of the greatest of the evils he complained of was the tendency among electrical firms to sectionise. That was a system which, if not checked, would end in flooding the labour market with incompetent and unskilled workers. What was necessary was that the boys entering the electrical trades should receive, not only a theoretical but a practical knowledge of electrical science and of the trade generally. They entered quite young into the business, and with the promise of a complete and practical education to fit them to be electrical workers; but such was not the case in practice. They were put upon a certain class of work, kept at it for years, and finally left the workshop with only a partial knowledge of their trade, and ready for any job that was offered, not through any fault of theirs, but of the system. To take an illustration: He had known of youths being put for five or six years to wind bobbins for electrical bells, and other trifling things. The employer was thus able to produce an article, but not by a skilled workman. He hoped the Board would endeavour to devise a way by which boys in the electrical trade would receive a practical training. He would also urge that none but those who intended to get their living in the trade should receive that training. The schools at present were glutted with students in electrical science. Of course, the instruction they received was mainly theoretical, but they would, doubtless, be prepared to take advantage of a practical training if allowed to do so, and the trade would be over-manned.

Mr. JAS. POOLE (Horological Institute) endorsed the remarks of the previous speaker to a great extent. Unfortunately, the system to which Mr. Senior referred was frequently governed by the price which the employer could get for an article, as in the case of a Government contract the price which the Government would give. It was impossible in such a case to make a thing at anything like a profit, unless by sectionising the work to the utmost. A workman would find it impossible to earn a bare existence at the prices paid for the work. The same difficulty ran through all the trades. In the Horological Institute practical classes were started in the year 1880, subsidised by the City and Guilds' Institute to the extent of £350 per annum, the greater part of which was spent upon the teaching staff. Only a very few lads attended the classes, and

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those who did took their own time over the work, which was simply an amusement for them. The trade, as a manufacturing trade, and as regards its position as a national industry, had not been benefitted at all by any education which those youths had received. He attributed a great deal of the failure to the training being too much open to anyone who liked to make use of it, and who, as a rule, simply did so as a kind of advertisement. Such people went through a course, obtained a certificate, and then set up as retailers on the strength of it, spoiling everything entrusted in their hands, while the real solid work was done by men who were scarcely able to write their own names. When any work was to be done they had to fall back on the old, partially-educated men. A little knowledge was a dangerous thing, and a thing might be a great deal better done by men who did not pretend to much education, but simply did what they were told. He thought they had got beyond the time when employers knew nothing about their business ; still, it was necessary that the workmen should feel that the employers understood the orders they gave, and, therefore, he urged the necessity for education for employers, that they might not be above their business as they often had been.

Mr. Coates (London Association of Foremen Engineers), as one of a representative body of London foremen, thought he could speak with some authority. He had been in charge of workmen in different branches of the engineering trade for over 30 years, during which time he had seen the rise and growth of technical education ; and he would say at once, from his experience, that so-called technical education had spoiled far more fairly good workmen than it had produced. In the first place it was a misnomer. Technical education should be something which taught a man a better way of performing the work by which he was to earn his living. It mattered little to him that a man had learned the differential calculus if he could file a key into a wheel only indifferently well. So far as producing work was concerned, and the filing of the key into its place in the time and at the price at which it could be sold, such training was absolutely useless to the employer. And, as regards colleges, he had had some 16 gentlemen apprentices, who had not received their training in the ordinary School Board technical classes, but in some of the colleges, and with one exception not one of them had ever done a piece of work worth looking at, although they spent six or seven times the time consumed by the ordinary workman. The failing of all the technical instruction he ever came in contact with was that boys were set by the teachers to do things quite irrespective of the time which should be occupied in doing them. Until the commercial element of time was introduced, technical education would be a snare.

Mr. Musin (Tin and Iron Plateworkers) endorsed much that had been said by Mr. Steward ; but in the case of the pattern-makers, his own section of the trade was more fortunate. They had to thank the Polytechnics and the City and Guilds' Institute for having given them practical technical classes in which apprentices were taught by practical workmen, who, after working at the bench all day, took charge of the lads at night. The technical education they required was to teach them how to cut out patterns and to deal with metals for their various purposes. For that not merely theoretical teaching was required. To most of these classes, he believed, workshops were attached. He had been surprised to hear it said that evening that technical education was no good. Some years back, as an apprentice, he looked about him in vain for a class of the description of those that were now flourishing. He had had to go to various geometrical classes, and to wade through an amount of unnecessary work to obtain a little practical knowledge. Now-a-days they had classes which taught the very thing that was required in his particular trade. Several of the lads working in the same workshop as himself were superior to many of the men in producing patterns for the work they had to do. At the same time, they were not altogether complete on the matter. For instance, these classes were not connected with the trade. He thought that every technical class should in some manner be in touch with the union or trade it represented. As to the question whether facilities should be given for apprentices to attend the classes in the daytime, he had been told by teachers that it was difficult to get apprentices to go practically into their trade after a hard day's work ; they tired of it. The only way, therefore, was to endeavour to get the masters to see the necessity of allowing their apprentices some time during the day in which to attend the classes and obtain the technical knowledge which it was almost impossible to get in the workshop, where every man was at his bench, and who, if he had the will, had not the time to teach apprentices their business. He would also urge upon the Board that in all classes the teachers should be men engaged in the trade which they taught. As to making the existence of these classes known, he suggested that those who belonged to trade unions, and workshops connected with unions, should endeavour to persuade the young men to take advantage of these opportunities for technical education. A word from a man urging a young man to go forward would do far more than all the bills and newspaper paragraphs that might be printed. They in the trade he belonged to were thankful for what had been done ; but, for himself, he would wish that the trade should be in touch with the classes, and have some authority in their guidance.

Mr. Barrett (Barge-Builders' Union) said he did not know whether the Board intended to ignore the barge-building trade of the London river. There was no mention of it in the agenda ; but, however that might be, he could assure them that the barge-building trade of the London river was entirely a separate trade by itself, and had been so from time immemorial. Believing that the rising generation and the lads now serving their time would have their interests well looked after by the Technical Committee, he would confine his remarks to the subject of the technical education of workmen in the trade. These should have at least an opportunity of learning the practical basis of their trade. He did not suggest that the members of the trade did not already know the practical part of their business, because he believed the great majority of them did, having had the opportunity of working at it ; but very few of them would, if they were asked, be able to tell the reasons why steel, for instance, should float, or why wood should float, simply because they had never been educated to understand such matters. The Board should, he thought, offer the workmen in the trade who were desirous of it, and he believed many of them were, an opportunity of learning the practical principles of the barge-building trade, and also that they should be allowed every opportunity to attend the various technical institutions in London. He urged this more particularly because he did not doubt that many of those present when they crossed the river, and looked at the craft going up and down, must have felt, as he felt, that the barges were a disgrace to such a country, and not merely to London. That was not the workmen's fault, but the employers', and they would never get the Thames to look handsome (as he believed it was the wish of the London County Council to make all London look handsome) until they improved the appearance of their barges. He did not know whether the Board supplied the implements necessary in technical education, but he wished to impress upon them that the men in the barge-building trade would be only too glad to take advantage of any scheme the Board might have in view.

Mr. Reginald Middleton (London Chamber of Commerce) said he would tell them, in the first place, why he was able to speak to a number of practical men. He had served his time at Stevenson's in Newcastle, had been through the workshops, been a pattern-maker, an engineer at sea, had built several large bridges, was a civil engineer in practice in London, and also an instructor in surveying at the Central Institute of the City and Guilds of London. Drawing was, in almost all cases, the foundation of all technical education. A man who could not draw was generally more or less useless in pattern work. The first step to be taken in almost all cases was to educate a man to draw. The writer who said that to draw a pint pot accurately was in itself a liberal education had only said what was true. As regards the teachers in the schools, as a teacher himself he might be able to say something. When first he went to the Central Institute he took up a perfectly new pupil who had had no experience in the work he had to teach. The subject had been previously dealt with very lightly, and, indeed, was very little known in the college. Since then he had gone on teaching perfectly new students every year for five years, and the effect of teaching in that college single new pupils who had never seen him before was that they knew more than the first pupils knew when they left, simply because they talked amongst themselves about the lectures he had given them. The best teacher was not necessarily the best workman, as the best critic was not always the best author. The art of teaching was one which came to some naturally, to others it came with great labour, and to many it was quite impossible, although they might know the work itself thoroughly. He thought they would find that when the technical schools were commenced the teachers would come of themselves. But they would have to begin with men who, though skilled workmen, were not very good teachers, but who would, in many cases, develop into good teachers, and where they did not their places would be taken by their own pupils in time, who would be good teachers. Exactly as drawing was a great desideratum, so was modelling. There was no reason why a man who had learned geometry in the schools should not know geometry in the shops. If he did not do so, that was merely because he had not been properly taught. A speaker had said that from his experience technical education was useless. Speaking of the college, with which he (Mr. Middleton) was connected, he thought that if the author of that remark only knew the students there, he would admit that technical education was most valuable. When he served his time in Newcastle there were absolutely no means of obtaining technical information ; he had had to pick up what he knew in the shops from the men, who, of course, were not educated in any technical sense, but simply knew the best way, as they thought, of handling their tools. He had had to learn the practical part of his business first and the theoretical part afterwards with much pain and labour in the course of his daily work. Now all that was changed, and the young man

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who had just gone through college came out of college knowing more than most of them, like the speaker, knew after ten years' work. A proof that that was so was that many of those pupils had, only two or three years after leaving college, obtained managerships of various works in London, entirely through merit, and without being pushed at all, and were found to be more valuable to the employer than the man who had served the same time in the office. In the course of his own professional work he had had a good many pupils, but those he had had from the Central Institute, who had come to him with very little practical knowledge, had picked up that knowledge far more readily than the others, and had become far more useful in much less time. Under these circumstances he thought they might say that technical education was valuable. He agreed with the same speaker when he said that technical education was to teach the pupil the work of his life. If what he was learning was not the work of his life, it had better be let alone. Technical education should be that, and therefore the teaching should be directed as much as possible to the work in which the pupil was to be engaged. But, at the same time, any information he might pick up along with it would be so much gain. With regard to sectional work, he was aware that it was a great grievance to many; but he was afraid that the tendency of the day was entirely in support of it. In the speaker's own profession, the man who took up a specialty was the successful one. Another individual might be more useful in more branches of his profession, but he was not the man who got on. In America, where mechanics were paid much more highly than here, the tendency to sectionalise was far greater, and the work turned out was generally better done and cheaper for that very reason. After all, everything depended upon the commercial value of the thing. If they could not turn out a good thing and very cheap they would not get the work, and in order to get the work done well and cheaply it was necessary to sectionalise. Watchmaking, sewing-machine making was better done when sectionalised. Another speaker had said that he was not afraid of Germany. It did not do to undervalue one's opponents. He had travelled a great deal, both on the Continent and in America, and he had seen that the people, who in his youthful days were far behind the English in mechanical knowledge, were, in many cases, now far in advance. There were branches of engineering which were far better understood on the Continent than in this country; for instance, in Switzerland, where they had much water-power; and he was afraid they must give the palm in all stationary engines to Germany. The Germans made better engines and understood them better than we did. He strongly advised the Technical Education Board to advance, not too fast, but as steadily as possible, and he advised every workman to be prepared to take up sectional work when it came.

Mr. Harrington (Zinc Workers' Society) said the zinc workers seemed to occupy a place all to themselves. It had been left to them to inaugurate their own classes. Four years ago, seeing the efforts made by other trades for their young fellows, they had thought it their business to do the same. They had a difficulty, seeing they were not subsidised, until the Regent-street Polytechnic came to their aid by placing their rooms and appliances at their service, and then they started a class and had had a remarkably good attendance, and some of the most able men in the trade as instructors. They had had a first term, a second, and a third term, at the end of which their funds fell very low, and they had no subsidies. It then occurred to them that, as other classes had their teachers paid for them, the zinc workers might also enjoy that advantage. They wrote to the governing body of the Regent-street Polytechnic, asking that they would subsidise their teachers, and that they might have three teachers at the minimum of five guineas a term. The governing body referred them to the Technical Instruction Board of the London County Council, who, after considering the matter, said they already paid a very large sum to the Regent-street Polytechnic, and referred the society to them. The Board were not aware that any class in the Polytechnic was in the same position as the society, and they left it to the Polytechnic to say what they would allow. The society wrote to the Polytechnic some two or three months ago, but had not had a reply, not, he was sure, from any want of sympathy with the society. Having thus fallen between the two stools, the society looked with confidence to the County Council. As to practical education as well as theoretical education, he thought it most valuable. The two should go hand in hand. In their own class they had some young fellows exceptionally sharp, and others not so sharp, able to follow instructions in a methodical sort of manner, but afterwards completely in a fog. If they had only practical education in applying the theoretical training it would be of the utmost advantage to them. Happening to be one of the Lord Mayor's delegates to the Paris Exhibition, he went one evening to the headquarters of a trade society very closely resembling his own, to which (although not subsidised in any way, so far as he could understand by means of an interpreter) a man who wanted to know anything might come and ask his more instructed fellow-workmen how to set about it. One portion of the building was filled with large models, and workmen were there demonstrating the practical part of their work to their fellow-workmen freely.

Mr. Eldridge (President of the Silver Trades Council) ventured to say that the gentleman who spoke of technical education as useless had spoken in sheer ignorance. For himself, he served his time as an apprentice in the silver trade for seven years; but, as regards the constituent parts of sterling silver, he had had to learn them since. Such ability as he possessed he had had to learn in other ways than in the shop. As President of the Silver Trades Council, representing about 1,000 organised workmen in that trade, he was anxious to emphasise and to urge upon the Board the importance of only giving instruction to those already engaged in the trade, or who were going to get their living by it, and of only supporting those schools that did give instruction to men working in the trade. They had no wish to confine the teaching to the particular branch in which a young fellow happened to be engaged; they would as far as possible have everybody engaged in a trade to know the general principles of that trade, as otherwise he would become a drug in the market, and tend to reduce wages instead of keeping them up. Had there been technical classes when he was an apprentice he would gladly have availed himself of them. In that case he would not have been obliged to accept such a small wage as he had done after serving seven laborious years at a wage which, had his parents not been in a position to maintain him, would have been quite insufficient for his needs. Though ability would always tell, however uneducated a man might be, still technical education would assist him far more than he could hope for without it, and a man who had the ability to be head and shoulders above his fellows, with better education, would be entitled to rise still higher; it would be also to the advantage of those with whom he worked and to the good of the trade generally. The only fear they had was that in a trade which dealt in luxuries the purchaser might not be himself sufficiently educated to be able to understand a thing when it was made, and to estimate it at its true commercial value. The difficulty was to produce a common article to suit the taste of the purchaser. The need was that the purchaser should be educated above the workman, so that he might know a piece of good work, and why it was good work. Technical education was bound to tell among the workmen; they would be better workman because more intelligent. It was also absolutely necessary that men engaged in ornamental work like his own should understand both modelling and drawing. It would often be of the greatest assistance to a workman to be able to set down on paper his ideas, instead of having at first to make the article before they could find out where their mistakes lay. The Board could not do better than continue to give this education, and, speaking for his own trade, and the branches associated with it, they would do their best to assist in laying the needs of technical education before the young men and boys who came into their trade. He wished every success to the efforts of the Board, if only they would adhere to confining it to the men engaged in the trade.

Mr. Sellicks (Chairman of the Council of the Amalgamated Society of Engineers) said the general sense of the meeting seemed to be that only those who intend to follow a trade as a living should be taught in the technical schools. After the Chairman's announcement that the Board had adopted that principle, it was unnecessary for him to make a point of it. One thing, however, seemed to have escaped the attention of the delegates, and that was the extra strain upon the physique of the boys when called upon to attend technical schools after a day's work. He would like to move a resolution dealing with that, because if the discussion should go on without focussing the ideas of the delegates at all, except for expressions of opinions, they would not reach any definite end. He would read the resolution he intended to put as follows:—

"That in the opinion of this conference, the advantages arising from technical education being of national importance, it is desirable that some provision be made by employers to enable apprentices to attend school in the daytime, and in the event of the Technical Education Board not being able to effect this by any other means, powers should be sought from Parliament to enforce it."

Continuing, Mr. Sellicks said they had already a compulsory Act of Parliament making what are called "half-timers," and it was as reasonable to expect that Parliament should enforce the allowing to lads of time in which properly to acquire the theoretical and practical part of their trade. He had practical experience of the inroads which these overtime studies could make upon the health of a boy not over strong. The resolution, he ventured to say, was one which most of them would sympathise with. Even should the employers be compelled to pay the lads it would not be a great expense to them, besides being to their advantage that the lads should be properly taught; and, if the employers could not afford the expense let the nation pay the cost, for if it were to the employers' advantage it was equally

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so to the nation. In regard to competition, it was regrettable that things had to be turned out at a certain price. They often heard it charged against workmen that they scamped work. He took it that the majority of those present were workmen, and would be prepared to endorse that charge. He maintained that the British workman of the day, given the chance, was as capable of turning out as fine work as was done in the Middle Ages, in any branch of the trade; but they could not do it if they had to compete and struggle. The cart was always at the door, and hence this hurry-scurry over the work and this eternal competition, and the employers turning round and charging the workmen with scamping their work. The employers imagined that they scamped it from choice; but nothing of the kind, a good mechanic loved his work. That should be the object of technical education. He believed it to be of immense value.

Mr. IMERSON seconded the resolution, which was carried *nem. con.*

Mr. PURVER (Wheelwrights' Society) said the technical education scheme seemed to him a good one; but, as a wheelwright smith, the question to his mind was how would it affect his particular industry? The apprentice system, as far as his trade was concerned, was long since dead and buried, he hoped never to rise again. Under that system the employers, having received a small premium with the boy, the apprentice was left to learn as little as he might, and then passed out to join the great army of the unemployed and unskilled workmen. If the Board wished to do the wheelwright trade any practical good Mr. Webb must use his influence upon the Council to obtain for the workmen better conditions under which they might work. That might do a great deal of good. At present what was desired was rather quantity than quality. They had not the time to consider a nice piece of work. A workman who might look twice at one job would be discharged. The masters needed educating as much as the men—in fact, they needed it more. If the masters would only realise that the better the class of work turned out the better for them in the long run, they would give the workman a chance to turn out a piece of work he could take some pride in.

Mr. WELLS (Wheelwright) also feared that the apprentice system was dead in the trade he belonged to. Boys in the wheelwright trade were left to pick up what they could. He would view with great pleasure any scheme for educating youths in the trade, as at present they practically received no training at all. The Wheelwrights' Society would certainly give their support to technical education.

Mr. JAS. RIGG (Rigg's Engineering Model Company) would point out the importance of drawing to mechanical engineers. He himself attached enormous importance to it, and in the case of his own apprentices, had insisted on their attending drawing classes in days before this technical education was thought so much of. Many of them now held important positions entirely owing to his having insisted on their learning drawing. He thought the Board might well use its influence with mechanical engineers to induce them to modify in some respects the system of apprenticeship. If manufacturing engineers could be induced to allow their apprentices to spend one-half of their time in the drawing office it would be an enormous advantage to both parties. He believed the technical schools gave a good education, but they were not yet capable of imparting a practical engineering training, which was only to be obtained in first-class engineering works. He would suggest that in the opinion of the meeting the engineering instruction for foremen and managers would be greatly promoted if the Technical Education Board could arrange that manufacturing engineers (during the first two years at least) should spend one half of their time in the drawing office.

The CHAIRMAN suggested that the object proposed by the last speaker would be better attained by leaving it in the hands of the Board. The Board could not very well ask all the engineers in London to allow all their apprentices to undergo that training; but they would do their best to lay it before those concerned to see if anything came of it.

Mr. WALKER (Electrical Trades Union) said he represented the electric lighting installation branch of the trade, and also telephone and telegraph work. He welcomed the work of the Council on behalf of technical education; but the classes should be restricted to men actually engaged in the trade. He found it stated that electric lighting and house fitting were among the trades as to which the Council made it a condition of any grant that this restriction should be observed; but in practice it was not always so. For instance, at the Battersea Polytechnic and the Shoreditch Polytechnic it was not the case. At the Battersea Polytechnic there were less than forty or fifty students in the class, and these included gas-fitters, waiters, potmen, and workers in all manners of trades were being taught in that class to the exclusion of the genuine workman, and, he was sorry to add, given every encouragement. At the present time there were about 3,000 men engaged in the line he represented, and at least 800 of these were estimated to be out of work at a time when the schools were manufacturing electrical installation workmen as fast as they could. In one class gasmen and lamplighters had been offered, as an inducement to learning the trade, that they would be able to earn at it from £4 to £5 a week. He asked the Board to enforce its rule to make no grants unless in favour of those who were solely engaged in the trade. Recently a firm of electrical engineers, having advertised for first-class workmen for electric lighting installation, had received something like 150 answers, and, out of these, nine gave as reference the Technical Schools of Shoreditch and Battersea Polytechnics, and each of them had originally been in some other class of business, labourers principally. The armature and magnet winders were a trade in themselves, and there was great room for improvement there. He hoped the Board would make it a rule, before making grants to any class, to see that armature winding and magnet winding were included in the subjects taught.

Principal H. WELLS (Battersea Polytechnic) did not desire to state that the last speaker was entirely wrong in saying that the Polytechnic he represented did admit men to their class who were not actually engaged in the particular work referred to, but he did say that the last speaker had given an exaggerated view, which was unfair to the position which the Battersea Polytechnic had taken up. Every one of the workshops, with the one exception referred to, was absolutely restricted to trade students; and the reason the restriction was not applied to this one was that at first they very much doubted whether a class could be got at all. When, however, they found the members becoming numerous, he (the speaker) took steps to ensure that the places in the class should be given, in the first place, to the people actually working in the trade. The Polytechnic's position was one of decided sympathy with the general lines that had been laid down.

The CHAIRMAN said that the Board felt themselves indebted to any trade union who might let them know of such things. Although there had been a certain amount of grumbling, the Board had not, he regretted to say, received a single letter from any trade union containing any criticism.

Mr. F. W. GALTON (Silver Trades Council) said much of what he had intended to say was covered by the resolution that had been carried. But, in addition to giving the boys facilities to attend the classes, another thing might be done, especially in the trades he represented, and also in, he might say, all the art trades in London, towards assisting the lads to go and see the wonderful collection in South Kensington. At the present moment South Kensington possessed what was probably the very finest collection of work done by the art trades carried on in London that had been got together anywhere. Then legislators had placed that wonderful collection, not where it might be of use to the workman—that was to say in the east end of London—but in the west end. It might have been placed there to meet the wishes of those who thought that rich people require to have their taste educated up to the standpoint of the workman; but certainly it had the effect of keeping away from the workmen the knowledge, which they could otherwise gain, of the means employed in the trade. In the first place they had not the time, and in the next place not always the money to pay the railway fares. The Technical Education Board had very wisely granted scholarships of £20 to enable young men to attend art classes, and he thought that rule might be broadened a little so as to include anyone who attended South Kensington and showed appreciable work as the result—that was to say, brought back a careful study or drawing of a piece of antique metal or carving—and that it might be held to be equivalent to attending a class. With regard to point (5), when he (the speaker) was an apprentice, not so many years ago, he used to find that when he went to an evening school he was thoroughly tired out, and generally he went to the one which was farthest away, not knowing that there were others in the neighbourhood. The trades unions represented that evening might make a special point of that, and some of the trades might draw up a list of names and addresses of apprentices, which, forwarded to the Technical Education Board, might enable them to bring to the notice of the lads the kind of work that was being done. At any rate, the trades might supply the Board with lists of trade-union workshops, and the number of apprentices employed in them, so that notice might be sent to the workshops, if not to individuals. In regard to the question of teaching to persons not actually employed in the trade, he would not be doing his duty to the resolution passed by the Silver Trades Council, whom he was appointed to represent, unless he laid special stress upon this point. He regretted that the Board should have come to the conclusion that wood-carving and repoussé work were parts of the general art training, as he distinctly thought that repoussé work was part of the trade. To go to the trouble of teaching a boy to manipulate difficult tools and materials, when he could get all the experience he needed by means of clay or wax modelling, was absurd, unless he was going to use such materials in working in the trade, in which case no objection could be taken to it. With the view of restricting the classes to persons within the trades, the Board might make it a rule to restrict the class to per-

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sons in the trade wherever the trade was one which was clearly defined. For instance, he did not think that the distinction between the fitter and the turner in the engineering trade ought to be maintained, nor the distinction between the heraldic and artistic engraver. But, wherever it had become the rule to regard two trades as distinct, as regards apprenticeship or otherwise, the restriction ought to be enforced. The object of the Board ought not to be teach a large number, but to make those in the trade better workmen. He therefore urged upon them to confine their teaching to boys in the trade at which they were actually at work, or in the one or two branches which did not actually overlap.

Mr. C. E. GROVE (Thames Ironworks Company) said it so happened that the Company he represented had considered nearly all the points raised by the speakers, so long ago as 1887, when they decided to establish their own schools for the instruction of their apprentices, draughtsmen, workmen, and others who might care to come, and also of a limited number of outsiders personally known and introduced by someone in some position in the firm. That had raised the whole question of technical education. There were two broad classes to be considered, first, the draughtsman and the premium-paying pupils. In regard to them, it was the invariable rule that they should spend the first year in the drawing office, in the first place tracing, and then drawing designs on their own account, after which they went into the shops to carry them out. With regard to the other class of apprentices—viz., those who went into the shops and stopped in them, and who were taken into the shops without any premium being paid—they learned their work from the workmen, and steps were taken that they should have as much variety of work as possible. What had been found necessary was that people should have a better knowledge of the scientific principles which underlay the trade, and that the company had endeavoured to secure in their schools. The students who attended these schools, young men from 16 to 20 years of age, and men even so old as 40, were generally deficient in elementary mathematics, and in teaching mechanics he was often brought up by the pupils not understanding the elementary principles. For the sake of those who wanted it, he undertook to give an extra lesson in arithmetic and elementary algebra; and in that class he had 32 students, 30 of whom came to learn vulgar fractions and simple equations. That was where technical education, if it was to be made scientific, must commence; and the Technical Education Board might do useful work if they could raise the standard, so that a boy when he went into the shop might have a little more mathematical knowledge to start with. The company had considered the question of day-class teaching, and had decided to relinquish it for the present, having regard to the inconvenience caused by workmen in different parts of the work leaving their tools standing idle. This inconvenience was the more felt when men in the position of superintendents left their work in the daytime; but, realising that the evening classes involved some sacrifice to the pupils, they had a practice, where a lad showed promise, of giving him a little more money and of putting a little better work before him.

Mr. LOWEN (London Society of Goldsmiths) impressed upon the Board the necessity of legislation to compel the masters to allow their apprentices to take advantage of the opportunities offered.

The CHAIRMAN said the Board were only too glad at any time to receive any suggestions from the trade unions.

Mr. KNOWLES (Battersea Branch of Amalgamated Engineers) suggested with regard to the paragraph 4, that the technical schools should be thrown open to advanced men—*i.e.*, foremen and men occupying positions in shops where apprentices were at work, so that they could have an opportunity of being with the apprentices in the evening.

The CHAIRMAN, in conclusion, thanked the delegates for their attendance, and observed that point No. 5 had been very little touched upon. The Technical Education Board was offering every year five scholarships for children between 11 and 13 years of age to enable them to prolong their training for a couple of years; also 30 to 50 intermediate scholarships to people of the ages of 15, 16, 17, or 18, and a few scholarships to carry the best of these to a first-rate scientific training. The Board also offered a considerable number of art scholarships every year, specially restricted to artisans under 25 years of age, partly for evening work and partly for day work. The difficulty had been to make known these advantages to the classes affected. They were offering considerable opportunities to evening classes in art schools, polytechnics, intermediate schools, and technical schools in London; they had established a domestic economy class for women, and were offering classes, all over London. They asked the delegates to take back to their unions some notions regarding the work the Board was doing, and to see whether they could not help the work, not only by their criticisms and suggestions, but also by helping to make it known. Every word that had been spoken that evening would be carefully considered by the Board.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *June* 16, 1894.

The Buda-Pesth Conduit System in New York.—The Metropolitan Traction Company has announced that it has accepted an offer from the General Electric Company to lay down three miles of electric conduit street railway similar to that at Buda-Pesth. The Traction Company will provide the road bed, steam-power and conduit, the latter to be the same as used for cables. The General Electric Company will furnish all the electrical equipment. The road will be tried for a year, at the end of which time, if successful, the General Electric Company will be paid; if unsuccessful, the latter will remove at its own expense all electrical apparatus and material, and a traction cable will be installed. It was unofficially stated some time ago that arrangements had been about concluded with the Siemens-Halske Company for the above conduit road, but it seems that it finally refused, while the General Electric Company accepted a proviso in the contract guaranteeing immunity from damages for infringement of patents.

The General Electric and Fort Wayne Companies.—The strained relations between the General Electric Company and the Fort Wayne Electric Company have at last culminated in an open rupture, and a fierce legal battle has been commenced. The latter Company obtained from a home judge the appointment of a receiver, who at once leased the manufacturing plant to the Fort Wayne Electric Corporation, which is practically identical with the other Company in its personnel, excepting that the General Electric interest is entirely left out. The new concern has already announced a complete new line of electrical apparatus, the design of which had been under preparation for some time in view of the expected separation of the warring interests. A new type of Wood arc machine is included with a capacity of 150 450-watt lamps.

The Pollard Lamp.—An injunction has been granted against the Pollard lamp, made in Boston, for infringement of the Edison lamp patent. In this lamp the usual leading-in wires are displaced by a film of silver deposited on the interior wall of a tube, the connecting wires only entering slightly at one end.

LEGAL INTELLIGENCE.

Re Woodhouse and Rawson United (Limited).

The public examination of the Directors and others concerned in the promotion and conduct of this Company was resumed before Mr. Registrar Hood on Wednesday. The Counsel engaged in the case were enumerated last week, but it should be added that Mr. Butcher, M.P., and Mr. H. G. Rawson represented certain of the parties.

Mr. H. G. RAWSON stated that the books and documents for which the Official Receiver had inquired had been found in the same place as they had been in for months and years past, and where they had been quite accessible to the Official Receiver, whose duties were of a sufficiently inquisitorial character to justify him in making a thorough search. Counsel further complained, on behalf of Mr. Rawson and the other Directors, of such insinuations being made by the Official Receiver as that the documents had been "spirited away." All the Directors courted the fullest inquiry, and were anxious to render every assistance in their power, and it was unfair that such suggestions should be made.

The learned REGISTRAR said that so far as he had been able to observe, subject to any specific cause of complaint there might be, the Official Receiver had conducted the inquiry in a fair spirit and with every consideration for the Directors.

Mr. F. W. PIXLEY, the auditor, once more went into the box, and was asked by Mr. McKay as to the reason for the difference of phraseology in his certificate of the accounts of the Woodhouse and Rawson (Limited) for 1888, and that of the accounts of Woodhouse and Rawson United for 1892. In the first case the statement was that the accounts were correct, "in accordance with" a special report made to the Directors; whilst in the more recent case the certificate more definitely stated that the certificate of the accounts must be taken in conjunction with a special report. Witness explained that in 1888 he simply declined to endorse the value of the profits assumed by the Directors, as to which he had no means of judging; but at the same time he had no reason to doubt the accuracy of their assumption. In the case of the 1892 accounts, he declined to certify to the accounts at all.

A tedious examination followed by Mr. PILLING, whose main point seemed to be as to whether in the last balance-sheet of Woodhouse and Rawson (Limited), in addition to £97,899 shown as undistributed profits, there should have been included the sums of £64,000 for patent rights

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and £75,000 for goodwill obtained on the sale of the concern to the United Company, so that the real amount of profits to be divided should have been £236,849. Witness admitted that those sums did represent profit, but was unaware whether they were ever realised. After further questions as to whether it was right that the Managing Director (Mr. F. L. Rawson) should have been credited at a particular juncture with commission on sums paid by the Okonite Company, Witness, replying to the Directors, thought the sum should be passed to Mr. Rawson's credit, and Counsel's opinion was taken.

Mr. JENKINS objected to the line of Mr. Pilling's examination, which, he contended, did not come within the section under which these examinations were held. It seemed that this was a hostile auditor trying to get expert evidence out of a brother auditor.

The learned REGISTRAR said it was very difficult to say what did and what did not come within the section, but he must request Mr. Pilling to conduct his examination with a little more discretion.

Mr. PILLING said he was a large shareholder, and had lost a lot of money in the concern, and he contended that he would never have lost a penny of it if the balance-sheet had been properly prepared.

Mr. PIXLEY, at the conclusion of his examination, made the following statement: With reference to the original prospectus of Woodhouse and Rawson United (Limited) issued in July, 1889, it was not, he believed, even pretended that anyone incurred any legal or moral responsibility by simply allowing his name to be placed on a prospectus as auditor. He should, of course, satisfy himself as to the respectability of the Directors, and as to the purposes for which the Company was promoted; but the publication of his name was merely an indication to intending subscribers that he would be the person who eventually audited the accounts at the expiration of the first financial year. When an industrial business was converted into a public company it was usual to obtain a certification of profits from a chartered accountant, who made a special investigation for such purpose; and in this case he was asked to give such a certificate. It was fully in evidence that this he declined, and although a reference was made to the profits shown by the audited accounts of Woodhouse and Rawson (Limited), none whatever was being made to his being the auditor, and no intending applicant for shares had, he contended, any right to assume that such was the case. If he took the trouble to call for the accounts he would then have ascertained that they were accompanied by a special report from the auditors. His sole clients were the shareholders of Woodhouse and Rawson (Limited). At the same time, although he declined to accept any responsibility in regard to those who might subscribe to Woodhouse and Rawson United (Limited), he had no reason whatever to doubt that the profit referred to on the prospectus was absolutely correct, and would be ultimately realised. As regards the issue of the subsequent prospectuses, inviting subscriptions for debentures and shares at a premium, he was never consulted upon them, and they were never even seen by him until after their issue. As regards the balance-sheet, three were issued to shareholders; viz., June 30, 1890, July 31, 1891, and July 31, 1892. During the interval that took place between the first and subsequent part of his examination he had been enabled to look more closely into his notes, which were exceedingly voluminous, and he had refreshed his memory upon several points. As regards the balance-sheet of June 30, 1890, every item on the credit side was investigated by him, and the value set opposite them most carefully criticised. The accounts when first presented to him varied from those ultimately certified. For example, nothing was written off patents until he pointed out that this should be done, the result being that £7,421. 16s. 9d. was charged against the profit and loss account. A great deal of evidence was produced to him as to the values put by the Directors upon the assets. There was included among the debtors a large sum from the International Okonite Company. That Company was successfully floated; and having regard to the fact that the public were subscribing for shares at par, and that a Director of Woodhouse and Rawson United (Limited) was a member of the Board, and therefore more likely than himself to know the value of the shares, he considered that he should have done wrong to have thrown doubts upon the value put upon them in the balance-sheet; namely, the par value. There was, moreover, a reserve or surplus, after the payment of the interim and proposed dividends, of £49,857. 12s., and in the face of that reserve, and from the facts known to him at the time, and after interviews and correspondence with the solicitors of the Company, and the opinions of eminent counsel on some of the important points, he was satisfied that it was his duty to pass those accounts, and he should do so again under similar circumstances. Coming to the balance-sheet of July 31, 1891, he thought there was a misapprehension that after sending the proposed certificate to the Managing Director, the accounts he subsequently signed without affixing the certificate were the same as those before him when he drafted that certificate. That was not so, for many alterations were made in the accounts as the result of the threatened certificate. In the first place it was distinctly stated on the accounts ultimately signed that the debtors were those of May 31st, and that the cash was that of May 31st, a statement being affixed showing the difference between the receipts and payments between June 1st and July 31st. Again, he called attention in the draft certificate to the fact that nothing was written off patents or patent rights and charged against profit and loss. The accounts ultimately signed included the sum of £4,156. 19s. 9d. written off for depreciation of patents. He received also an undertaking by the Directors of the Company that the amount due from Mr. Rawson should be paid off, and also an undertaking from Mr. Rawson himself. It was also pointed out to him that the vendor Company being indebted to Mr. Rawson personally, this Company had full security, and as a matter of fact it was ultimately proved that this balance was extinguished. As regards his calling attention to the fact that the profits on the financial and the industrial business were not separated, he considered it was beyond the scope of his authority to insist on this, and one of the pledges he received was that reference should be made to the financial business in the Directors' report, and this pledge was fulfilled. The audit certificate also contained a distinct statement that the amounts taken credit for—for plant, stock, works in progress, and investments not quoted—had been certified by the Company's officials. At the same time the items were most closely questioned by him, especially the investments, amounting to £119,338. 15s. Of this sum £43,000 consisted of debentures, Preference and Ordinary shares, in the International Okonite Company. In addition to the fact that he knew one of the Directors was on the Board of the other Company as stated, the Stock Exchange Official List of that date was produced to him in support of the Directors' valuation. As regards the Phœnix Trust Company's shares, Mr. Rawson was a Director of that Company, and he informed him that they had in hand about £5,000 already towards the distribution of the next dividend on those shares, and Woodhouse and Rawson United had already received a dividend of £6,900 on them: whilst they expected another £5,000 in dividend shortly. As regards the other shares, the only evidence that he could obtain was that their value was par, and it was a significant fact that in his cross-examination no document had been produced to contradict this valuation. It must also be remembered that, with the exception of the Phœnix Trust, the companies whose shares were referred to were not launched to promote schemes brought to Woodhouse and Rawson United as promoters; they were the results of scientific work, and experiments made by the Company's own engineers in their own workshops. Large sums of money were expended in experimenting and developing those processes, which were tested, patented, and ultimately disposed of to companies in exchange for cash and fully-paid shares. These shares were not, of course, quickly realisable, but the accounts would have been absolutely incorrect had they not taken to credit the value of those shares at their nominal amounts. The expenses connected with the experiments in developing and testing those processes, and the costs of the formation of those companies, were fully charged against the profit and loss account. To provide against over-valuation of the shares there was still, after payment of the dividends, a reserve of £44,000 on the balance-sheet of July 31, 1891. As regards the balance-sheet of July 31, 1892, in the first place he found the books in the greatest confusion, a very large number of vouchers for payments being missing. He also ascertained that the anticipations of the Directors as to the sale of the shares, were not being realised, and that money was being borrowed at high rates of interest. He therefore came to the conclusion that he could not sign those accounts, and affixed a special report to the shareholders calling their attention to the general unsatisfactory position of the affairs of the Company. It had been suggested to him in the course of the examination that it would have been better had he issued such a report with the accounts to July 31, 1891. He admitted that in the light of present knowledge it might have been better had he done so; but an auditor must not act upon impulse, and he considered he was right in signing the accounts for 1890 and 1891. The Board of the Company was composed of men of high reputation, and he had every reason to believe they were acting solely in the interests of the shareholders. Should an auditor suspect that the Directors of a company were misapplying its funds or carrying on the business to their own interest at the expense of the shareholders, he might consider—and he was glad to say the members of the Institute of Chartered Accountants did so consider—that an auditor should step outside what might be considered his bare duty, and interfere; but in this case he had no such suspicion.

Sir JOHN STOKES (examined by the Official Receiver), said he was interested as a shareholder in Woodhouse and Rawson (Limited). He had no doubt that the Directors of the United Company took care to see that they obtained everything in the shape of patents which it was within the power of Woodhouse and Rawson (Limited) to sell, with the exception of certain things specifically reserved in the agreement. Personally he took no part in the negotiations until after allotment, as he was one of the liquidators of Woodhouse and Rawson (Limited). He took no part in examining into the position of the other companies which were acquired; he left it entirely to the provisional Directors, Sir John Coode, Sir Albert Cappel, and Col. Howard Vincent. When those gentlemen retired he did not feel it incumbent upon him to make special inquiry into the condition of those businesses, as their retirement had no reference to them. He was not aware of the fact that the manufacturing company began the year 1889 with a loss of £34,936, which mounted to £44,718 by the end of the year. He learnt, as liquidator of Woodhouse and Rawson (Limited), that the manufacturing Company could not pay their indebtedness in full to the former, but could not say whether they could only pay 10s. in the pound. He knew that amongst the assets of Woodhouse and Rawson (Limited) was an option in the Elmore Company's shares. There was a dispute at the time of the amalgamation as to whom that option belonged, and the Limited Company considered that it belonged to them; he, personally, did not understand that it passed to the United Company. He did not think any part of the inducement to give way in regard to the ownership of that option was that the guarantee fund should be returned; but he had no clear recollection of what the inducement really was. He was, of course, anxious as the liquidator of Woodhouse and Rawson (Limited) to get the guarantee fund of £75,000 back. It might be the fact, but he could not say, that every one of the Directors of the United Company, except Sir Rawson Rawson, was a shareholder in the Woodhouse and Rawson Company. He held the view that generally the interests of the shareholders in the one company were identical with those in the other, and anything he could do to facilitate the liquidation of Woodhouse and Rawson (Limited) he considered would benefit the shareholders of the United Company. The return of the £75,000 chiefly affected the holders of the founders' shares. He did not consider that his position as liquidator of Woodhouse and Rawson (Limited) clashed with his position as Director of the United Company. He understood that the United Company was to conduct both an industrial and a financial business, and there was a clause in

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the prospectus which referred to that. The prospectus did not suggest that only industrial businesses were to be acquired. He did not think it was right to say that the industrial businesses had shown any profit, for the Limited Company had carried out a good deal of industrial business; he was not, however, prepared to say that it was from that source that the profits were obtained, the transactions in regard to the Elmore Company being chiefly responsible for that. He could not say that the shares in the Manufacturing Company were ever worth anything or not. He could not remember whether the Limited Company ever conducted any successful venture excepting that in regard to the Elmore shares. He considered the United Company, in addition to the flotation of the Kensington Co-operative Stores and the successful use of the option in Elmore shares, made a profit at the time on the Okonite Company. They spent £12,000 in developing the Epstein patents, but whether the shares they held in the Epstein Company were worth that amount now he could not say. He did not know that the Receiver of that Company had offered the 8,000 shares in that Company at 1s. each.

Mr. H. G. RAWSON said there were very special circumstances in that case, and the 1s. only represented part of the consideration.

Examination continued: He thought the money that had been lost had gone in developing the industrial operations of the Company. He could not say it was not a fact that £46,000 went in shares of the Okonite Company. He was ill at the time of that operation. Nor was he aware that £10,000 had been realised by the sale of some of the shares. He did not know the exact date of the formation of the Epstein Company, which the Official Receiver said was July 31st, the last day of the financial year. The value of their interest in the Epstein patent was put down at £35,000; £4,000 had been paid Mr. Epstein for part interest in the patent, and £12,000 was expended in developing it. They had been following up the development of that patent for three years or more, and it was upon their belief in the value of the patent that they estimated the £35,000. There was nothing, except their desire to act as reasonable men, to prevent their putting the profit at £50,000 or £100,000, as no one else was interested except Mr. Epstein and the United Company. He was not aware that on July 31, 1891, only 300 shares were taken apart from those held by the United Company and Mr. Epstein. The amount owing to the United Company by Mr. Rawson was discharged by the former taking over the Debenture stock in the United Company which Mr. Rawson had acquired through the Limited Company. Those debentures were issued to Mr. Rawson at 50 per cent. discount, but the United Company accepted them at 100 per cent. When the interim dividend was declared in January, 1889, the source of profit upon which they based that dividend was the Elmore shares. He could not say that if the option had not been given up by the Limited Company the United Company would not have been in a position to pay an interim dividend out of realised profits. As a matter of fact, it seemed to be the case that the interim dividend and the new issue were considered at the same meeting; but he resented the suggestion that they were purposely timed to go to the public together. He had no recollection of letters read, signed "A. Grant," and coming in one case from the Phœnix Trust Company, and in another from the National Financial Corporation, relating to projected transactions in the Founders' shares of the United Company. He did not recollect a letter from the auditor recommending the Directors to call in an independent valuer to appraise to value of the shares held in other companies, so as to relieve themselves of responsibility in the matter, and he did not know that an independent valuation ever was made.

By Mr. STIRLING: A committee of shareholders was appointed to investigate the affairs of the United Company, and that Committee issued a report in March, 1892, which the Directors published, together with observations thereon. He was consulted with regard to those observations, and accepted responsibility for them.

By the OFFICIAL RECEIVER: He did not accept responsibility for the issue of the prospectus, although his name was upon it.

The REGISTRAR said it was rather a matter for argument as to whether witness was responsible or not, seeing that he did not join the Board until after allotment.

By Mr. PILLING: He did not discover, as liquidator, that an egregious blunder had been made in the estimate of the profits of Woodhouse and Rawson (Limited). They rather wished they had kept it in their own hands. Certain proportions of the proceeds of the Debenture Stock were distributed amongst the shareholders. He did not admit that the assumed values of the shares were not realised. It would be a wrong statement to say that £100,000 worth of assets were not realised.

By Mr. H. G. RAWSON: He did not think there was ever a question of voting upon matters between the Limited Company and the United Company. He recollected that a time came when it was proposed to dissociate, in the accounts, sums spent in the financial from those spent in the industrial business; but he could not say whether it was proposed to include money spent in testing patents in the industrial part of the accounts, or not. The difference between £16,000, the sums already mentioned as having been spent on the Epstein patent, and £35,000, the sum at which they were valued in the balance-sheet, was by no means clear profit, as there were other expenses connected with the development of the patent which were not specificially mentioned. He could not say that the Okonite Company was one of the few companies successfully floated in the latter part of 1890.

By Mr. F. L. RAWSON: He had had frequent differences of opinion with his questioner as to the course to be pursued in regard to certain matters. He believed that he (Mr. Rawson) in all he did strove for the interests of the shareholders.

By Mr. JENKINS: Witness had, in 1890, chiefly devoted himself to the industrial part of the business, although he attended committee meetings regarding financial affairs. He relied upon the information given him with regard to the value of the shares. He believed all the balance-sheets put forward during his directorate were fair, accurate statements of the affairs of the Company.

Mr. MALCOLM DUNDAS, the first Secretary of the Company, examined by the Official Receiver, said he was quite new to the work when appointed, and worked under the supervision of the Managing Director. The minutes of a meeting of the Directors, held at No. 1, Queen's-gate, the residence of Lord Aberdare, when it was decided to go to allotment, were in his writing, but he was not present at that meeting. At another meeting of the Board, held at Mr. Pope's chambers, in Parliament-street, he was not present, and the minutes must have been supplied to him by someone else. He was not at that time aware that it was an essential part of his duty to attend the Board meetings and record what took place. He was present at the meeting when the questions of the interim dividend and the new issue were discussed and resolved upon, but he could not recollect anything of the discussion which took place.

At this point the inquiry was adjourned until the next day.

THURSDAY, JUNE 28TH.

On the proceedings being resumed yesterday, the OFFICAL RECEIVER said that, with regard to the statement made by Mr. H. G. Rawson as to some of the missing documents, he wished to say that a certain amount of correspondence had been found, and he was quite willing to accept the assurances of the Managing Director that he was making every search; but it was the fact that some most important documents, relating to the valuations, were not forthcoming. He trusted they would be by the end of the examination.

Mr. DUNDAS again went into the box, and, examined by the Official Receiver, said he recollected seeing the circular announcing the withdrawal of Sir John Coode, Sir Albert Cappell, and Col. Howard Vincent; but it was not prepared or sent out by him, though purporting to be signed by him, the initials, however, being wrong.

By Mr. F. L. RAWSON: He (Mr. Rawson) was always anxious to have the minutes accurately recorded. Before becoming secretary to the Company he had had considerable experience in banking, and had since had considerable experience as a secretary. Whilst he was with the Company he considered everything was carefully and properly done so far as he knew.

Lord ABERDARE and Mr. HOSTER, one of the Directors and liquidators of Woodhouse and Rawson, were then examined. The examination of this last witness occupied the whole of the afternoon, and fuller particulars will be given in *The Electrician* next week.

The examination was then adjourned until Thursday next week.

Anglo-American Telegraph Company (Limited) v. Compagnie Francaise du Telegraphe de Paris a New York.

This action, for damages for alleged illegal breaking of a pooling agreement, which has occupied the attention of the various French Law Courts since the beginning of 1887, has reached its last stage.

It will be remembered that on December 31, 1886, the French (or Pouyer-Quertier) Company, acting on a letter received from the French Minister of Posts and Telegraphs, notified the Anglo-American Company of their intention at once to break the "common-purse" agreement entered into in 1880 by the Atlantic Cable Companies. Legal proceedings were taken by the Anglo-American Company, who claimed damages of 2,000fr. a day during the continuation of the rupture, and on January 9, 1888, the Tribunal of Commerce gave judgment in their favour. An appeal was lodged, and on April 24, 1888, the Cour d'Appel ruled that, as the letter of the Minister of Posts and Telegraphs was not quite clear in its terms, recourse must be had to the administrative jurisdiction for an authorative interpretation of its meaning. The Conseil de Préfecture ruled that the P.-Q. Company were justified in breaking the agreement on receipt of the Ministerial dispatch; but the Conseil d'État, on appeal by the Anglo-American Company, decided that the Ministerial letter could not authorise the P.-Q. Company to break a properly-effected agreement between the parties; but that the Company should have applied to the Government for permission to carry out the arrangement made with the Anglo-American Company. Notwithstanding this decision, however, the Minister of Commerce and of the Colonies expressly prohibited the P.-Q. Company from resuming the broken agreement. Under these circumstances, the latter Company entered a fresh appeal from the adverse decision of the Tribunal of Commerce, and this appeal was heard in the Cour d'Appel, before M. Périver, on May 30th, and June 5th, 6th, 7th, 12th, and 26th. Maitres Rodolphe Rousseau and Waldeck-Rousseau appeared for the French Company, and Maitre Barboux for the Anglo-American Company.

On Tuesday last the Advocate-General summed up, and his conclusions were favourable to the Anglo on all points, except as regards the assessment of damages. These conclusions were to the following effect:

I.—*There was no "force majeure" authorising the P.-Q. Co. to break off the Pool Agreements of 1880 and 1882;*

II.—*The persistent refusal of the P.-Q. Co. to carry them out justified the Anglo Co. in asking the Court to cancel them with damages;*

III.—*Damage had certainly been suffered by the Anglo Co., but to what extent was not clearly shown, and therefore it could only be ascertained by a reference to experts.*

The following were his arguments on each of these three propositions:—

I.—NO FORCE MAJEURE.—In the first place (he said) the Ministerial letter of December 31, 1886, did not constitute *force majeure*. That has been decided in the last resort by the Council of State, and, therefore, the question would not be re-opened. In the next place, the Ministerial letter of May 21, 1891 (Jules Roche's), did not constitute *force majeure* either, for the following reasons:—(1) It was a mere opinion, and not a formal decision: (2) If a decision, it was not a decision in the last resort, the P.-Q. Company having a right to appeal, which it was its own fault if it

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did not exercise; (3) It was contrary to the opinion of the former Minister (M. Cochery). The Advocate-General here went into the facts of the case in order to show that on the P.-Q.'s own admission, nay, on its own assurance as contained in the final agreement of January 17, 1991, M. Cochery considered the Pool Agreement of 1880 as not coming within the meaning of Art. 9 of the P.-Q. Cahier des Charges. He took occasion to point how badly the P.-Q. Company had behaved through, and how richly they had deserved the castigation inflicted upon them by the tribunal, by the Advocate-General, M. Manuel in 1888, and by M. Levavasser de Precourt, the Commissary of the Government at the Council of State.

II.—Necessity to Cancel the Contracts.—This, of course, was a natural consequence of the Advocate-General's argument on the first point.

III.—Damage Suffered, but Amount Unascertainable except by Reference to Experts.—The Advocate-General first of all examined the relative positions of the parties when the first Pool Agreement (1880) was entered into. Upon this point he agreed entirely with the Anglo Company, viz.:—(1) The object of the agreement was, on the part of the P.-Q. a *present*, on the part of the Anglo a *future*, advantage; (2) The P.-Q. Company had held to the agreement as long as it found it to be to its interest to do so; (3) It broke off because it thought it could make better terms with another Company; (4) The other Company was a party, since it lent the P.-Q. Company £40,000 without interest, in order to get the benefit of its cable. The only point, therefore, remaining to be considered, in the opinion of the Advocate-General was the *quantum* of damages. This, he observed, it was impossible as matters stood to ascertain with any degree of precision. The Anglo-American Company had proposed, indeed, different modes of assessment: (1) A return of the £246,000 paid to the P.-Q. Company over and above its own earnings; (2) A fictitious reconstitution of the pool, bringing in the P.-Q. Company a debtor to the extent of £89,066 up to 1892 inclusive, with a reservation as to ulterior damages up to 1920, which he held, contrary to the contention of the P.-Q. Company, to be the date of expiry of the contract. Neither of these two schemes, however, could be admitted. The cause of damage, according to the Advocate-General, arose from the breaking-off of the agreement only, and not from anything that had been done previously. Up to December 31, 1886, there had been no breach of contract on the part of the P.-Q. Company. On the other hand, the Anglo might have paid the P.-Q. £246,000 more than it had earned, yet there was nothing to show that it had not done so out of increased receipts owing to the contract itself. For in that case the P.-Q. Company could show a clear consideration for the money paid. The Advocate-General analysed the tables very carefully and very accurately, and rejected this scheme. At the same time, he treated a counter-table put forward by the P.-Q. Company as altogether unreliable, and, moreover, confessedly so. What, then, should be the criterion? It would be a *bonâ fide* statement drawn up by the P.-Q. Company of all the messages it had carried gratuitously; but as the P.-Q. Company did not seem inclined to do this, there was no alternative but to refer the matter to experts.

It is anticipated that the decree will be pronounced in about a fortnight.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

Tenders Invited.—The Council of the County Borough of West Ham invite tenders for the electric lighting of the Public Hall and Free Library, Barking-road, Canning Town, E. Specifications, &c., may be obtained of Mr. Lewis Angell, borough engineer, at the Town Hall, Stratford, E., and tenders must reach Mr. Fred. E. Hilleary, the town clerk, by four o'clock on July 10th. Further particulars appear in our advertisement columns.

——— The County Borough of Bury invite tenders for the erection of buildings in connection with the electric lighting central station. Tenders must be in to Mr. J. Haslam, town clerk, by six o'clock on Monday next.

——— The Edinburgh tenders for cast-iron road boxes, copper strip connectors, &c., gun-metal grip boxes, cable connectors, and cones have to be in by Wednesday next.

Electric Traction in Egypt.—Our readers are reminded that July 1st is the last day for sending in tenders to the Egyptian Ministry of Public Works for the construction and operation of electric tramways in Cairo.

Tenders Accepted.—The tender of Messrs. Sharp and Kent has been accepted for the electric light installation at the new Grand Theatre, Blackpool.

——— The contract for lighting by electricity the Art Exhibition, to be held at the Blackburn Free Library in August next, has been let to Mr. H. Brennand.

——— The St. Pancras Vestry have accepted the tender of Mr. J. O. Richardson, of Peckham, for the erection of the main buildings, boundary walls, &c., of the King's-road electric lighting station for £5,178.

Sale by Auction.—Messrs. Wheatley Kirk, Price and Goulty announce the sale, by public auction, at the Vulcan Iron Works, St. Neots, of the entire contents of the several works hitherto carried on by Mr. George Bower. The stock includes engines, exhausters, ammonia liquor pumps, gas-holders, and a large quantity of machinery and plant. The sale takes place on July 17th, 18th and 19th, each day at 10, for 11 prompt.

Vacant Appointment.—Applications for the post of Chief Electrical Engineer to the Vestry of St. John, Hampstead, have to be in by Monday next.

Appointments.—Mr. B. J. Diplock has been appointed Secretary of the Fowler-Waring Cables Company (Limited) in place of Mr. D. Stephen, who resumes his duties as accountant of the Company. Mr. James Tiddy, late Manager of the Central and South American Telegraph Company, has been appointed electrician-in-charge of the testing rooms of the Fowler-Waring Company at North Woolwich.

Liquidations.—In the matter of the Collier Audible Telephone Syndicate (Limited), it was stated on Thursday, on the hearing of a petition for its winding up, that arrangements had been entered into for the sale of the assets for a sum sufficient to provide for the costs of the liquidation, and 20s. in the £ to the creditors. The petition was directed to stand over for three weeks, on the understanding that the debt and costs due to the petitioners should be in the meanwhile paid.

——— Creditors of Elmore's French Patent Copper Depositing Company (Limited), whose debts are otherwise than in respect of a debenture or mortgage, must send in particulars of their debts or claims to Mr. J. H. H. Duncan, the liquidator, 39, Coleman-street, London, E.C., on or before the 23rd prox.

Partnership.—Mr. W. H. Massey, of 25, Queen Anne's-gate, Westminster, S.W., has taken into partnership Mr. Vincent S. Allpress. The firm will be known as Massey and Allpress, consulting engineers.

Dissolution of Partnership.—Messrs. Crawshaw and Wray, trading as the Wray Electrical Engineering Company, of Bradford, have dissolved partnership. Debts will be paid by Mr. Cecil Wray.

Removal Notice.—The Edison and Swan United Electric Light Company will, on August 27th next, remove into their handsome new premises, Ediswan-buildings, 36 and 37, Queen-street, Cannon-street, E.C.

Incandescent Lamps.—Messrs. Gabriel and Angenault, who are well known on the Continent, have just opened a London branch at Connaught-mansions, Victoria-street, S.W., for the sale of incandescent lamps which have already obtained a considerable reputation on the Continent. A stock of the lamps sufficient to meet the largest and most varied demands is to be kept.

A Light Motor.—Messrs. Mavor and Coulson have recently supplied the Battery and Motor Company with a 500-watt Sayers motor for 500 revolutions per minute, which weighs under 2 cwt., and has an electrical efficiency of over 90 per cent.

Lighting the Gigantic Wheel.—Messrs. J. G. Statter and Co. have secured the contract for lighting the gigantic wheel at the Earl's Court Exhibition, the contract including the supply and erection of generating plant, the lighting of the 40 cars on the wheel, and the illumination of the wheel itself with 160 lamps. The total installation comprises 280 lamps.

Battery Patents.—Notice is given that it is the intention of the Electric Construction Company (Limited) and the Electrical Power Storage Company (Limited), who are exclusive licensees under the letters patent granted to J. H. Johnson, of 47, Lincoln's Inn-Fields, in the matter of an invention by M. Camille Faure of "improvements in galvanic polarisation batteries or magazines of electricity and the application of the same, and in apparatus connected therewith," to apply for an extension of time for the said letters patent.

New Lamps for Old.—The adaptability of the electric light to oil and candle fittings is strikingly exemplified at the town residence of the Baroness Burdett-Coutts, in Stratton-street, Piccadilly. For upwards of a hundred years this mansion, which contains so many valuable pictures and other art treasures, has been lighted entirely by oil and candles; but these have now given place to the more modern glow lamp. The change presented some difficulties, for it was the express wish of the Baroness and Mr. Burdett-Coutts that in no case should the old fittings be removed, the former sources of light be altered, or the bare filament of the lamps be allowed to meet the eye. The work was placed in the hands of Mr. V. G. Middleton, of Westminster, S.W., and is a satisfactory change from the old to the new. Very beautiful is the effect of the heavy glass candelabra, 16 c.p. lamps being placed behind curtains of glass lustres, and small 4 c.p. lamps, enclosed in cut-glass bulbs, taking the place of the old candles. In the picture gallery light is admitted in the day-time through circular glass lunettes in the ceiling. Glow lamps have been placed above these lunettes, and when alight brilliantly illuminate the whole gallery, at the same time being practically out of sight. In the reception rooms alone there are some 580 16 c.p. lamps, or their equivalent, and some hundreds more in the offices and upper floors. The electrical work was carried out by Messrs. Townsend and McIntyre, and the fittings and glass work by Messrs. Perry and Co., of Grafton-street, W.

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MESSRS. BAILY, GRUNDY AND BARRETT (LIMITED).—This Cambridge firm have recently carried out a number of installations of a public and private character.

ABERDEEN.—An extension is being made to Trinity Hall, Aberdeen, by the addition of a minor hall, or upper room, and additional committee rooms and a strong room. The whole of the building is to be lighted throughout by electricity. The Town Council on Tuesday decided that the charge for electric current for the public lighting should be 3¾d. per lamp per hour. The original estimate of the cost of working the electric lighting station, laying down plant, &c., was £25,000; but as only £20,000 was necessary to complete the work then in hand, only the smaller sum was borrowed. It is now found necessary, however, to borrow the additional £5,000, and it has been arranged to do so. A question was asked Mr. Murray, the electrical engineer, as to whether he had advised the putting in of gas pipes in addition to the electric lighting apparatus, which Mr. Murray indignantly denied. There was no necessity for gas pipes to be put into any building where it had been decided to use the electric light; there was absolutely no risk of the electric light breaking down.

BIRKENHEAD.—A Local Government Board inquiry took place on Tuesday as to the application of the Corporation for sanction to borrow the sum of £20,000 for electric lighting purposes, and other monies, the sum being broken up into two amounts of £1,576 for the purchase of land in Bentinck-street for a site for a central station, and £18,424 for the supply and erection of buildings and plant. The Town Clerk explained that possibly the Inspector might withhold his certificate for the latter amount, because at the moment the Corporation had not really approved the plans prepared by their electrical engineer, Mr. Shoolbred. Although the Corporation were not in a position to submit the details, they were practically agreed upon the scheme.

BOOTLE.—The Town Council have decided that the necessary work in connection with the construction of the engine-house, required for the electric lighting installation, shall be carried out by its own borough surveyor, including the alterations to the existing machinery and engine-house.

BOLTON.—The result of the Corporation's decision to supply electric light fittings on the hire-purchase system has been that the applications for electric current have considerably increased.

BOURNEMOUTH.—A Local Government Board inquiry has been held at the municipal offices into the application of the Corporation to borrow £4,000 for electric lighting purposes. There was no opposition. It was pointed out that the Corporation had already erected engines in the pleasure ground for the purpose of pumping salt water, and now desired to utilise the spare power for the purpose of lighting the pier and gardens by electricity, for which they hold a Board of Trade licence.

BRISTOL.—No reply has been received from the Local Government Board as to the application of the Corporation for sanction to borrow £24,650 for the electric lighting extension. The inquiry was held on April 25th last, and the money is urgently required for extensions, several of which are blocked until the Local Government Board's sanction is received.

CALCUTTA.—The electric light is making rapid progress in India for the purposes of mill lighting. A recent installation is at the Calcutta Flour Mills, where Messrs. Kilburn and Co. have erected a Crompton dynamo which supplies the current for 38 incandescents of 32, 16 and 8 c.p. The Oriental Telephone and Electric Company (Limited) opened an electric light department in Calcutta about four months ago, and their Manager, Mr. Lester Betts, has just carried out the initial installation at Messrs. A. C. Mookerjee's Roller Flour Mills.

CHARGE OF FRAUD.—At Bow-street Police Court, on Wednesday, Mr. Lawrence Henry Bloomfield, electrician, of Queen Victoria-street and Richmond, answered to a summons charging him with obtaining by false pretences £120 from Richard Lonsdale. Mr. Purcell, for the plaintiff, said that he wished to withdraw the summons. The facts of the case did not warrant all that was set forth in the information, and there was reason to believe that there had been no intention to defraud. Mr. Vaughan, the magistrate, said that, according to the information, there was a *primâ facie* case, and the matter must be explained. Mr. Humphreys said that, according to the information, the complainant was told by the defendant that he had secured a contract with the Brighton and Hove Electric Light Supply Company. The complainant contended that the defendant had not secured such a contract. As a matter of fact, the defendant had not secured it; but he was in communication with a man named Stevens, who promised to secure it for him. The defendant borrowed money from the complainant for the purpose of buying electric lamps in Germany, and, as a matter of fact, he went to Germany and made purchases there. Mr. Vaughan said that the complainant had better give evidence, and then Stevens ought to be called. The complainant stated that he was an electrical engineer carrying on business in the Strand. Last year the defendant said that he was an agent for a Dutch firm of electric lamp makers, and the complainant agreed to supply him with money for the purchase of lamps. In February last the defendant said that he had secured a contract with the Brighton and Hove Electric Lighting Company (Limited). Believing this to be true, the complainant advanced him £120 to enable him to go abroad and purchase lamps. In reply to the magistrate, the complainant said that the defendant told him he had secured the contract through another man, although he made no mention of that in the information. Mr. Vaughan said that in the face of that admission it would be useless to proceed further. The other man referred to might have made a false statement to the defendant as to the Brighton and Hove contract. There appeared to be no intention to defraud, and the case must be dismissed.

CHURCH LIGHTING.—The Duke of Newcastle announced, at a public luncheon in connection with the Patronial Festival of St. Alban-the-Martyr, Holborn, W.C., that among the improvements for the church the introduction of the electric light was included.

DEWSBURY.—Messrs. A. Hurst and Son have secured an order from Mr. W. Newsome, who has erected a large pile of buildings at the junction of Croft-street and Bond-street, to put down an electric lighting plant for four arcs and 72 16 c.p. incandescents, the plant to include a 6 H.P. gas engine.

DUNDEE.—It is suggested that "if a profit should speedily be obtainable from the Electrical Department it could not be better utilised than in reducing the debt upon the gas works." At the annual meeting of the Gas Commission the financial statement for the year was presented by Mr. James Mitchell, who said that in framing the electric lighting accounts at the beginning of the year they were without data to go upon. It was, however, satisfactory to find that, while the expenditure considerably exceeded the estimate, there was a corresponding increase in the revenue account. They had estimated a receipt of £2,035 from the sale of current and meter rents, whereas they had received £2,649. Their experience in the working of the Electric Light Department was similar to that of other towns, the first few years showing a deficiency, which disappeared on an increased demand for the light. They had a first-class station, and had every reason to congratulate themselves on the success of their electric light undertaking, which would doubtless shortly become a source of profit. They had at present 186 customers, using current equal to 5,293 16 c.p. lamps, and this number was rapidly increasing. An estimated increase of £670 was looked forward to for the current year. Mr. Mitchell concluded the reading of his report by moving that electric current be supplied for the present year at 5d. per unit. ——It has been decided to place the contract for the maintenance of the accumulators at the electric lighting station with the Electrical Power Storage Company, of Great Winchester-street, London, E.C.

ELECTRIC MINING MACHINERY.—An electric drilling machine has been introduced in the Lumpsey mines at Brotton. The machine was tried last week for the first time, and gave every satisfaction.

FAREHAM.—The Local Board on Wednesday last week again considered the question of the purchase of the works of the Fareham Electric Light Company. A letter was read from the Secretary agreeing to the terms suggested by the Board, whereby the Company sell their undertaking to the Local Board for £5,000, and agree to lay underground the electric mains in certain streets, and to provide a new engine, similar to that now in use, for an additional sum of £1,000. After some discussion, it was arranged that, pending the application to the Local Government Board for permission to borrow the necessary loan, the Clerk should prepare a contract for the purchase of the electric works, which would be considered at another meeting of the Board.

FOLKESTONE.—At the last meeting of the Corporation a letter was read from the Brush Provincial Company, asking for the Corporation's sanction to an application for a Provisional Order, and proposing to undertake to bear all expenses in connection therewith. The Corporation were asked to enter into a contract with the Company to light the sea front. The Town Clerk had replied to this letter that the Corporation had not yet abandoned the idea of themselves undertaking the electric lighting of the district. It will be remembered that the Folkestone Corporation, after deciding upon a scheme involving an outlay of £30,000, subsequently quashed this decision, and have now before them an offer made by Mr. Baker to prepare a scheme under which Folkestone is to be lighted electrically at an outlay of £12,000. This scheme, however, has not yet seen the light, and it is on account of this delay that many members of the Corporation are anxious that the Brush Company's application should be granted. It was ultimately decided that a meeting should be called to discuss the scheme to be prepared by Mr. Baker.

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HAMPSTEAD.—At the meeting of the London County Council, on Tuesday, the Financial Committee recommended a loan of £25,000 to the Vestry of Hampstead for electric lighting purposes, to be repaid in 25 years. The Vestry asked that the term of repayment should be extended to 42 years, as the Council had given its sanction to loans being repaid in that period for similar works by the Vestry of St. Pancras. The Committee were of opinion that the term of repayment should not exceed the life of the works upon which the money was to be expended. After a prolonged discussion the recommendation of the Committee was disagreed with and the request of the Vestry acceded to by 52 votes against 21.

HUDDERSFIELD.—At the last meeting of the Borough Council it was decided to purchase from the Silvertown Company the cable required for the electric lighting works, and a deputation was appointed to inspect, with a view to purchase, a 250-kilowatt Brush alternator, now running at the City of London Electric Lighting Company's Station at Bankside.

KINGSTON.—The Town Council have decided to arrange for the extension of the electric lighting area up the Kingston Hill, round by Queen's-road, and through other principal thoroughfares.

LEEDS.—An offer made by the Yorkshire House-to-House Electricity Company to supply current for any number of arc lamps up to 30 on the line of mains through some of the principal streets in the centre of the City at 4d. per unit, has been declined by the Lamp Committee of the Leeds Corporation, on the ground that a large sum of money has recently been expended in fixing large gas lamps in the principal streets.

LIVERPOOL.—The Liverpool Electric Supply Company have given formal notice to the Watch Committee of the Corporation of their intention to apply for a Provisional Order to supply electricity for public and private purposes in various parts of the city, including Queen-street, Oldhall-street, Devonshire-road, Springfield-street, and the Goree Piazzas.

MADRAS.—The Indian Government are considering a proposal for lighting by electricity the Presidency Post and Telegraph Offices in Madras.

NORTHUMBERLAND COUNTY COUNCIL.—The Committee of Visitors having recommended that the County Lunatic Asylum should be lighted by electricity at an estimated cost of £7,010, but at the last meeting of the County Council carried an amendment to substitute gas for electricity by 21 to 18.

PORTSMOUTH.—Considerable activity is noticeable here in electric lighting matters. The Arts Club has decided to adopt electricity, and the proprietors of several of the principal residences are negotiating.

PROVISIONAL ORDERS.—The amendments made by the House of Lords to the West Hartlepool electric lighting order have been considered by the House of Commons and approved.——The Aberdare Electric Lighting Order, which has already passed the House of Lords, has been certified for second reading by the examiners of the House of Commons.——The Plymouth Provisional Order has satisfactorily passed the Examining Committee of the House of Commons.——The Provisional Order applied for by the Shropshire Electric Light and Power Company has passed the House of Commons Examiner and stands for second reading.——The Bill under which the Bolsover Gas Light and Coke Company seek power to supply electric current within the district has been certified for second reading in the Commons, having passed the House of Lords.

ROYAL AGRICULTURAL SHOW.—The show at Cambridge held during the present week has been, owing to the fine weather and the general excellence of the exhibits, a pronounced success. There is in the exhibits little to interest our readers, except in the Implement Section. The judges appointed in this section include Prof. J. A. Ewing, Cambridge; Prof. D. S. Capper, King's College; and Mr. J. P. Denison, who were appointed to appraise the merits of the various oil engines on show. Amongst the exhibitors in the Implement Section were Messrs. Clarke, Chapman and Co., Crossley Bros. (Limited), W. F. Dennis and Co., John Fowler and Co. (Limited), Leeds; Gilbert Gilkes and Co., Greenwood and Batley (Limited), E. S. Hindley, Ransomes, Sims and Jefferies (Limited), Marshall, Sons and Co. (Limited), Robey and Co. (Limited), and W. H. Willcox and Co. Messrs. Crossley Bros. secured a second prize in Class I. for their 6½-H.P. oil engine. Messrs. Baily, Grundy and Barrett, at Messrs. Crossley Bros.' stand, had on show an Elwell-Parker 90-ampere dynamo driven by a 10-H.P. Crossley oil engine, supplying current to the electric cooking stoves in the Royal Pavilion. These stoves were used for cooking the luncheon to H.R.H. the Prince of Wales, and were in daily use throughout the exhibition. The dynamo also supplied current to a Crompton motor working a Pickering hoist. The cooking utensils used were lined with Messrs. Baily, Grundy and Barrett's new silotena process. Messrs. Robey and Co.'s exhibit included a horizontal steam engine, fitted with their patent automatic trip expansion gear. The engine is specially constructed for heavy work, and is designed for estate work, where by night it can be employed for driving an electric lighting installation. Messrs. Robey's exhibit formed one of the largest on the show grounds and, in addition to their well-known steam engines, included several examples of the Robey oil engine, both of Richardson and Norris's and of Bell, Richardson, and Norris's patents. Of the former description was an 8-H.P. stationary engine, fitted with the latest improved combustion chamber. The special feature of this arrangement is the air inlet, exhaust outlet, vaporiser, and igniter. These engines are built to run equally well with full, half, or light load. There was also on view a 10-H.P. oil engine, the design of which approximates closely to that of the Robey portable steam engine, fitted with a specially-sensitive Becker-type governor, securing great regularity. The working parts are easy of access, and adjustments can be readily effected while the engine is in motion.

ST. PANCRAS (LONDON).—The Electricity Committee of the St. Pancras Vestry having communicated with Messrs. Kelly Bros. regarding the employment of London men in executing the work of building the main central station buildings, that firm stated they could not put themselves under any restrictions as to the men employed, and have withdrawn their tender. Fresh tenders are to be invited.

SHIP LIGHTING.—"La Marguerite," the new palace steamer of the Victoria Steamboat Association, which made its trial trip from London to Boulogne on Saturday last, is lighted throughout by electricity, the work upon this, as upon other boats of the Association, being carried out by Mr. William Mackie, of Turk's Head-yard, E.C.

——— Messrs. J. H. Holmes and Co., of Newcastle-on-Tyne, have lately fitted the steamer "Petersburg," built by Messrs. Hawthorn, Leslie and Co., with an electric lighting and ventilating plant. The lighting plant is adapted for 300 16-c.p. incandescents, and the ventilating plant for six electro-motor fans. The fittings throughout the ship are of very handsome design, and in the emigrant quarters are detachable; so that, if room is required for cargo, they can be speedily removed, the wiring being so arranged that no risk of fire is incurred with these detachable fittings when out of use. The electro-motor fans are the largest yet used in ship ventilation. A 10-hours' test proved that everything had been satisfactorily arranged. Portable electric fans are provided for the saloon.

SUNDERLAND.—The Local Gas Company has informed the Highways Committee of the Corporation that a condition would be imposed under the new contract for lighting the streets by gas, that in cases where gas lamps are supplanted by electric lamps a payment of 10s. would be demanded from the Corporation for each gas lamp discontinued. If electric lighting were installed in any gas area the Company would discontinue to light the 600 c.p. Sugg gas lamps in such area.

THEATRE LIGHTING.—The Directors of the Alhambra, London, have recently adopted the electric light throughout for their stage work. The installation has been designed and carried out by Messrs. F. W. Henton and Co. By the arrangements now adopted gas, calcium lights, &c., are entirely dispensed with.

TUAM.—The local Electric Light Company have notified the Local Board that they intend to apply to the Board of Trade for a Provisional Order for lighting the town by electricity.

WINDSOR.—Sir H. D. Gooch has instructed the Windsor branch of Roger Dawson (Limited) to instal the electric light at Clewer Park. About 100 incandescents will be required, and the plant will include a steam engine and a battery of accumulators.

WOLVERHAMPTON.—The Directors of Thomas Parker (Limited) have accepted the tender of Mr. H. Lovatt, of Wolverhampton, for the erection of their new works on the Wednesfield-road.

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

June 7, 1894.

11,069. A. MUIRHEAD. London. Improvements relating to the transmission of signals through submarine telegraph cables.

11,100. F. N. DENISON. London. Improvements in electric dental motor apparatus.

June 8, 1894.

11,123 B. W. WELLS and M. MARTIN. Glasgow. Electro protective system for locks.*

11,136. R. WOOD. London. Improvements in the regulation of electric distribution systems.

11,160. H. W. RAVENSHAW and Messrs. EASTON, ANDERSON, AND GOOLDEN (Limited). London. Improvements in apparatus for starting electric motors.

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11,211. W. Grimes. London. Improvements in railway electrical signalling apparatus.

11,219. C. A. Hussey. London. Incandescent electric lamp and sockets therefor.*

11,225. H. Bevis and H. Hirst. London. Improvements in and relating to arc electric lamps.

11,241. F. R. Boardman. London. An improved electric lamp.

SPECIFICATIONS PUBLISHED.

Note.—All Specifications can now be obtained at the uniform price of 8d. each.

1893.

4,106. Epstein. Secondary battery plates.

10,398. Lenox. Electrical communication with vessels or buoys.

10,441. Hughes (De Voe). Conduit Electric Railway.

10,569. Crompton and Dowsing. Regulating the temperature of electrical heating, &c., apparatus.

11,426. Todd and Lewis. Electric motor.

12,153. Waterhouse. Measuring, &c., electric currents.

12,362. Armstrong and others. Marking meat by electricity.

12,523. Wollaston. Electric brushes, &c.

13,336. Hoeffner. Electrolytical production of nickel, &c.

13,412. Conrady. Electric generators.

14,091. Brain. Electric fuses.

14,202. Pyke and Harris. Dynamo-electric generators and motors.

1894.

139. Callender. Telephone exchange systems.

5,663. Kleine and Lindner. Cut-offs for gas, electric, &c., conduits.

6,742. Siemens Bros. and Co. (Limited), and Grimston. Electric switch.

8,043. Wyman and Goodwin. Insulating cleat for supporting electric conducting wires.

8,149. Lake (Van Vleck and another). Electrical measuring instruments.

COMPANIES' MEETINGS AND REPORTS.

Electric and General Investment Company (Limited).

The fifth ordinary general meeting of the shareholders in this Company was held at Winchester House, Old Broad-street, on Tuesday, under the presidency of Mr. George Herring.

The SECRETARY (Mr. J. Cecil Bull) read the notice calling the meeting, and the report of the Directors was taken as read.

The CHAIRMAN said: As the attendance of shareholders is not very large, I do not think I need go through too much of the report. I believe we shall all agree upon one thing—that large dividends and small speeches are infinitely better than large speeches and small dividends. The profit and loss account shows a gross profit to the amount of £10,735, including the balance of £65. 16s. 5d. brought forward from last year, and we pay you now in dividends £7,000, leaving £369. 10s. 4d. to be equally divided (according to our articles of association) between the Founders and the Ordinary shareholders. We have also provided for contingencies the sum of £8,000, and I think that when you see by the footnote in the balance-sheet that there is a contingent liability amounting to £35,000 odd, you will agree with me that this is a proper thing to do. At the same time, I may comfort you with this statement—that we have no reason to fear; and although we are certain that this liability will be called up, yet we feel almost as certain that the shares for which there is this contingent liability will be well worth the money, and more too. I will now go to the balance-sheet. The capital, authorised, subscribed, and called up, is the same as before. The reserve fund remains the same. The provision for contingencies I have mentioned. The loan account is money borrowed from the bank. The sundry creditors are the usual ordinary creditors of a company like this, and some of them are already paid. The item of "unclaimed dividends" explains itself, and the balance of profit and loss account I have already mentioned. Now we come to the most serious point—"investments at cost." We have kept the entry in that way, but I can safely say—and I am happy to see the auditor present—that the investments at cost price could be realised even in these depressed times for this amount and more. Speaking for myself, I should be only too glad to give this amount for them now, and therefore I consider that we may rest perfectly assured that we are in a good position with regard to this matter. The sundry debtors, amounting to £918, are quite good, and cash in hand speaks for itself. I will now go to the profit and loss account, and on the one side you see the general charges, including the different items of which the amount is made up, and the additional remuneration which the Directors get after paying a dividend of 10 per cent. These general charges amount to £2,365. The interim dividend which we paid was at the rate of 10 per cent. per annum, leaving the net profit available as before mentioned. On the other side of the account you see the amount of our receipts, and we only carry down what we really consider the profit for the time being. I do not think I shall have many questions put to me, but I shall be only too happy to answer them. I now propose—

"*That the Report of the Directors and the statement of the accounts to May 31st, 1894, with the appropriation of the surplus profits as proposed, be and the same are hereby received and adopted.*"

Mr. J. B. BRAITHWAITE, jun., in seconding the motion, remarked that the shareholders would see that the Company was getting into a very sound condition. They now had a reserve fund amounting to the whole of their paid up capital.

The resolution was carried unanimously.

The CHAIRMAN then proposed—

"*That a Dividend at the rate of 40 per cent. per annum for the half-year ended May 31st, 1894, making with the interim dividend of 10 per cent. paid for the six months ended November 30th, 1893, 25 per cent. for the year, be and the same is hereby declared on the capital paid-up on the Ordinary Shares, that a dividend of £30 be declared on each Founder's Share, and that the respective dividends be paid on June 27th, 1894.*"

Mr. B. H. VAN TROMP, in seconding the motion, said it must be a great satisfaction to all the shareholders to know that the Company had been so well conducted that they were able to pay the dividend proposed out of the profits they had made, and with perfect fairness towards everyone.

The resolution was carried unanimously.

The Right Hon. Lord CLONCURRY then proposed the re-election of the retiring Directors, Messrs. Herring and Van Tromp. He was, he said, sure that the shareholders would unanimously pass the resolution, for their success was mainly due to the unremitting attention of the Chairman.

The MANAGING DIRECTOR (Mr. Emile Garcke) seconded the motion, which was unanimously adopted.

The auditors, Messrs. Rait and Kearton, were afterwards re-elected for the year ending May 31st next.

The proceedings then terminated.

Reuter's Telegram Company (Limited).

The thirtieth ordinary general meeting of this Company was held on Wednesday, at the offices, Old Jewry, Admiral the Right Hon. Sir J. C. D. Hay, Bart., K.C.B., presiding.

The SECRETARY (Mr. W. F. Bradshaw) read the notice convening the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN then said: Gentlemen, I now rise to move the adoption of the report, and I may explain why the general meeting has been held later than usual this year. The reason is that since the opening of our advertisement business it has been found difficult to present the accounts so early as was the case before the commencement of the advertisement business, and even last year and the year before it was with difficulty that the accounts could be furnished at the end of May. In view of this circumstance it was thought advisable to simplify matters by postponing the general meeting for a few weeks, by which the advantage has been gained of being able to meet the shareholders after all arrangements with Reuter's International Agency have been finally completed and legally settled. In future, we hope to revert to an earlier date for our general meeting. The advertisement business having been discussed at the recent special general meeting, my remarks on this occasion will be directed to the other branches of the Company's operations. I wish we were able to present to you a more favourable report. I believe, however, that you will not be wholly unprepared for the statement I have to make, in view of the fact that during the whole of last year business continued in a state of the greatest depression. Like so many others, we have been adversely affected by the fall in silver. The subscriptions to our various news services in India, the Straits and China being paid in silver, we have lost considerably by the decline in the value of the rupee and dollar respectively. The loss due to this cause will be apparent when I remind you that the difference between 1s. 6d. a rupee, the rate current when our contracts were entered into, and the actual rate means a loss to us in India and the Straits alone of about £2,000 per annum. The partial paralysis of trade arising from the same cause has reacted on our business in other departments. We did not fail at once to make the necessary changes, and hope that the fresh arrangements will improve our position before the end of this year. You will readily understand the large outlays rendered necessary by the protracted civil war in Brazil, the troubles in Argentina, and the Matabele campaign, not only in telegrams, but also in obtaining the information embodied in those telegrams. The accuracy and promptitude of our service regarding these matters have been generally recognised, and I am happy to be able to inform you that to-day we enjoy a larger measure of support from the Press than we have done at any previous period of our history. This shows that our business is sound; and, but for the causes previously explained, and over which we had no control, the results for 1893 would have been more favourable. While on the subject of our news business I should like to state that we were put to a great deal of unexpected expense last year, owing to the action of a news organisation in the United States with whom we had a contract for some time. We have been saddled with heavy outlays, which considerably swell the amount figuring in the accounts under the head of expenses. This matter is now before the Courts, and I will only say that we hope to obtain compensation for the loss we have sustained. Our present arrangements in America are most satisfactory, and we are on the closest terms of alliance with the Associated Press. In conclusion, I beg to move "That the report and accounts now presented be received, adopted, and entered on the minutes."

The Hon. MARK F. NAPIER, M.P., seconded the motion, which was carried unanimously.

Baron GEORGE DE REUTER proposed, and Mr. FREDERICK J. GRIFFITHS seconded, the re-election of Admiral the Right Hon. Sir J. C. D. Hay as a director.

The motion was carried, and after the re-appointment of Messrs. Welton, Jones and Co. as auditors, the proceedings terminated.

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Hobart Electric Tramway Company (Limited).

The first annual general meeting of the shareholders was held at the offices of the Company, College Hill Chambers, Cannon-street, on Wednesday last, Mr. D. J. Mackay presiding.

The SECRETARY (Mr. G. Carnaby Harrower, C.A.) read the notice calling the meeting, the report of the Directors and statement of accounts being taken as read.

The CHAIRMAN said: Gentlemen, at the first ordinary general meeting of the Company, which was held on June 30, 1892—nearly two years ago—Sir Edward Braddon, who presided, detailed the circumstances that attended the formation of the Company, and sketched out our prospects as they at that time appeared. Since then we have passed through a financial crisis of unprecedented magnitude, which has, in greater or less degree, affected all the Colonies. The crisis did not directly affect our Company, as the funds for the completion of the tramway had been provided at its formation; but it is probable that our traffic receipts have been affected by the altered financial conditions in the Colony. It is fitting that, in the first place, I should explain the cause of the protracted delay that has occurred in presenting our report, which you will see is for a period of about twenty-one months. The Company was registered on March 4, 1892, and our report is for the period to December 31, 1893. You will recollect that under the contract with the original Company it was provided that the vendor Company should complete the lines to the satisfaction of this Company, and hand over the same in time to enable Messrs. Siemens to commence the running by January 1, 1893; and by the contract with Messrs. Siemens it was provided that the lines would be open for public traffic by that date. Instead of opening the line upon this date we were unable to do so, as the report shows, until September 21st following. Messrs. Siemens were unable to deliver a portion of the plant on account of a strike at the works of one of the contractors. After the plant had arrived in Tasmania a difficulty arose with the Government, at the instance of the local telephone company, who alleged that the service would interfere with their service. This difficulty proved to be serious, and involved protracted delay; but eventually it was amicably adjusted, under an arrangement by which our wires were placed so as not to interfere with those of the telephone company. The suspension of operations was a serious matter to us, as meantime our debenture interest had to be provided, and no revenue was being received. The service was opened on September 21st, and the tabulated statement in the report (given below) shows with what result, there being a considerable surplus after providing for maintenance charges. This surplus would doubtless have been larger but for the fact that the full service was not supplied at the start. It is only natural to expect troubles to arise at the commencement of running; but I am pleased to be in a position to announce that the service is now fairly well maintained, and that when we see our way to provide the additional sidings required we shall be in a position to fulfil the expectations held out in the prospectus as to the extent of the service. In the report you will observe reference is made to the settlement with Messrs. Siemens of the amount due under their contract, and it is right that I should allude to this matter. Messrs. Siemens, under their contract, were to hand over the line in working condition with a full service by December 31, 1892, but the difficulties to which I have referred prevented this being done. We accordingly intimated a claim to Messrs. Siemens for loss of revenue for the nine months beyond the contract date. Messrs. Siemens put forward a counter-claim for loss occasioned to them by our not providing them with way-leaves as set out in the contract. After many meetings we adjusted a settlement on the basis of their being paid the balance due under their contract but no extra charges, on condition that we departed from our claim for loss of revenue. Under Messrs. Siemens' contract they undertook to work the line for 12 months from December 31, 1892, at 4d. per car mile, receiving not less than £1,000 per month, including in same wages of conductors, drivers, and of all the necessary maintenance staff. By a subsequent arrangement with Messrs. Siemens they undertook to work the line to March 31st last, on which date we took the maintenance into our own hands, having with Messrs. Siemens' concurrence entered into an arrangement with their Mr. Parker to supervise the running. Under this arrangement we know that there will be a considerable annual saving. We consider ourselves fortunate in having secured the services of Mr. Parker, who acted as Messrs. Siemens' engineer during the period of construction. Referring to the balance-sheet, there are one or two items which you will probably expect me to explain. The debenture debt is stated at £41,760, but the amount provided for was £45,000. The balance of the issue has since been allocated. These bonds are terminable, being redeemable January 1, 1906, at 105, or at any time during their currency on six months notice. There is also an option to exchange into Ordinary shares at par. Provision will require to be made for the redemption of the issue, and the matter is one that will require the consideration of the Board during the current year. As the bonds carry interest at 5 per cent. the suggestion has been made that in the event of our requiring to make a further issue for extension of mileage and addition to plant, we should be able to replace the present debt by an issue of Debenture Stock at a lower rate. From such an issue advantages would accrue to both the bondholders and the Company. If the bondholders converted they would receive their equivalent in the new Stock, which would have the advantage of a readier market, while we should have our debt on a permanent basis and at a lower annual charge. This suggestion is one which will receive the careful consideration of the Board. On the debtor side "sundry creditors, £1,215," consists mainly of the balance due to Messrs. Siemens for maintenance (£750), the other items being engineers' fees £218, and trusteeship for debenture-holders, income-tax on debenture interest, and auditors' fees, &c., &c., £247. The item, "Balance claimed by vendors," is in dispute. We await further information in regard to this item, and meantime it has been placed in suspense. The items on the other side of the account, representing expenditure in London and Hobart, explain themselves. They represent the charges extending over a period of 21 months. You will observe that no revenue account has been submitted. We propose that all payments and receipts to December 31st be put to capital account, and that the revenue account shall commence as at January 1st, when it might be held that the Company had really made a start. In next year's accounts a profit and loss account will be submitted. You will probably now consider that I have entered with sufficient fulness into the various matters referred to in the report. It is gratifying to be able to state that the interest on the debentures has been regularly paid up to date, and that funds are in hand for the service of the coupons due July 1st. Before I sit down I would refer to the fact that Sir Edward Braddon, the late Chairman of the Company, having returned to Hobart, has been elected to a seat on the Committee there. This reduces the number of the London Board to three, with a corresponding reduction in the fees payable to the London Directors. We desire to carry on the business economically and efficiently, and we hope that the arrangements we have now adjusted to this end will show results which you will consider satisfactory when we submit our next accounts. The cars and electrical machinery have given entire satisfaction to our Local Committee and the public of Hobart, and our electric tramway is one of the features of attraction in Tasmania. We, of course, regard the undertaking mainly from a commercial standpoint; but if to this is added, as in our case, the being the first to demonstrate in the Southern Hemisphere—at any rate, in the Australian Colonies—the advantages of electric traction, the interest in our enterprise is naturally enhanced. Your Directors trust when we next meet we shall be able to congratulate ourselves upon the possession of a successful commercial enterprise. I now move the adoption of the report and balance-sheet, and shall be glad to answer any inquiries you may find it necessary to make.

Dr. A. MATTEI seconded the motion, which was unanimously agreed to.

On the motion of Dr. MATTEI, seconded by Mr. STEWART, Mr. Charles Barclay and Sir Edward N. C. Braddon, who retire at this time, were re-elected.

The auditors, Messrs. C. N. Read, Son and Co., having been also reappointed, the proceedings ended with the passing of a vote of thanks to the Chairman and Directors.

The following tabular statement given in the Directors' report shows the mileage, the takings, and the working expenses (not including those of administration) from September 21, 1893, (opening of line), to March 31st last.

Month.	No. of cars employed.	No. of car miles.	Gross takings.	Working expenses paid or due Messrs. Siemens under contract.	Balance left.
Sept. 21—Oct. '93	483	30,450	£1,618	£1,190	£428
November „	364	24,888	1,113	788	325
December „	414	32,460	1,426	522	904
January, 1894	411	33,093	1,720	1,000	720
February „	373	30,204	1,439	1,000	439
March „	427	33,537	1,428	1,000	428

NEW COMPANIES, STATUTORY RETURNS, &c.

ELECTRIC NOVELTY SYNDICATE (LIMITED).—This Company was registered on June 23rd, with a capital of £4,500, in £1 shares, to acquire an invention for "improvements in electrical toys," also an invention for an electrical appliance or apparatus for indicating the names of stations on railways, to acquire all improvements on the said inventions, and any other inventions connected with the manufacture of electrical apparatus, to adopt an agreement dated June 19th between Richard Myers and Edward Nicholls (on behalf of the Company), and to carry on the business of manufacturers of, and dealers in, electrical or other mechanical toys, electrical batteries, apparatus and appliances, electricians, mechanical engineers, suppliers of electricity, and the general business of an electric light company in all or any of its branches.

EYLAND AND SONS (LIMITED).—This Company has been registered with a capital of £15,000 in £5 shares, to acquire the business of opticians, &c., hitherto carried on by Eyland and Sons at Walsall, Staffordshire, and to carry on and extend the same.

FRASER AND FRASER (LIMITED).—This Company was registered on June 23, 1894, with a capital of £30,000, in £10 shares, to acquire and take over as a going concern the business carried on at the Railway Works, Bromley-by-Bow, London, E., and to carry on the business of steel makers, iron and steel converters, and manufacturers, mechanical engineers, electrical engineers, tool makers, tin-plate makers, boiler makers, metallurgists, consulting engineers, &c.

J. AND E. GLEDHILL (LIMITED).—This Company has been registered with a capital of £4,000 in £50 shares, to acquire the good-will of the business of contractors' engineers, hitherto carried on at Lindley, near Huddersfield, and elsewhere, by J. and E. Gledhill.

LIVERPOOL RUBBER COMPANY (LIMITED).—This Company has been registered with a capital of £123,117. 10s., divided into 6,605 Five per Cent. Non-Cumulative Preference shares of £3. 10s. each and 20,000 Ordinary shares of £5 each, to enter into and carry into effect an agreement between the Liverpool Rubber Company (Limited) and Henry G. Tippet (its liquidator) and this Company, and to carry on the business of india-rubber manufacturers in all its branches.

NORTHERN ENGINEERS' SUPPLY COMPANY (LIMITED).—This Company was registered on June 19th with a capital of £3,000, in £5 shares, to supply goods and articles to ironfounders, mechanical engineers, mill-

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wrights, tool makers, brass founders, machinists, ship owners and builders, railway and canal companies, &c.

PATENTS (PIONEER) SYNDICATE (LIMITED).—Among the objects of this Company, which was registered on June 20th with a capital of £10,000, in £1 shares, is the carrying-on of the business of civil, mechanical, electrical, and general engineers.

SALISBURY ELECTRIC LIGHT AND SUPPLY COMPANY (LIMITED).—This Company was registered on June 21st, with a capital of £20,000 in £1 shares, to carry on in the City of Salisbury the business of manufacturing and supplying electric current, light and power, to endeavour to procure a license from the Board of Trade under the Electric Lighting Acts, 1882 to 1888, and, further, make due application for a Provisional Order under the said Acts, and to carry on any business in connection therewith which the Directors may consider desirable. The subscribers (with one share each) are:—William H. Gramshaw, William M. Hammick, J.P., William Marlow, J.P., Douglas J. K. Macdonald, Arthur R. Malden, Alfred R. Dawson, and Arthur J. Dempsey. The first Directors are to be appointed by the subscribers to the Memorandum of Association.

AMERICAN RIVER ELECTRIC POWER SUPPLY COMPANY (LIMITED).—In reply to official inquiries the secretary stated on June 4th that the Directors of the concern did not proceed to allotment, and all the money was returned to the applicants for shares.

BRITISH INSULATED WIRE COMPANY (LIMITED).—The annual returns of this Company, made up to June 28, 1893, and March 28, 1894, have been recently filed. The nominal capital is £110,000, divided into 300 Founders, 3,950 Preference, 9,450 Ordinary "A," and 8,300 Ordinary "B" shares of £5 each. 300 Founders, 3,770 Preference, 6,902 Ordinary "A," and 7,053 Ordinary "B" shares have been taken up, of which 219 Founders, 975 Preference, 475 Ordinary "A," and all the Ordinary "B" shares have been issued as fully paid. Upon 81 Founders, 2,695 Preference, and 6,327 Ordinary "A" shares the full amount has been called, while upon 100 Preference and 100 Ordinary "A" shares calls amounting to £3. 15s. per share have been made, realising £46,270. An agreement, dated April 20, between Felten and Guilleaume, of Mülheim, Germany, and this Company, provides for the grant of the sole and exclusive licence for making, using and vending, in the United Kingdom and the Isle of Man electric cables, in accordance with an invention for improvements in electric cables, dated April 12, 1892, and numbered 7,029, in consideration for the allotment to the former or their nominees of 1,000 Ordinary "B" shares, which shall be deemed for all purposes to be fully paid up. During the continuance of the licence a royalty of 5 per cent. on the selling price of all electric cables manufactured, used, sold, or otherwise disposed of, from April 1, 1894, is to be paid.

BROWETT, LINDLEY AND CO. (LIMITED).—The annual return of this Company made up to May 2nd has been filed. Out of a nominal capital of £20,000, divided into 1,600 Ordinary and 400 Preference shares, 1,362 Ordinary and 200 Preference have been taken up, of which 800 of the former class have been issued as fully paid. Upon the remaining 562 Ordinary and 200 Preference shares, the full amount has been called and paid.

CALLENDER'S BITUMEN TELEGRAPH AND WATERPROOF COMPANY (LIMITED).—The annual return of this Company, made up to June 5th, has been filed. 6,316 shares have been taken up out of a nominal capital of £80,000, in £10 shares. 3,000 of these have been issued as fully paid, and the full amount has been called on the remainder, resulting in the total payment of £33,160.

CAMBRIDGE UNIVERSITY AND TOWN ELECTRIC LIGHTING COMPANY (LIMITED).—A letter dated May 10th, from Messrs. Baily, Grundy and Barrett (Limited), electrical engineers, of 2, St. Mary's-passage, Cambridge, states that the above-mentioned Company has never made any allotment of its shares, or commenced to carry on any business. It has a nominal capital of £50,000, in £10 shares, and the seven signatories' shares are the only ones taken up.

MOSLEY AND COMPANY (LIMITED).—This Company has just entered into an agreement with Matthew A. Mosley, Robert Wright, and John H. Richardson, all of Wakefield, Yorks, for the acquisition of an invention connected with "improvements in or appertaining to the electro-deposition of zinc," for which provisional protection had been granted. The consideration for the same was fixed at £8,000, payable by the allotment of 8,000 fully paid shares, and 15 per cent. of the net proceeds realised by the Company from the sale or working of the foreign patents.

RAILWAY ELECTRIC READING LAMP COMPANY (LIMITED).—The first annual return of this Company, made up to January 12, 1894, was recently filed. Only the seven subscribers' shares have been taken up out of a capital of £100,000 divided into 16,000 Ordinary and 4,000 Deferred shares of £5 each, and no calls have as yet been made.

CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).—The Directors of this Company have declared an interim dividend on the Preference shares of the Company at the rate of 6 per cent. per annum for the six months ended the 30th inst., the dividend to be payable on and after the 19th prox.

EASTERN TELEGRAPH COMPANY (LIMITED).—This Company announce that, subject to final audit, the accounts show, after placing about £110,000 to reserve fund, a balance available sufficient to pay at the general meeting on July 12th next, the fixed dividend of 3s. per share, being at the rate of 6 per cent. per annum on the Preference shares, less income tax, and a final payment of 2s. 6d. per share with a bonus of 3s. per share, both free of income tax, on the Ordinary shares, making with previous payments on account, a total distribution of 6½ per cent. on those shares for the year ended March 31, 1894. The transfer books will be closed from July 4th to 12th inclusive.

CITY NOTES.

BIRMINGHAM MINT.—The Directors of this Company at their last meeting announced the payment of a dividend of 7 per cent. on the share capital for the past year.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended June 24th were £863 as against £765 in the corresponding period of 1893, being an increase of £98. The total receipts for the half-year amount to £22,616, as against £21,799 for the corresponding period of 1893, an increase of £817.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).—The Directors of this Company on Wednesday declared an interim dividend, for the quarter ended March 31st last, of 2s. 6d. per share, free of income-tax, payable on the 16th prox. The Share Register will be closed from the 7th to the 14th prox., both days inclusive.

EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY (LIMITED).—This Company notify that the coupons due on July 1st prox. on their Five per Cent. Mortgage Debentures will be paid on and after that date at the banking house of Messrs. Barclay, Bevan and Co., 54, Lombard-street, E.C.

ELECTRIC AND GENERAL INVESTMENT COMPANY (LIMITED).—The warrants for the dividends on the Ordinary and Founders' shares in this Company, recently declared, have been posted.

ELECTRIC TRANSMISSION OF POWER IN MINING.—The Chairman of the Lisbon-Berlyn Company (Limited) at a meeting of the shareholders on Monday last referred to the plant recently put down for providing motive power at the Company's Frankfort mine. This, he explained, was at present inadequate, but at the Lisbon and Berlyn property, situate about ten miles from Frankfort, the Company had all the motive power it required, and by means of electric transmission they would be able to drive their stamps at the Frankfort. At the Lisbon-Berlyn property they had a waterfall of over 400ft., or nearly three times the height of Niagara. They had proved the value of their property, and it was necessary, in order to enable them to increase their output, to put down at once an electric installation, the estimate for which was £6,600, but which would ultimately amount to about £10,000.

ELEKTRICITATS-AKTIEN-GESELLSCHAFT VORM. SCHUCKERT AND CO.—For the year 1893-94 this Company has a credit balance of 2,103,934 marks, out of which it is proposed to pay a dividend of 9 per cent., and to carry forward 463,663 marks.

ELEKTRICITATS-AKTIEN-GESELLSCHAFT VORM. W. LAHMEYER AND CO.—This Company's balance-sheet for 1893-94 shows the receipts for the year to have been 215,358 marks, while the total expenses have reached 258,059 marks, leaving a deficit of 42,701 marks.

FRENCH COPPER COMPANIES.—It is announced in *L'Industrie Électrique* that the French Elmore Company and the Compagnie Française des Métaux are to be amalgamated, with a capital of 25 million francs. This, if correct, will give M. Secrétan the renewed control of the French copper market.

HOBART ELECTRIC TRAMWAY COMPANY (LIMITED).—Notice is given that the interest due on coupon No. 5 of the First and Second Mortgage Debentures will be payable at the Commercial Bank of Scotland, 62, Lombard-street, London, E.C., on and after July 1st next.

INDIA-RUBBER, GUTTA-PERCHA, AND TELEGRAPH WORKS COMPANY (LIMITED).—A half-yearly general meeting of the Company will be held at the Cannon-street Hotel, London, on Thursday next, the 5th prox., at 12 noon, for the purpose of obtaining the sanction of the shareholders to the payment of an interim dividend of 5 per cent., or 10s. per share, free of income-tax. The Company's Share Register will be closed from the 27th inst. to the 5th prox., both days inclusive.

INTERNATIONALE ELEKTRICITATS-GESELLSCHAFT IN WIEN.—A dividend of 6 per cent. is proposed on the working for 1893-94, against 5½ per cent. paid in the preceding year.

IRISH TRAMWAYS.—The Cork Tramways Company (Limited) invite applications for 1,700 shares of £10 each, £5,000 of which has already been subscribed by the Great Southern and Western Railway Company and some of the leading citizens of Cork. The money is required to construct tramways of a total length of about 3½ miles, with power to work by electricity or horse-power.

ORIENTAL TELEPHONE AND ELECTRIC COMPANY (LIMITED).—The first ordinary general meeting of this Company will be held on Wednesday, July 4th, at one o'clock p.m., at Winchester House, Old Broad-street, E.C.

SALT LAKE AND OGDEN GAS AND ELECTRIC LIGHT COMPANY (LIMITED).—The Gas, Water and General Investment Trust notify that the coupons of this Company's First Mortgage Six per Cent. Bonds due July 1st next will be paid at the National Provincial Bank of England, Bishopsgate-street, on and after July 2nd.

STOCK EXCHANGE NOTICES.—The Stock Exchange Committee appointed Wednesday last a special settling day in the Ordinary shares, Nos. 1 to 20,000, of the County of London and Brush Provincial Electric Lighting Company (Limited). They have ordered the further issue of 8,180 Seven per Cent. Cumulative Preference shares, Nos. 20,001 to 28,180, of Crompton and Co. (Limited) to be quoted in the Official List.

SWAN UNITED ELECTRIC LIGHT COMPANY (LIMITED).—An extraordinary general meeting of this Company will be held at the Cannon-street Hotel, E.C., on Tuesday, July 3rd, at 12 o'clock, for the purpose of discussing and confirming the resolution passed at the extraordinary general meeting held on the 14th inst.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended June 22nd (after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited), were £2,401.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, June 20.		Price Wednesday June 27.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending June 27.	
			TELEGRAPHS.					£ s. d.		Highest	Lowest
£1,012,880	Stock	9/0	Anglo-American	40	42	37	40	6 5 1	Jan., Apr., July, Oct.	39¼	39
£2,933,560	Stock	18/0	Do. Preferred	76	77	70	72	6 11 11	,, ,,	76¾	64½
£2,933,560	Stock	5/0	Do. Deferred	7	7½	6¼	6¾			6⅜	6¼
£184,500	100	4%	African Direct Telegraph 4% Deb. (Reg. & Bearer)	102	105	102	106	3 15 6	January and July	104½	..
130,000	£10	3/0	Brazilian Submarine	12¼	12¾	12	12½	5 4 0	Mar., June, Oct., Dec.	12⅝	12½
£18,700	£100	5%	Do. 5 per Cent. Bonds	101	104	101	104	4 16 2	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	109	113	109	113	4 8 6	June and December	..	..
10,000,000	$100	$1¾	Commercial Cable Capital Stock xd	139	143	139	143	4 17 11	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	12	13	12	13	6 3 1	February and August	..	..
6,000	10	10%	Do. Preference 10 per Cent.	18½	19½	18½	19½	5 2 7	,, ,,	..	..
12,931	5	1/7½	Direct Spanish (fully paid)	4	4½	4	4½	4 8 11	April and October		..
6,000	5	10%	Do. Preference 10 per Cent.	9	9½	9	9½	5 5 3	,, ,,	9½	
60,710	20	2/0	Direct United States Cable, 1877	9¼	9¾	8	9	6 13 4	Jan., Apr., July, Oct.	9 3/16	9
400,000	10	2/6	Eastern	15	15½	15	15½	4 5 3	,, ,,	15 3/16	15
70,000	10	6%	Do. 6 per Cent. Preference	15¾	16½	15¾	16½	3 13 10	,, ,,	16½	15¾
£1,297,847	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	113	116	113	116	3 9 0	May and November	115	114
£102,100	100	5%	Do. 5 per Cent. Debentures, 1899	107	110	107	110	4 10 10	February & August	..	..
250,000	10	6/6	Eastern Extension	15½	15¾	15½	15¾	4 11 1	Jan., Apr., July, Oct.	15¾	15½
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	114	118	114	118	3 7 10	February & August	..	..
£62,700	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	105	108	105	108	4 12 7	January and July	107½	..
£95,100	100	5%	Eastern and S. African 5 per Cent. Mor. Deb., 1900	105	108	105	108	4 12 7	,, ,,	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures, 1909 (regd.)	105	108	105	108	3 14 1	February & August		..
£200,000	£25	4%	Do. 4% Mauritius Sub. Debs.	107%	110%	107%	110%	3 12 9	May and November	..	..
180,227	10	2/6	Globe Telegraph and Trust	8⅝	8⅞	8⅝	8⅞	4 15 6	Jan., Apr., July, Oct.	8 11/16	8⅝
180,042	10	6%	Do. 6 per Cent. Preference	15½	15⅞	15	15½	3 18 3	,, ,,	15½	15
150,000	10	7/2	Great Northern	21	21½	21	21½	3 19 1	Jan., April, and July	..	..
£190,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	105	108	105	108	4 12 7	March & September	107½	.
17,000	25	37/6	Indo-European	43	45	43	45	5 11 1	May and November	.	..
37,548	10	5/0	London Platino-Brazilian	5	7	5	7	..	,, ,,	.	..
£100,000	100	6%	Do. 6 per Cent Debentures	107	110	107	110	5 9 1	March & September	..	..
£100,000	£100	4%	Pacific European Tel. 4% Guar. Debs. "Red" 1942	103	106	103	106	3 15 6			.
11,839	8	4/0	Reuter's	5	6	5	6		April and October	6	5
3,381	£100 Cert.	35/0	Submarine Cables Trust 6 per Cent.	110	115	108	113	5 6 2	,, ,,	111	..
15,609	10	5/0	West African Telegraph	3	5	3	5	.	January and July	..	..
£249,900	100	5%	Do. 5 per Cent. Debentures	102	105	102	105	4 15 3	March & September	103½	102½
30,000	10	2/0	West Coast of America	2½	3	2½	3		January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	100	105	100	105	7 12 5	June and December	..	..
88,321	10	9d.	West India and Panama	1⅛	1⅜	1⅛	1⅜			..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10	10½	10	10½	5 14 3	May and November	10⅜	10
4,669	10	6%	Do. 6 per Cent. 2nd Preference	9	10	9	10	6 0 0	,, ,,	..	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	109	112	109	112	4 9 3	June and December	..	..
64,242	15	7/6	Western and Brazilian	6¾	7½	6½	7	..	May and November	..	..
33,129	7½	7/6	Do. 5 per Cent. Cumulative Preferred	6	6½	5¾	6¼	.	..	6	..
33,129	7½	7/6	Do. 5 per Cent. Deferred	2	2½	2	2½			2	..
£171,900	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	107	110	107	110	5 9 1	February & August	.	..
£214,800	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	107	110	107	110	5 9 1	,, ,,	.	..
$1,211,000	$1,000	7%	Western Union 7% 1st Mort. (Building) Bonds	111	115	111	115	6 1 9	May and November	..	
£166,900	£100	6%	Do. 6 per Cent. Sterling Bonds	100	104	100	104	5 15 5	March & September	..	..
			TELEPHONES.								
44,000	5	10/0	Chili Telephone (fully paid)	1½	2½	1½	2½	..	..	..	..
224,850	10/0	2⅜d.	Consolidated Telephone Const. & Maintenance xd	3/16	5/16	3/16	5/16	..	May and November	..	..
171,504	£1	6d.	Oriental Telephone and Electric (fully paid)	½	⅝	½	⅝	..	Yearly	..	..
484,597	5	2/6	National	5	5½	4⅞	5⅜	4 17 7	June and December	5⅛	4 15/16
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	15	16	15	16	3 15 0	,, ,,	..	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	14½	15½	14½	15½	3 17 5	,, ,,	..	..
119,234	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	5⅝	5⅞	5⅝	5⅞	4 5 1		5¾	..
1,000,000	Stock	4½%	Do. Debenture Stock, 4½%	112	115	112	115	3 18 3	January and July	115	..
58,000	5	1/0	United River Plate	1½	2	1½	2		,, ,,	..	..
£146,733	Stock	5%	Do. 5 per Cent. Debenture Stock	90	100	90	100	5 0 0	,, ,,	..	..
			ELECTRICITY SUPPLY COMPANIES.								
40,000	£10	..	City of London Electric Lighting (fully paid)	12	13	12½	13½	..	..	..	..
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	13½	14	13¾	14½	4 4 3	..	14	13 15/16
19,900	£5	..	Electricity Supply Co. for Spain	.		.		.	..	..	..
£30,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	4½	5½	4½	5½	.	.	..	..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	..		..		.	..	..	..
8,322	£5	..	House-to-House Electric	..		..		..	..	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid).	..		..		.	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	.		..		..	January and July		..
5,523	£5	1/9	Liverpool Electric Supply (£4. 10s. paid)	..		..		.	..	..	..
39,477	£5	2/6	Do (fully paid)	6⅜	6½	6⅜	6½	..	..	.	..
111,000	5	..	London Electric Supply	½	⅝	½	⅝		..		..
49,900	£10	5/0	Metropolitan Electric Supply (fully paid)	8½	9	8½	9	2 15 7		8¾	..
£100,000	Stock	5%	Do. 5% Debs. (Bonds of £10, £20, and £40)	107	110	108	111	4 10 1	June and December	111	..
6,452	£10	..	Notting Hill Electric	4½	5½	4½	5½				..
19,980	£5	4/6	St. James and Pall Mall	7	7½	7	7½		..	7½	
20,000	£5	7%	Do. 7 per Cent. Preference	8¼	8¾	8¼	8¾	4 0 0	..	8⅝	..
59,900	5	2/6	Westminster Electric Supply (fully paid)	6¼	6¾	6¼	6¾	2 19 3	..	6½	6⅜
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
90,000		1/6	Brush Electrical Engineering	2¾	3	2¾	3	6 0 0	..	3	2⅞
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	2⅛	2⅜	2⅛	2⅜	5 1 1		2 1/16	..
£125,000	Stock	4½%	Do. 4½ per Cent Debentures	109	112	109	112	4 0 4	March & September	.	..
20,000	5	2/6	Crompton and Co., 7 per Cent. Cumulative Pref.	2¾	3¼	2¾	3¼	.	January and July	..	..
12,139	5	.	Edison and Swan United						..	.	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	..		..		..	..	–	..
120,000	2	..	Electric Construction	½	¾	½	¾	.	..	..	–
12,845	2	..	Do. 7 per Cent Cumulative Pref.	1¼	1¾	1¼	1¾	..	..	..	.
91,195	2	10/0	Elmore's Patent Copper Depositing	1⅛	1⅜	1	1¼	..	..	1 1/16	1
20,000	5		Fowler-Waring Cables (fully paid)	½	1½	½	1½				..
50,000	10	15/0	India Rubber, Gutta Percha, &c., Works	23½	24½	23½	24½	5 2 9	February & August	24⅛	23⅝
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103	105	103	105	4 5 9	March & September	..	..
15,995	£10	6/4	International Okonite Ordinary	..		..		.		–	–
16,000	£10		Do. 8 per Cent. Preference	..		.		.	December and June	–	–
20,000	9		Manchester Edison-Swan "A" (£1 paid)	—	⅛	—	⅛		..	–	..
78,949	5	3/6	Swan United (£3 10s. paid)	2	2½	2	2½	7 0 0	May and November	2⅜	..
37,350	12	36/0	Telegraph Construction and Maintenance	39	41	40	42	5 14 3	March and July	41½	40½
£150,000	100	5%	Do. 5 per Cent. Bonds	104	107	104	107	4 13 6	January and July	..	–
37,514	£5	..	Woodhouse and Rawson Ordinary (£3 15s. paid)	–		–		..	..	–	–
41,098	£5	..	Do. Preference (fully paid)	..		–		..	–	–	–
			RAILWAYS AND TRAMWAYS.								
£630,000	Stock	½%	City and South London Railway	36	38	36	38	1 16 2	May and November	..	–
£67,130	Stock	4%	Do. 4% Perpetual Debenture	119	121	119	121	3 6 2	May and November	119⅜	–
7,000	10	5%	Do. 5% Perpetual Preference	12½	13	12½	13	3 16 11	..	13	12⅞
37,500	£10	1%	Liverpool Overhead Railway	8 3/16	8 5/16	8 3/16	8 5/16	..	..	..	–
6,29	10	5%	Do. 5% Preference	12¾	13¼	12¾	13¼	3 16 2	.	..	..
£125,000	Stock	4%	Do. 4% Debenture	112	114	112	114	3 10 2	January and July ..	..	–

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THE ELECTRICIAN:

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NOTES.

Not the least strange of life's many little ironies is the exceeding infrequency with which institutions founded under the most favourable auspices, and with the most benevolent intentions, inure to the benefit of those whom the founders had in mind. But if the demon of misdirection can be exorcised, the clear-sightedness and self-abnegation shown by Mr. Ludwig Mond in endowing the Royal Institution with a "Davy-Faraday" laboratory for the purposes of physical chemistry research should accomplish this feat. Mr. Mond, in modestly refraining to connect his own name with this munificent tribute to pure science, in clearly defining its scope, and in connecting it with the classic names of Humphrey Davy and Michael Faraday, has done all that lies within the power of a single individual to insure that sound work, sober work, and genuine scientific work shall be the fruits of his free-will offering. May the new laboratory be instinct with the spirit as well as honoured with the titles of Davy and Faraday!

We regret to record an accidental death at the Blackfriars transformer sub-station of the London Electric Supply Corporation. The four mains from Deptford enter by a small cellar under the sub-station, and are connected by omnibus bars and switches to the outgoing mains to London. The inner conductors alone are connected to the bare metal-work of the switches, the outers are all connected together by well-insulated cables, and, under ordinary circumstances, no serious shock can be obtained in this cellar, the floor of which consists of a rubber-covered platform on oil insulators. A leak had been discovered on one of the London mains, and this main was cut out by switches, and was tested. It was decided to connect a Deptford main on one side of the cellar to a London main on the other side by two plugs and a length of cable as a temporary expedient. The switch-man, who was thoroughly familiar with his work, and who had been in the employ of the Company for five years, put the plug on to one of these mains, which, according to the strict rules of the Corporation was, while work was being done upon it, "dead." Thinking that the plug might slip off, he used some binding wire to fasten it, and sent his mate for more. It is supposed that the loose end of the binding wire flicked against the "live" omnibus bar about one foot above the plug, and that he thus received a shock, throwing him back. Unfortunately, he had left open a wooden bar protecting the terminal of the faulty main behind him and this allowed his head to strike a live Deptford terminal and at the same time the faulty London main. A serious arc was struck, blowing the fuse at Deptford, and of course killing the unfortunate man. Of the two accidental causes, the use of binding-wire where a bit of string or spun yarn would have sufficed, if, indeed, it were wanted at all, seems to be the more important. No need is apparent; but this man, after five years' experience, must have had some reason. The general arrangement of the sub-station proper, its substantial switching gear, admirable cleanness, and orderliness show that both the Corporation and its staff have done, and do, all that is possible to carry out the work in the best possible manner.

It is not the fashion for the weak to go to the wall; a few feeble folk join together and form a party; this is a species of socialism. Another plan is to choose a strong man and to lean up against him. The ventilation of the Underground Railway could not be tacked on to any political clique, and the obvious alternative was to worry the Board of Trade. Mr. Bryce will soon be asked to arrange that the thermometer shall not exceed 82° in the shade, except on Saturday afternoons and Sundays. The newspaper correspondents who have been busily inventing partitions to divide the tunnels seem never to have investigated the atmosphere of the City and South London Railway, where their ideal is completely carried out. They are, of course, oblivious to the fact that the tunnels would have to be widened and the lines separated to make their brattices practicable. The only cure is to use electric traction, and even this, judging by the South London line, will probably fail to be complete. But we are hardly ready yet for this equipment. It is not a problem for tramway electricians, but must be solved by men like Mr. Greathead, with the assistance of the most experienced contractors. The City and South London line was a very valuable experiment, the Liverpool line is a perfect success, the Waterloo and City line, for which a coffer-dam is now in construction near Blackfriars Bridge, will be built on the experience of these, and will be followed shortly by the Central. London Railway. After that is running the next step should be to see what can be done for the old Underground Railway. But who will compensate the sufferers from hay fever and asthma, who at present find that a few minutes in the darkness and the sulphur and coke-dust-laden air gives a relief that nothing else but a sea voyage can bring?

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In these days of censorships and meddling by officials with the affairs of individuals, there is room for a Suppressor of Dangerous Inventions. The Comptroller-General of Patents may, indeed, refuse to grant a patent for an invention of which the use would, in his opinion, be contrary to law or morality, but that hardly meets the present case. While patents for house-breaking tools and lottery machines and the like are thus discouraged, Lieut. Bersier's automatic electric steering compass has been tried in the French squadron for several months, and is honoured by a long description in *The Times*. The invention, though calculated to destroy more lives than the most lethal torpedo, deserves some attention on account of its ingenuity. To avoid the making of contact, which would interfere with the motion of the compass card, sparks from a Ruhmkorf coil are used, and in order that the rolling of the ship may not alter the length of the spark-gap, semicircular plates of metal insulated from each other and from the compass bowl to which they are fixed, receive the sparks from the metal point on the edge of the card. Electro-magnets, batteries, a 150-watt motor, and other apparatus is used, and "can be applied to any existing steering gear." Electrical course-signallers, and course-recorders are not new, and, if applied to a separate compass, may have their uses. We are not aware that the many machines and appliances which are to be found in a modern war vessel are intended to reduce the number of the crew, and we are inclined to think that should the crew become reduced to one man, that man will take the helm. Our feelings towards the French nation are too friendly to allow us to hope that this automatic electrical compass will come into extensive use in the French Navy.

The Paper by Dr. Koepsel, of which we give an abstract in our present issue, is one of some practical interest, especially in view of the discussions which have lately taken place on the subject of the testing of iron in workshops. We have frequently called attention in these columns to the danger which underlies most of the methods at present in use, namely, the uncertainty of the effect of joints, and our readers will notice the confirmation of these views given by Dr. Koepsel in the early part of his Paper. We have, therefore, little doubt that he is right when he says that if there must be a joint, it is as well to make so large a gap in the circuit that its effect swamps that of small differences in the contacts made by the test bar. If, as appears to be the case, it is found that the labour of winding complete rings and the trouble of ballistic measurements are sufficient to make the method impracticable, we think that Dr. Koepsel's apparatus is one deserving of consideration. The observations are of the very simplest. The men who, according to the speakers at the Institution of Electrical Engineers, are often incapable of reading a galvanometer deflection, are surely capable of reading the position of a needle on a dial.

Whether the instrument is sufficiently accurate for all purposes is not clear, as the size of the curves is such that the reader is unable to judge by what percentage the ballistic and deduced curves differ, and we must therefore take it on faith that they do not differ much. But it must be noted in this connection, that a small error in the value of **B** may produce a large variation in the area of the curve, a point which is important in connection with transformers. Other questions arise which can only be settled by practical work with the apparatus. For instance, would it not simplify matters to make it a torsional zero-reading instrument, and thus do away with the compensation which would be necessary for the magnetising effect of the swinging coil itself? The author does not mention this, and it is quite possibly so small that it can safely be neglected.

It looks as if some alternator builders were really thinking seriously of following Mr. Blakesley's historic suggestion, that they should build their machines to give "true sine curves," in order that the theory of the machines might correspond with his geometrical methods. The practice has recently become extremely popular in America, where a considerable number of manufacturers are advertising the possession of a "true sine curve" as a valuable feature of their alternators. The grounds upon which such claims are based do not always strike one as being adequate, and one may be forgiven for harbouring a little doubt about the purity and excellence of the "sine" which may be tapped at the terminals. Whether the alternator builders are striving to impart some fresh objective value to their machines, or whether they are graciously trying to get their machines into step with the effusions of the mathematicians, or whether those same effusions have acted injuriously on their otherwise practical brains, we are unable to say. Probably an alternator with a true sine curve, even though it may disdain to run in parallel with a machine having a more bactrian characteristic, is little or no better intrinsically, from a commercial point of view, than the less highly-bred article. But the former has the dignity of hob-nobbing with the text-book mathematicians, while the latter knows only the greaser and the switchboard attendant. Some day a steam engine builder may advertise a steam engine guaranteed to give "true hyperbolic expansion" and a text-book indicator diagram. Then the mathematicians will swarm around that engine, and with tears of joy they will get it coupled to the alternator with the "true sine curve."

Mr. S. A. Varley.—The Government have granted a pension of £50 per annum to Mr. S. A. Varley.

Personal.—The degree of LL.D. has recently been conferred upon Mr. Nikola Tesla by the Columbia College, U.S.A.

Tramways Institute of Great Britain and Ireland.—At a special general meeting of this Institute held at the Holborn Restaurant yesterday, a Paper on "Electric Traction" was read by Mr. A. Dickenson.

The Indian Telegraph Department.—The Telegraph Department continues to open new offices, in spite of the scarcity of money, says the *Indian Engineer*. No fewer than 76 new combined offices have opened since April 1st.

Telegraphic Communication in Japan.—Included in the Japanese Budget for the financial year 1894-95 is an item of £15,570 to provide for the establishment of a submarine cable between Saga-Leki, Okmaiva, and Oki.

German Professorial Appointments.—Prof. Ludwig Boltzmann, of Munich, has been offered the chair of physics at the

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Vienna University, rendered vacant by the death of Prof. Stefan. Prof. Kaiser, of Hanover, is to be the successor of Hertz at Bonn.

Royal Institution.—At the last general monthly meeting of the Royal Institution the special thanks of the members were returned for the following donation to the fund for the promotion of experimental research at low temperatures:—Sir Douglas Dalton, £25.

Waterloo and City Railway.—A coffer dam is now in process of construction on the Surrey side of the river just above Blackfriars Bridge to enable a shaft to be sunk for the purpose of facilitating tunnelling under the Thames in connection with the Waterloo and City Railway.

Cable Interruptions and Repairs:—

	Date of Interruption.	Date of Repair.
Tarifa-Tangier	June 12, 1894	June 24, 1894.
Bissao-Bolama	Nov. 24, 1893	—
Sierra Leone-Accra	July 2, 1894	—

The Commercial Cable Company's New Cable.—Messrs. Siemens Brothers have telegraphed that the steamer "Faraday" completed the laying of the Commercial Cable Company's third Atlantic cable on Monday. The insulation was perfect. During the laying of the cable no hitch of any kind occurred, but since the last report operations were much impeded by dense fogs.

Epping Forest Railway.—In the House of Commons on Tuesday, on the motion of Sir J. Kennaway, the London, Walthamstow, and Epping Forest Railway Bill was ordered to be recommitted to the original Committee, the Committee having leave to sit and proceed upon Thursday. The original Committee could not, however, be got together yesterday. We understand that the promoters of the Bill and the London County Council have come to terms as to the running of workmen's trains.

A Telegraphic Celebration.—The 25th anniversary of the establishment of cable telegraphic communication with the Far East will be celebrated by a banquet at the Imperial Institute, on Friday, July 20th, to be attended by gentlemen representing every section of the British Empire. More than 500 guests will be present at the banquet, which is to be followed by a reception and garden *fête*, for which several thousands of invitations will be issued. A very interesting feature of the celebration will be the display of cable telegraph instruments in working communication with the four quarters of the world. The instruments will be used by the Prince of Wales during the evening for the despatch of messages to the Governors of the various British Colonies and Depencies, and for receiving replies thereto.

Proposed Extension of the Faure Patent.—The Electric Construction Company as we announced last week in another column propose to petition the Privy Council to prolong the life of the Faure Patent, No. 129 of 1881 for "Improvements in Galvanic Polarisation Batteries or Magazines of Electricity and the Application of the same and in Apparatus connected therewith," the title and specification of which patent have been altered and amended by disclaimer and memorandum of alteration filed January 10, 1882, and which title so amended is "Improvements in Galvanic Polarisation Batteries or Magazines of Electricity." Notice is given that on August 13th application will be made for a time to be fixed for hearing the matter, and any person desirous of being heard in opposition to the petition must enter a caveat to that effect in the Privy Council office on or before that date.

Northern Society of Electrical Engineers.—Arrangements have now been completed for an excursion to the Antwerp Exhibition. A special saloon carriage will be attached to the train leaving the London Road Station, M. S. and L. Manchester, at 3 p.m., on Friday, 20th July, arriving at Harwich at 9:20 p.m. The party will embark on the steamer which leaves Harwich (Parkeston Quay), at 10:15 p.m. and arrives in Antwerp at 10 a.m. Saturday. The party will return from Antwerp at 6:45 p.m., on Monday, 23rd July, arriving in Manchester at 3 p.m. the following day. Those members who do not find it convenient to travel from Manchester can join the party at Harwich. Friends of members, wishing to accompany the party, may be introduced according to No. XXVI. of the "Rules and Regulations." Messrs. Thomas Cook and Sons are arranging for hotel accommodation.

The Electric Light and Naval Photography.—An interesting experiment has been tried at Devonport, which had for its object the testing of the adaptability of the electric light to an instantaneous system of naval photography. The electric light was worked from the dynamo on the port flagship "Devastation," from which a cable was laid to Cremyll. The rays lit up the Hamoaze and its surroundings with picturesque effect, and demonstrated the uses to which electricity can be applied in naval and military as well as in other walks of life. More recently the operations extended over a wider area. The current on this occasion was supplied from dynamos on the "Scourge," moored in Barnpool, to Garden Battery, and the illuminant was, the *Naval and Military Record* says, so penetrating that photographs were procured of two torpedo-boats belonging to the "Defiance," which had been despatched outside the breakwater.

A Large American Alternator.—There is now in process of construction at the Schenectady works of the General Electric Company a large alternator, which is to be completed by August 15th for the Edison Illuminating Company of St. Louis. The alternator is to be of 16,000 lights capacity, and will be coupled direct to a Corliss-Hamilton engine of 2,000 H.P., and will be one of the largest ever constructed in America. It is the first of a series to be built by the General Electric Company for the St. Louis Lighting Company. As may be judged by the output of the machine, its dimensions and weight are very great, the armature being 16ft. in diameter, the diameter of its shaft 20in. and the weight of the armature without its shaft 75,000lb. When completed, the armature core and coils will be tested by an alternating current of 5,000 volts. This alternator, which will be run at a speed of 90 revolutions a minute, making 7,200 alternations and giving an output at full load of 800 kilowatts with an electromotive force of 12,000 volts, will have 80 field poles of laminated iron and an ironclad armature. The curve of the electromotive force, it is claimed by the builders, will be a perfect sine curve, and a type of construction will be followed which will allow the fields to slide upon rails parallel to the axis of the armature, which will make it possible for ready access to be had for making repairs.

The New Wood Arc Lighter.—The Fort Wayne Electric Company, which had made a name and a business for itself by the manufacture of the Wood closed-coil arc-lighter with a brush-shifting regulator, was one of the many electrical manufacturing concerns captured by the General Electric Company in its recent raid upon the electrical industry of the United States. A few weeks ago the captured Company suddenly severed its connection with the General Electric Company and celebrated its freedom by giving birth to "the largest self-contained arc machine ever built." On a recent test it ran 153 9·6-ampere arcs on a 38-mile circuit for a period of 18 hours. The following data regarding the machine will prove of interest: E.M.F. at terminals, 7,050; revolutions per minute, 500; weight of armature complete, 2,288lb.; weight of dynamo, 14,600.b.; weight of dynamo with sub-base, 15,800lb.; temperature of field magnets after 10 hours' run, 68°C.; temperature of armature core after 10 hours' run, 95°C.; temperature of wire, 60°C.; temperature of room, 27°C.; In the new machine the field magnet frame has been placed in an upright position. The cores upon which the field coils are wound are massive wrought-iron forgings, joined by a heavy cast-iron yoke at the top and provided with cast-iron pole pieces. But perhaps the most novel feature is the fact that the Wood machine was coupled direct to a Willans high-speed engine. This combination was got up to meet the specifications of the Detroit municipal electric light plant.

What is Entropy?—It is not surprising, writes Prof. Lodge in the *Engineer*, that some doubt has been expressed as to the usefulness of the conception of entropy to engineers. I myself was somewhat doubtful about it, thinking it possible that the essential facts represented by its laws might be better grasped

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and dealt with in other and more indirect fashion. But I find that the leaders in engineering science are coming to the conclusion that the ideas connected with the term are essential, and that the term itself is decidedly useful as briefly summarising those ideas. No fresh idea can be practically useful until we have grown accustomed to it. The term temperature by this time feels all right, so do the terms heat and pressure and volume; but the term entropy has at present an unusual sound, and still feels like something abstruse and troublesome. If its employment were to have the effect of really complicating the explanation of things, then its introduction should be resisted forcibly; but if things are themselves complicated, and the entropy, or any other method, introduces a reasonable simplification and comprehensiveness into their treatment, then its introduction is justified. . . . A more or less helpful analogy is the following, based on the fact that entropy is a thing which falls in temperature down an adiabatic, without altering in quantity, so that it is in that respect like the water of a waterfall. It is one of the factors of energy but not the whole; the other factor is temperature above average surroundings—or height above average level in the case of the water.

Municipal Electric Lighting at Manchester.—The report of the Electric Light Department of the Manchester Corporation for the year ended March 31, 1894, was submitted to the Council at its meeting on Wednesday. The supply of current was commenced on July 31, 1893. The number of consumers at the close of the year was 412, and the number of incandescent lamps in use was 18,478, arc lamps 250, and 11 motors, representing 16-H.P. The total quantity of current supplied and charged for was 439,379 units, and the amount of revenue from both methods of charge, including fixed charge per lamp and rate per units consumed, was £1,067, which works out to about 5½d. per unit. The amount for which borrowing powers have been obtained is £150,000, and of this sum £127,830 has been borrowed. The amount of capital expenditure to March 31, 1894, was £127,374. The total amount of revenue from sales of current and rental of meters was £10,198. The cost of generation, distribution, and management was £5,509, to which amount must be added for interest from the commencement of the undertaking £3,461. 6s. 7d.; bankers' commission, £60; and sinking fund, £1,376; leaving a debit balance of £209 to be carried forward to next year's account. The generating plant in operation was estimated to supply an average of about 20,000 16-c.p. lamps, and to be quite equal to any demand which would be likely to be made upon it for two years or more. So numerous, however, have been the applications that the plant is already loaded to its full capacity, and it was found that without extension there would be difficulty in fully supplying the demand for next winter. Under these circumstances it has been decided to extend the plant by one Lancashire boiler, two 360-H.P. vertical compound condensing engines, and two dynamos. These works are now in progress, and will be available for next winter. The applications for a supply of current outside the present area are so numerous that the Committee have decided to make inquiry, and to report to the Council as to the desirability of laying mains in certain leading thoroughfares, and of providing the additional plant and machinery required to generate the current, for which there is every probability of a great demand.

Phosphoresence at Low Temperatures.—The production of liquid oxygen in considerable quantities has afforded a convenient means of investigating the behaviour of substances exposed to light at a temperature of 180deg. below zero, and at a meeting of the Chemical Society held on Thursday week, at the Royal Institution, Prof. Dewar gave an account of the researches which he has lately been carrying out in this direction. Finding that at low temperatures chemical action is almost, if not quite, in abeyance, Prof. Dewar was led to try whether photographic action also ceases. He found that it does not, though it is diminished by 80 per cent. or more. While investigating this, he noticed that the apparatus with which he was working was phosphorescing brightly, and he was thus induced to study phosphorescence itself at low temperatures. Beginning with gelatine and celluloid—substances which he was using in his photographic experiments—he found them to be very luminous when cooled to 180deg., and exposed for a second to the beam of a strong electric light. In the same way phosphorescence was produced in numerous other organic substances, such as ivory, bone, india-rubber, egg shell, feathers, cotton wool, linen, leather, blossoms of flowers, &c. One of the most beautiful phosphorescing bodies was the complex salt, the platino-cyanide of ammonium, which shone with a splendid green light. White of egg was brighter than the yolk, while albumen frozen on the outside of a tube and exposed to light coming through a quartz lens, so that there was no glass to obstruct the ultra-violet rays, phosphoresced with a bright and blue light. From these and other experiments Prof. Dewar is led to the provisional generalisation that the more complex a body is in structure, the more likely it is to phosphoresce, perhaps because, in some way, its structure enables it to take up the light-vibrations with the more facility. Pure water is weakly phosphorescent; but if it is very slightly impure it becomes strongly so. A perfectly clean plate of metal does not phosphoresce; but the merest trace of grease—such as is left by a touch of the hand—will make it brightly luminous. The capability of oxygen for phosphorescing is another curious fact. In the gaseous state it can be made to glow if exposed to an electric spark while rushing into a large vacuum tube. Here, strange to say, the presence of a trace of organic matter destroys the effect. Prof. Dewar stated that a drop or two of ether or of scent in the room would make the experiment impossible for hours.

The Davy-Faraday Research Laboratory.—Mr. Ludwig Mond, F.R.S., has made a proposal to the Managers of the Royal Institution to convey to the members of that Institution the freehold of No. 20, Albemarle-street, to be held by them for the purpose of a laboratory to be named "The Davy-Faraday Research Laboratory of the Royal Institution," and for the purpose of providing increased accommodation for the Institution. The Managers, at their meeting on Monday, most cordially and gratefully accepted the munificent gift made in the communication from Mr. Mond, of which the following is an extract:—

"In the year 1843 a proposal was made to establish at the Royal Institution a School of Practical Chemistry, which was not only to give practical and systematic instruction to students, but was also to provide a place where original researches could be conducted by individuals skilled in manipulation, and where the professors could work out their problems by the aid of many qualified hands. I have felt that the need for such a laboratory has become greater and greater since the work of the scientific investigator has become more and more subtle and exact, and, in consequence, requires instruments of precision and a variety of facilities which a private laboratory can only very rarely command; and surely this need exists nowhere to a greater extent than in England, and nowhere can such a laboratory be expected to bear more abundant fruit than in this country, which possesses such an unrivalled record of great scientific researches, which have emanated from private laboratories not connected with teaching institutions, and amongst which the laboratory of the Royal Institution stands foremost, and has kept up its reputation for nearly a hundred years. It has been my desire for many years to found a public laboratory which is to give to the devotees of pure science, anxious and willing to follow in the footsteps of the illustrious men who have built up the proud edifice of modern science, the facilities necessary for research in chemistry, and more particularly in that branch of the science called physical chemistry. As only want of space prevented the Royal Institution undertaking this task 50 years ago, I took the opportunity which offered itself last year of acquiring the premises, No. 20, Albemarle-street, adjoining the Institution. Being convinced that the managers of the Royal Institution will give all the encouragement and aid in their power in the foundation and working of such a research laboratory, I hereby offer to convey to the Royal Institution the freehold of No. 20, Albermarle-street, and also the lease I hold from the Institution of premises contiguous thereto, to be held by them for the purpose of a laboratory, to be named 'The Davy-Faraday Research Laboratory of the Royal Institution,' and also for the purpose of providing increased accommodation for the general purposes of the Royal Institution, as far as the available space will allow, after providing for the requirements of the research laboratory. I also offer to make, at my own expense, all structural alterations necessary to fit the premises for these purposes, and to equip the Davy-Faraday Research Laboratory with the necessary apparatus, appliances, &c., and to make such further adequate provision as will hold the Royal Institution free from all expense in connection with the premises and the working of the said laboratory. . . . I am aware that my offer will not provide for the third object of the scheme of 1843, viz., to enable the professors to work out their problems by the aid of many qualified hands; but I trust that if the laboratory which I offer to found proves successful, others will come forward who will supply the means for attaining this end, by the foundation of scholarships and bursaries to qualified persons willing to devote themselves to scientific work and not in a position to do so without assistance."

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ON IMPULSIVE CURRENT-RUSHES IN INDUCTIVE CIRCUITS.

BY ALFRED HAY, B.SC. (EDIN.)

(Continued from page 230.)

Experiments on Current-Rushes in Circuits of Constant Permeability.

§ 7. The coil used in these experiments had a self-induction of 0·0076 henry, and a resistance of 1·06 ohm at the working temperature. The non-inductive resistance (which was made of platinoid) connected in series with the coil amounted to 0·092 ohm, thus bringing up the total resistance to 1·152 ohm. The periodicity was 125 ∿ per second. Hence, referring to equation (3) of § 4, we have $r = 1·152$; $L = 0·0076$; $p = 2\pi \times 125 = 785$; $\tan\theta = 5·18$, which gives $\theta = 79°$ approximately, and $\sin\theta = 0·98$. We shall suppose that the E.M.F. applied to the circuit is a simple sine function whose maximum value is

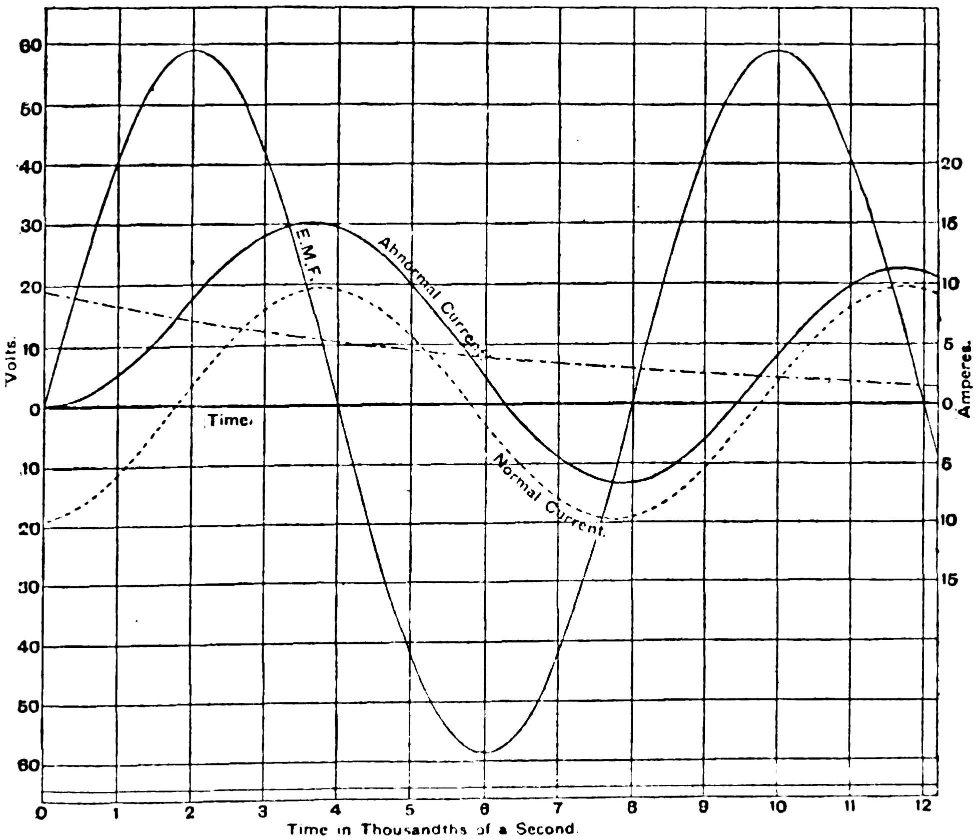

FIG. 2.—Theoretical Curves.

59 (it will be explained in § 8 below why this particular value is chosen). Substituting the values for $E\ \sqrt{r^2+p^2L^2}$, $\frac{r}{L}$ and $\sin\theta$ in equation (3), we find

$$i = 9·7\{\sin(pt - \theta) + 0·98\, e^{-152t}\},$$
$$\text{or} \quad i = 9·7 \sin(pt - \theta) + 9·5\, e^{-152t}. \quad . \quad . \quad . \quad (4).$$

We can now plot the curves of E.M.F. and current on squared paper. The most convenient way of doing this is to assign a number of values to pt in degree measure, find the corresponding sines, and multiply each of these by 59. This will give us the E.M.F. curve. In precisely the same way we may plot the curve of the normal current, given by the first term of the right-hand member of (4), remembering that this curve is displaced relatively to the other by 79°, or 0·22 of the complete period. Finally, we plot the second term of the right-hand member of (4) by assigning to t a set of values which are multiples of some fraction of the complete period. Thus, if we advance by thousandths of a second, or eighths of a complete period, we obtain the following set of values:—

t =	·001	·002	·003	·004	·005	·006
$9·5\,e^{-152t}$ =	·82	·70	·60	·52	·445	·383
t =	·007	·008	·009	·010	·011	·012
$9·5\,e^{-152t}$ =	·327	·282	·243	·209	·18	·15

The abnormal wave of current is obtained by adding corresponding ordinates of the last two curves.

All these curves are shown in Fig. 2, with their corresponding scales. The sine curve of greatest amplitude is the E.M.F. curve; the dotted sine curve is the curve of normal current, after everything has settled down into a steady periodic state. The chain dotted curve is the exponential function which distorts the current waves, the result of the distortion being shown by the thick-line curve, which, it will be noted, is not symmetrical with respect to the axis of time. The greatest ordinate of the abnormal current-wave during the first half period is about 15·2, so that the current-rush (see § 3) is $\frac{15·2}{9·7} = 1·57$.

§ 8. We shall now compare these theoretical curves with curves obtained experimentally for the same coil. These are given in Fig. 3, the points determined by experiment being indicated by small circles. The E.M.F. curve, it will be noted, differs from the corresponding curve of Fig. 2 in being somewhat more sharply peaked; on the whole, however, the deviation from the simple sine form is but slight. The fundamental harmonic of the curve has an amplitude of about 59; this is the reason why in plotting the theoretical curve we assumed an amplitude of 59. The normal current curves are almost identical in the two cases, the higher harmonics producing but little distortion in the experimental curve. There is some difference between the initial current waves; the first, fourth, and fifth quarter-waves are almost coincident in the two cases, but the second and third quarter-waves, although similar in form, appear to be somewhat displaced relatively to each other. The current-rush in the first half-wave of the experimental curve is $\frac{15}{9·7} = 1·55$, which differs but little from the theoretical value (§ 7).

§ 9. The general agreement between the theoretical and experimental results will at once be apparent; a single glance at Figs. 2 and 3 would, in fact, be sufficient to establish the soundness of the theoretical predictions regarding the current-rush. In § 4 it was pointed out that the greatest rush occurs when the circuit is closed at the instant corresponding to the zero value of the E.M.F. In order to test this point, experi-

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ments were made to determine how the value of the current-rush is affected by varying the phase of the E.M.F. at which the current is switched on, and it was in all cases found that a displacement from the zero value of the E.M.F. reduced the rush. In this, then, also, theory and experiment are in complete accordance.

Since we are dealing with a circuit of constant permeability, it follows that the current curves in Fig. 3 will also be, to some different scale, curves of magnetic induction. We may speak of a "rush" in the magnetic induction just as we speak of a "rush" of current. There is thus a "rush" of magnetic induction accompanying the current-rush, and it follows (§ 5) that this rush must always be less than 2.

§ 10. Having thus shown, both theoretically and experimentally, that current-rushes occur in circuits of constant permeability, we may now briefly sum up our knowledge regarding such rushes as follows :—

(1.) The phenomenon of a "current-rush" (accompanied by a corresponding "rush" of magnetic induction) consists in the appearance, at the instant of closing the circuit, of certain abnormal waves, which *gradually* become modified so as to assume the normal form.

(2.) The distortion of the initial waves consists in an enlargement of one set of half-waves, accompanied by a reduction of the other set. As time goes on, the abnormally large half-waves diminish in size, and the abnormally small ones increase, until a state of equality is reached, which is the normal state.

(3.) The current-rush is a function of the resistance and inductance of the circuit; it increases with the latter, and diminishes with the former. In no case, however, can it attain the value 2.

(4.) The change from the abnormal to the normal state takes place comparatively rapidly at first, then more and more slowly. In all cases where there is a considerable rush, an interval of time corresponding to *several periods* must elapse before an even *approximately* normal state can be reached.

(5.) The damping of the abnormal waves is due entirely to the resistance of the circuit. This will be evident from equation (3) in § 4. It is interesting to consider what *would* happen (and what, of course, never *does* happen) if the circuit could be entirely deprived of resistance. Putting $r = 0$ in equation (3), we get

$$i = \frac{E}{pL}(\cos pt + 1), \quad \ldots \ldots \quad (5)$$

which shows :—(*a*) That the waves would preserve their initial type without undergoing any modification; (*b*) That they would lie entirely above the time-axis; in other words, that a simple harmonic E.M.F. would produce, not an alternating, but a *uni-directional* fluctuating current, and hence (*c*) that the magnetic induction would always be of the same sign. Although no circuit in practice can be made to produce these rather extraordinary effects, yet, by increasing the time-constant of a circuit as much as possible, we can get a current-rush which does not fall far short of two, and abnormal waves which will (owing to the small amount of damping) preserve their type over a considerable number of periods.

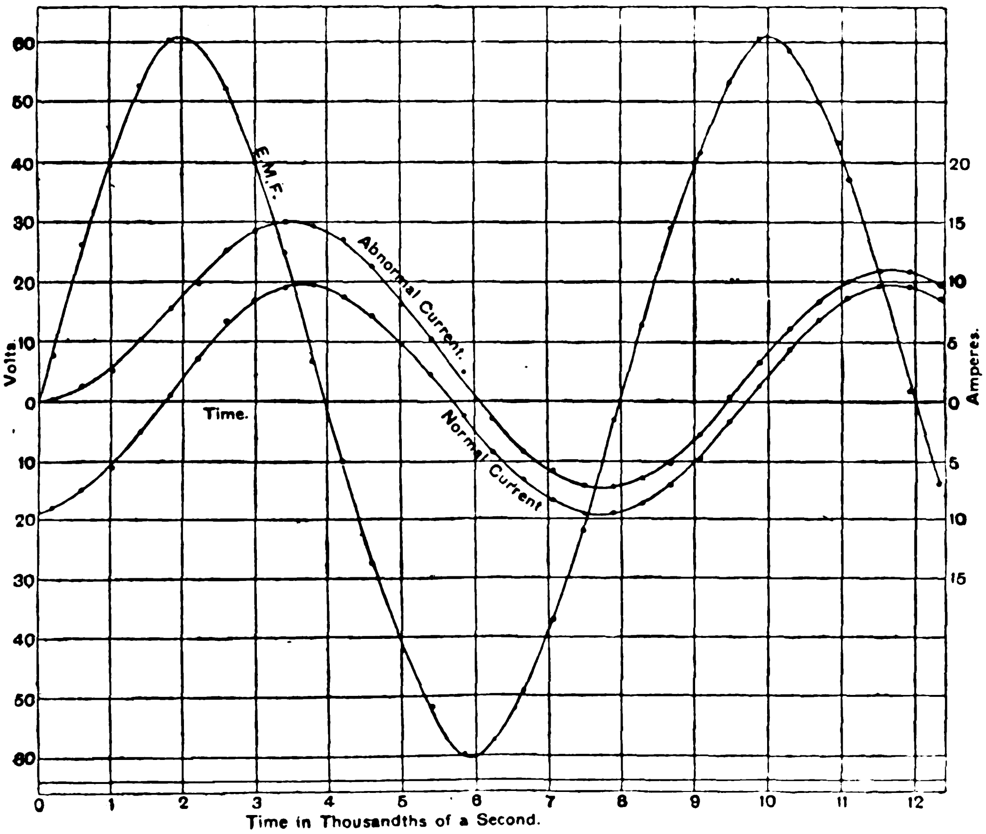

Fig. 3.—Experimental Curves.

Erratum.—On page 230, line 15 from top, omit the words "and to reduce the ordinates of the positive half-waves."

(To be continued.)

ELECTRIC MOTIVE POWER.*

BY ALBION T. SNELL.

(*Continued from page 659, Vol. XXXII.*)

Electric Transmission of Power in Mining Operations.

Perhaps the most obvious field for the utilisation of electricity in power work is to be found in mining. At all events, the first practical plants were applied for mining purposes, and by far the greater number of electric motors running in Great Britain to-day are used in this connection. The superiority of electricity as compared with compressed air or hydraulic power for driving dip pumps and other underground machinery was recognised as soon as the electric motor was discovered. But it was not until about 1885 that the new plant was well enough engineered to be cheap and reliable. The first application of

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sufficient magnitude to demonstrate indisputably the possibilities of the electric motor was made at Messrs. Locke and Company's, St. John's Colliery, Normanton, by the General Electric Power and Traction Company (Immisch and Co.), to the designs of the author. The motor was of about 60 brake horse power, and worked a set of ram pumps raising 120 gallons of water per minute through a vertical head of nearly 900 feet. It was an assured success from the start, and although modifications and improvements have been since introduced in many of the details, the general principles still obtain as standards for continuous current mining work. The application of polyphase currents has opened up fresh possibilities and largely extended the scope of electric power work by obviating the need for commutators and brushes, and therefore removing the chief objection to the use of motors in collieries. The author confidently regards polyphase motors as essentially the machines of the future for mining work.

There is a wide difference between collieries and metalliferous mines in the character of the work; and, indeed, the local conditions of different mines vary so largely as to require special treatment in almost every case. But the main difficulties peculiar to mining work, *i.e.*, which do not usually obtain with surface plants, may be classified under three heads:

(*a*) "Falls" from roofs and sides, and "creeping" of the floors.

(*b*) Water, either continuous or intermittent.

(*c*) Explosive gases.

These may occur singly or conjointly, and evidently require properly selected plant and careful disposition of mains, junction boxes, switches, cut-outs and machines. What is successful at one pit, or part of a pit, is not necessarily so at other places; and hence various methods are employed—some good and some indifferent. Only an engineer experienced in this class of work is able to specify with fair probability of success the best kind of material, and most suitable method of erecting plant for each case. Much defective work has been done from want of practical acquaintance with collieries and mines, although the plant supplied has been usually good of its kind. The bugbear of competition—the lowest tender—has also much to answer for here as well as in other departments of electrical engineering; and the practice of asking contractors to tender to their own specification instead of to that of an independent consultant has largely contributed to the breakdowns which are far more frequent than need be. The absurdity of such a course is rendered the more apparent when it is considered that however up-to-date the mining engineer may be, he cannot possibly have such a close acquaintance with the quality and classes of electric cables, different *points* in dynamos and motors, and the various details of an electric plant as the expert who gives his entire time to such work. And, moreover, the expert is not hampered by patents or special types of machines, etc., as a contractor is very likely to be, especially if he be a manufacturer.

It is proposed to consider here some of the chief difficulties peculiar to mining work, and to examine the methods most in vogue to meet them, and also to suggest, as far as possible, the best plant and disposition of same to do different work under various conditions.

It is convenient to treat this part of the subject under the following divisions:—

1. Engine House and Equipment.
2. Conductors, Shaft, and Underground Cables, Junction Boxes, Switches and Fuses.
3. Motors and driven machines.

These will be considered in separate sections.

Engine-House and Equipment.

The engine-house will generally be upon the "surface," although in some cases where a steam-engine is already at work near the pit bottom it may be necessary to erect a dynamo below ground. Electric plant frequently plays so small a part in the main machinery of a colliery that it is not permissible to provide a separate house for the dynamo. In such cases the winding-engine house or the fan-engine house will be probably selected. If the fan-engine has a margin of power, and is kept running at a constant speed, it may be possible to couple the dynamo to it through a fast and loose pulley. But this is not a common occurrence, nor is it always advisable. The fan forms a steady continuous load, and its engine should be carefully proportioned, both as regards size and speed, to give the most efficient running. And further, since the safe working of a colliery depends to a very large extent upon the ventilation, many mine managers very properly refuse to allow fan-engines to be put to any other work than that of driving the fan.

It may be assumed, then, that the dynamo (or dynamos) will be driven by an independent engine. In the early days of electric work in mines it was frequently necessary to use any odd engine that happened to be available at the time, and hence some very curious combinations. The author has seen a modern efficient dynamo coupled by belting to a large slow-speed engine of antiquated type, rendered still more inefficient by being supplied with wet steam at less than 40lb. pressure, so that the high efficiency of the dynamo was practically annulled.

Managers, however, are beginning to recognise the saving in coal and steam made by using high-pressure boilers and quick-running engines, and the electrical engineer has now little difficulty in arranging for suitable steam plant. Having regard to the fact that the fuel burnt at collieries is usually the most unsaleable there, and frequently almost dust, mechanical stokers are of special use. Vicars, Proctors, or any of the well-known types, answer the purpose admirably, and will be found to effect economy in labour. The type of boilers will depend upon the class of water and local circumstances. Generally, however, Lancashire boilers, with cross tubes, give the best all-round results, and have the advantage of being easily set and repaired by ordinary labour. The working pressure may vary from 80lb. to 120lb. per square inch. Whereas multitubular boilers, although admirable for raising steam at short notice, are comparatively difficult to clean out, and require much more careful attention and skilled labour to effect repairs. The same applies to water tube boilers in connection with this class of work.

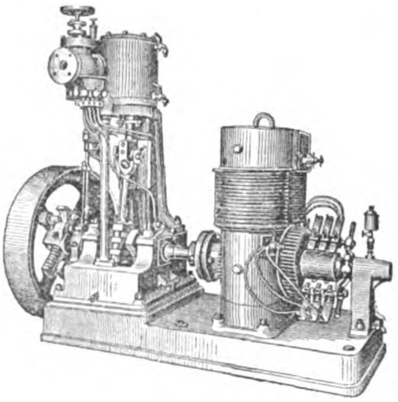

Fig. 100.—Steam Dynamo-Open-Type Engine

In most cases where the engineer has a free hand, and the pressure does not exceed say 500 volts, he will advise steam dynamos—*i.e.*, engine and dynamo directly coupled. See Fig. 100. This arrangement gives a positive drive, reduces the space occupied to the smallest dimensions, effects considerable saving in first cost, and gives increased facility for repairs; while a stand-by set can be compactly placed ready for instant use at a moderate increase in the cost of the running plant. Granting the use of a high-speed engine, the question of open or closed type arises. There are various arguments in favour of each. The open type (see Fig. 100) has the advantage that all the rods and bearings are in full view, and can be inspected while the engine is running, and also it is readily got at to make repairs. But it is likely to be affected by dust, and is to some extent liable to accidental damage from external causes.

The closed type (see Fig. 101), on the contrary, is completely protected from dust and chance external damage, and the crank shaft splashes into a lubricant in the crank chamber, thus

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ensuring lubrication so long as the oil is maintained at the proper level. The chief objection is that repairs, however trifling, necessarily take a long time to execute, for the casing has to be first removed, and then the rods, &c. cooled before anything can be touched. And if the crank chamber be allowed to run dry, the big-end brasses may be cut to pieces before the fact is noticed. This should not be a common mishap, however. Messrs. Willans and Robinson supply with their well-known closed-type engines a sight gauge, which shows continuously the height of the lubricant in the chamber. The speed of the engine will be selected with reference to its dimensions and that of the dynamo to which it is to be coupled. The number of revolutions will be large compared with those mining managers are accustomed to, being from about 300 to 500 per minute. The question of single or double-acting engines is a wide one, and both sides are admirably championed. Perhaps both types, if properly made, are equally good.

The type of dynamo will depend very much upon the class of work. The pressure, as already suggested, will not be much higher than about 500 volts. A number of manufacturers build excellent machines, and it is easy to select a suitable dynamo or motor if a fair price be paid.

In plants where the work comprises pumping, hauling, coal-cutting and lighting, the generators should be capable of parallel working, feeding omnibus mains. But if there are only large motors, each coupled to, say, pumps or other independent machines, then it may be advisab'e to run separate

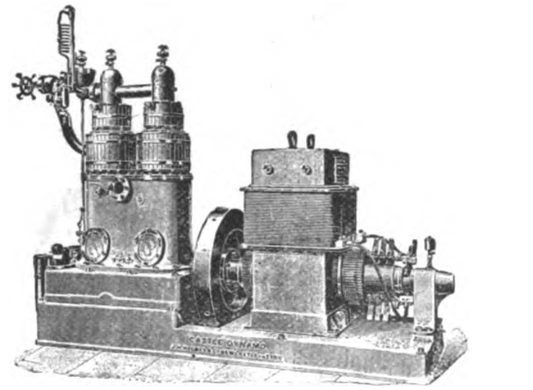

FIG. 101.—Holmes-Willans Steam Dynamo-Closed-Type Engine.

pairs of mains to each motor, and to have a separate generator to each circuit. If the loads permit of one type of motor and one type of generator, a couple of spare machines will be sufficient to cover all. For driving pumps series winding is usually preferable for both generators and receivers if a continuous current system be adopted.

If polyphase currents be used the same suggestions are applicable with suitable reservations. The pressure at the generating station may be restricted to about 500 volts, and then transformers will not be necessary for stationary motors of from 10 b.h.p. and upwards. But in coal-cutters and rock-drillers this pressure is too high for the men to handle the machines with comfort, and it will be advisable to use step-down transformers to reduce it to about 50 volts. At this pressure a "shock" will be impossible and the machines can be safely worked even in the dampest places.

In some cases of long-distance transmission it may be advisable to use a much higher pressure in the "line" between the generating station and the step-down transformers. The question then arises whether the line pressure should be reduced to say 500 volts at the pit bank, supplied at this pressure to large stationary motors, and further reduced for small or portable machines. These are questions, however, which must be decided for each case upon its merit, and a mine manager will do well to take the opinion of an independent expert before signing a contract for plant.

Shaft Conductors.

The classes of conductors suitable for the severe conditions of mining work are not very numerous and differ chiefly in the kind of insulation, and the means employed to protect them from mechanical injury and the effects of water.

Broadly there are two kinds of insulation which have stood the test of time, viz, vulcanised rubber and bituminous compounds. The former class is costly and thus better adapted for the lighter classes of cables, say up to strands of 19/15 S.W.G., which, owing to their position, do not require to be covered with a coating of lead or armoured with steel strip or galvanised iron wire. The latter class is cheaper and hence is more suitable for large trunk mains; but since it rapidly loses its insulating properties if in contact with water, it is necessary to encase the compound with lead which should be armoured to protect it from injury. The best form of bituminous cable is made concentric see Fig. 102. The centre conductor is doubly guarded and even if the metal sheathing be cut through only the outer conductor is earthed, and the cable as a whole is workable until an opportunity occurs for repairing the injury.

The author finds it expedient, even in large plants, to limit the size of each conductor to, say, a cable of 19/14 S.W.G. strands; and, if this be of insufficient cross section for the current, to duplicate the conductors and connect them to omnibus bars. With this provision an accident to one conductor does not cause a complete stoppage, for the damaged cable can be disconnected until the fault be localised and repaired. It is oftentimes a matter of impossibility to make repairs during the drawing of coal, and hence the importance of providing spare

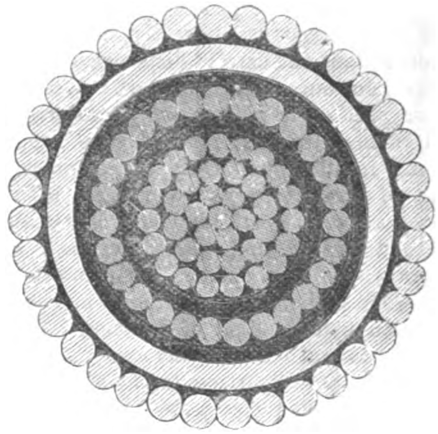

FIG. 102.—Armoured Concentric Cable with Lead-Covered Bituminous Insulation.

conductors. Also the weight of the smaller main, or pair of mains in concentric form, is less and it is more easily handled and fixed in position. And, further, the cost of repairs to the smaller size of cables is generally much less, owing to the greater ease with which the joints can be made.

The methods of running cables down shafts and fixing them in position differ in almost every case. Pit shafts are usually of circular form, sometimes driven through the live rock, sometimes built round with courses of brick or stone laid on cast-iron cribs at intervals, sometimes faced with heavy timber walls, and occasionally lined with cast-iron sections through quicksands or strata heavily charged with water. If wooden "*conductors*" are used to guide the cages, heavy cross bearers of timber are built into the sides of the shaft at intervals to carry them. When iron rope guides are used, the shafts are practically void of timbering.

These different conditions evidently demand different methods of supporting the cables.

In the first place, it is absolutely essential to guard against falling coal and stones either from the cages or from the sides of the pit. The best position for placing the cables will, therefore, be largely determined by the shape of the cage, and whether its sides are covered up so as to restrict the falling of loose pieces of coal to the open ends. Again, stands of iron pipes already placed may limit the space still further. In general it is not advisable to run electric cables near to pipes, because workmen repairing the latter may damage them. Another consideration of importance is whether the up-cast or down-cast pit is the better adapted for the purpose. If the "winding" be done from the down-cast, as is usual, it may be convenient

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to use the up-cast. But care must be taken that the up-cast air is not laden with any erosive vapour, such as is sometimes the case when the exhaust from an underground engine and the gases from a furnace, burning coal containing a large percentage of sulphur, are turned into the up-cast. The author knows of one case in which a pair of lead-covered cables run in such a pit were corroded through in dozens of places in the course of a few months. In some soils there are found erosive agents that attack iron and rapidly rust it away, and in others a similar action takes place with lead. Generally it has been the author's practice to use the down-cast shaft; but there is no rule, and in all cases it is possible to ensure success by making suitable arrangements.

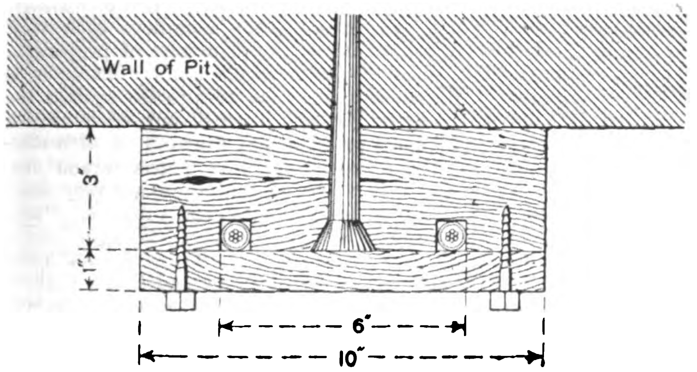


Fig. 103.—Wood Casing for Pit Work.

The plans adopted for supporting cables in shafts differ widely. In all cases, however, where it is desired to give the work a permanent character, the cables must be entirely encased in wood, run in iron pipes, or heavily armoured. These three methods are not always equally applicable from various considerations; and local conditions may make one of them the cheapest or most desirable. If there are a set of say 4in. pipes already erected in a shaft, and it is desired to run a pair of say 19/16 S.W.G. cables down them, and the depth is not great, a pair of vulcanised rubber mains may possibly be suspended in them from earthenware insulators. The weight on the supports will not be great, for the cable will sag from side to side of the pipes, and thus may nearly carry its own weight if sufficient slack be allowed. In running cables down pipes,

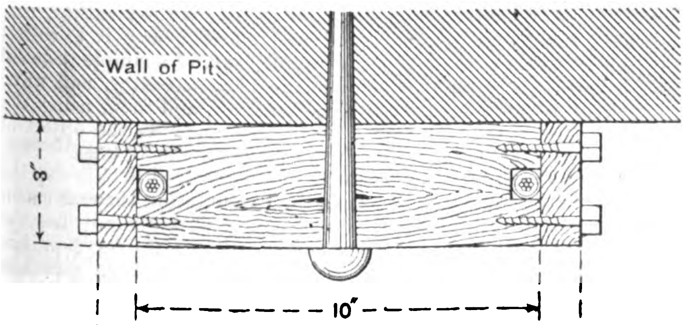


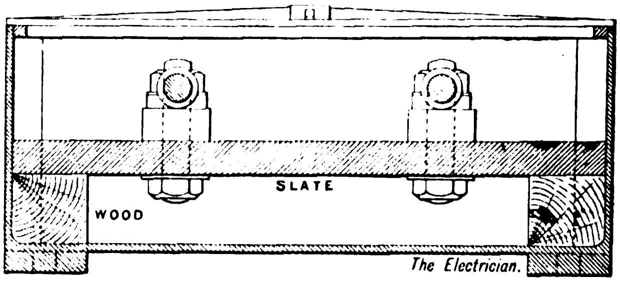
Fig. 104.—Wood Casing for Pit Work.

it is advisable to first insert a small flexible iron rope, and use this to haul in the insulated conductor, which should be payed out from the drum, perpendicularly into the centre of the pipes, over a wheel of sufficient radius. This method prevents damage to the covering of the cable. The interior of the pipes should be scoured to clean off sand from the cores, or the insulation will inevitably be abraided during the hauling-in.

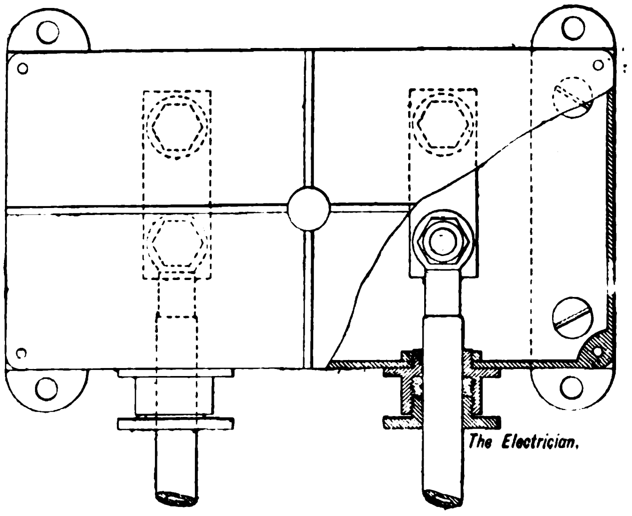
If the pipes be of large diameter, and the depth too great for the mechanical strength of the cable, it is necessary to support it at intervals. This may be done in several ways, but it will be necessary to break the continuity of the iron pipes to insert wedges, clamps, or similar devices.

It may be better then to adopt a wooden casing which will support the cable all along its length. In using wood, however, care must be taken that the section is of sufficient strength, and that the "lengths" are spiked firmly to the pit sides. The grooves may be cut in the face, as shown in Fig. 103; or in the sides of the casing, as in Fig. 104, which illustrates a method used most successfully by the author in a number of mines. The covering boards may be held in position by coach screws. This enables an examination of the cables to be made at any spot—which is oftentimes a convenience. The grooves should be cut an easy fit for the cable, which will then be perfectly supported, and only a light attachment at the top is necessary. It is always advisable, however, to securely loop the top ends around earthenware insulators firmly carried at or near to the surface.

Concentric cables lead-sheathed and armoured are so stiff that they may be clamped directly to the pit sides, and then form a strong compact job. As they are very heavy, there is need for strong brake gear on the surface to pay them out by, as they cannot be fastened in position until the whole length is down the pit. It is advisable with very heavy cables to lash ropes at intervals, and pay them out at the same rate, thus relieving the top end of the cable of part of the weight. This class of cable is steadily finding favour for pit work.



Sectional Elevation. One-third full size.



Plan (part section). One-third full size.

Fig. 105.—Davis's Junction Box, for use in Mines.

On no account should joints be permitted in new shaft cables, although it may be necessary to make repairs in old ones. A cable with continuous insulation is much more likely to stand the wet and exposure of a pit than one with joints made with a dielectric different from the rest of the insulation, and likely enough defective from the beginning. And it should be recollected that jointing is an extremely difficult operation in a shaft, owing to falling water, the cramped position, and the strong draught of air which together render soldering an impossibility in many cases, and often make the insulation uncertain owing to the presence of moisture. Of course it is possible, assuming time be allowed, to provide special apparatus which in the hands of skilled men will enable excellent work to be done; but breakdowns usually occur unexpectedly, and frequently have to be made good by the resident staff with such simple materials and facilities as may be at hand.

In most cases the author prefers to arrange junction boxes at the top and the bottom of shafts, so that the shaft cables can be severally tested independently of the surface and underground work. These boxes must be housed in dry places secure from mechanical injury. To attain this there should be sufficient

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free length of cable at top and bottom to allow the boxes to be placed well away from the drawing decks and pit bottom. A very effective junction box manufactured by Messrs. J. Davis and Co. is shown in Fig. 105.

(To be continued.)

THE TEACHING OF MECHANICAL DRAWING.*

BY PRINCIPAL S. WELLS.

Few subjects are more widely taught in technical schools and colleges and on the modern side of ordinary schools, than that of geometrical and mechanical drawing. Indeed, the inclusion of that subject in their curriculum is probably the only claim which some schools have to the title of "technical" or "modern" at all. It is certain that there are few subjects of equal importance taught in such widely different ways, and producing results so varied in quality. Its teachers range from the "art master," whose knowledge of machine details is generally limited to the possession of some badly-arranged diagrams, or out-of-date copies, and whose strong points are seen in the amount of shading and colouring which usually characterises drawings produced under his directions; to the mechanic who has an elementary Science and Art certificate in Subject II., and who teaches the subject much as the famous Chinese tailor taught his art—by simply copying. It is curious also to notice what different drawing courses are adopted in our leading university and technical colleges. In more than one the teaching of practical geometry is pooh-poohed as unnecessary, and the student commences his drawing lessons with "tracing," and learns the meaning of "plan," "elevation," and "section" for the first time when he commences the drawing of some machine part from a copy or model. With this method we entirely dissent; we have the fullest sympathy with those professors who object to the Science and Art syllabus, which puzzles students with maze-like problems on intersection of points, lines, and planes, when they might more usefully be learning how to make a readable drawing; but we contend that practical geometry is as natural and necessary a prelude to machine or building drawing as is the alphabet to grammar, or algebra to trigonometry. We hold a very decided opinion, and this we know is largely shared by others, that the Science and Art syllabus for Subject I. is not suited to the requirements of nine-tenths of our technical students who wish to gain an intelligent knowledge of mechanical drawing. It covers far too much ground for one thing, for graphic arithmetic and statics ought not to be included, and richly deserve a separate classification, and it is not sufficiently practical for the plumber, the bricklayer, the mason, or carpenter, who wants a knowledge of drawing to help him with his every-day work. Geometrical exercises on some of Euclid's propositions or theories, the projections of oblique planes, the actual distance between two imaginary points or lines, and similar problems are no doubt intensely interesting to the mathematical and better-educated student, and form capital mental training; but they are beyond the scope of, and of little use to, the ordinary working youth seeking for something useful and practical, and whose instruction in drawing should be "manual" rather than "mental." We fancy these reasons are at the bottom of the difficulty which is found in getting trade students to attend a drawing class; they prefer to obtain their drawing from their own instructor, who is not likely to give them unpractical work; but we cannot say that we think this altogether the best and wisest system, for its tendency is to narrow the drawing to specific objects without due regard to the teaching of really necessary and useful principles. What is wanted is a course of drawing instruction, which, commencing with the division of lines and angles, and simple problems to teach accuracy, shall continue with the construction of scales and regular polygons, problems in lines and circles, continuous curves, construction of ellipses, simple problems on loci, and leading up to plans, elevations, sections, developments, and interpenetrations of the common regular solids and isometric projections. Such a course as this would be of equal service to workers in all the engineering, metal work, and building trades, and we hope the London Technical Education Board will see to it that the course shall find a place in the time-table of our polytechnics and technical institutes. Engineering and metal-plate work students might well extend the course to include further problems on loci, and the construction of cycloidal curves, as applicable to wheel teeth and other examples of actual construction; and in all cases students should be shown how to develop and make paper or card models of the solids they draw, especially with problems on interpenetration. We believe that a course of this character should be a *sine quâ non* for every student whose work requires him to read or make drawings, and upon its completion he would be in an excellent position to come under the instruction of his own trade teacher, and apply his knowledge to the making of working drawings. It is, however, with the method of this continuation or trade drawing that we are most at variance, for how can a student be taught to make a proper drawing by the process of simply copying from a "copy" or a "model." It is positively appalling to watch the progress of this method of teaching. We have seen students make drawings from copies for months together and never know what they have been drawing beyond the merest generalisations; while, as for the "model" system, we have only to remember seeing students commence to draw a plummer-block by putting in the holding-down bolts, or a stop-valve by drawing the hand-wheel, to create its own condemnation. We say most unhesitatingly that the effect of copies or models is that students do not draw different parts in the right order; they do not learn the names and objects of the parts or their proper relation and interdependence, or the form and sizes of such common parts as bolts, nuts, rivets, washers, bosses, &c., and, worst evil of all, they complete each view separately, and thus entirely overlook the principles of projection, without which design, even of the most elementary character, is utterly impossible. We should like also to protest against the idea that drawing cannot be taught in a lecture, but must receive individual tuition. There are principles of drawing as of mathematics and mechanics; there are methods as generally and usefully applicable as to any other science, and there are very many things which can be and should be taught as class subjects. Such, for examples, are the number and position of different views, most suitable scale, whether sections, and, if so, of what parts are required; method of commencing drawing and fixing position of centre lines, order of drawing different parts, usual methods of showing, and sizes of common parts, and how the sizes of other parts depend upon them, dimensioning drawings, and many other matters which students are left more or less to chance to learn if individual instruction is the only method adopted. Nor must we forget to point out a great evil which results from "dimensioned copies," in that the student never learns the sizes of common parts, and how they, and they alone, determine the sizes of other parts, to which they are connected. We have seen "copies" of cylinders in which every trifling detail was dimensioned, even to the thickness of nuts and the diameter of a split pin, and we say that a student has no more right to draw a cylinder unless he has learned such details as these, than he has solve triangles before he has commenced algebra. We have heard somewhere of a student who commenced the drawing of a connecting-rod by putting in one of the lock nuts, and, although we expect the incident has been somewhat exaggerated, we think it is quite the kind of thing that might happen with the "copy" and "model" system. But we do not wish to be mistaken; we believe in models most emphatically, and in, what is better still, actual examples, and we believe every class in mechanical drawing should be well supplied with practical examples of all common parts. Yet we do not think these models should be distributed among the class and the students told to make drawings of whatever falls to their share; we say rather, that the only really really educational and efficient way is to collect the students in a class, take the example, say, of a simple pedestal bearing, describe what views and sections are necessary, and why; show them first how to fix the centre lines, and then, using the blackboard as a drawing-board, teach them how as the object of the pedestal and bolts is simply to support the brasses. Then the brasses should be shown first, *in all views*; and in this way the parts should be taken and drawn in their right order, the reasons for their form and size explained, but not the sizes given. Let the student sketch the blackboard work by all means—for how few students can make decent freehand sketches—and then give him the problem in the form of a question, in which the name and size of all the parts are stated. They can then separate to their drawing-boards, and, by being allowed to consult their sketches and the model but not to measure it, they will not only produce a drawing, but will understand what it all means when it is done. Of course, this is only an illustration of a method which teachers would modify to suit the capacities of a class; but having seen it tested we know it is workable, and that its results are immeasurably superior to those of the other methods to which reference has been made. We are afraid we must acknowledge that students who follow such a course as this might not be as lucrative to the teacher working for grants as methods more commonly adopted, and there is again the temptation to say that South Kensington blocks the way! But this is not altogether true; their "Machine Construction and Drawing" syllabus is not one of their worst, although it is certainly not their best, and it has become all too easy to seek the mote in their eye without regard to the beam in our own. It would be impossible to teach up to their syllabus by any method in 30 lessons of one hour each; what is really wanted is lessons of two to two-and-a-half hours where half-an-hour to an hour is devoted to lectures and the remaining time to work with the drawing-board. This, and nothing less than this, should be the aim of every institute and teacher who wishes to teach mechanical drawing as it should be taught.

* From the *Technical World*.

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PHYSICAL SOCIETY.

At a meeting of this Society held on June 22, 1894, Prof. W. E. AYRTON, F.R.S., Past President, in the chair, Mr. Larmor was elected a member of the Society.

Capt. ABNEY, before exhibiting his

"Photographs of Flames,"

demonstrated that a candle flame contains solid particles by passing a beam of polarised light through it, the track of the beam through the flame being clearly seen in one direction, whilst in a direction at right angles it was practically invisible. The same thing was also shown by passing the light through a turbid liquid. Photographs of Argand and candle-flames, with pencils of sunlight and electric light passing through, were then exhibited, showing similar phenomena. Several series of photographs of flames of candles and various forms of gas-burner taken with diminishing exposures, were then shown, in order to illustrate the different luminosities at different parts of the flame. Those taken with long exposures showed the bright parts nearly equally white, but as the time of exposure diminished only the most luminous portions were recorded on the plate. From the photographs the author concluded that when used with a slit as a photometric standard, the Argand burner was unsuitable, for portions of different luminosity come into view when the slit is approached or receded from. The ordinary fish-tail burner was better in this respect.

Questions were asked and remarks made by Prof. S. P. Thompson, Prof. Perry, and Mr. Trotter, in reply to which Captain ABNEY said drop shutters with slits from 1in. to $\frac{1}{16}$in. wide had been employed, and some of the exposures were only a few thousandths of a second. The displacement caused when the object was not stationary could easily be allowed for when the velocity of the shutter was known.

Prof. O. HENRICI read a paper on

"An Elementary Theory of Planimeters."

Considering the generation of areas by the motion of straight lines, the author defined the sense in which such areas are to be taken. Choosing the positive sense of a line O T of variable length as outwards from the centre O, about which it turns, and the positive direction of rotation as counterclockwise, the following rule for determining the sense of an area was given: Imagine yourself standing at a point P, and looking along the positive sense of O T, whilst it passes over P, then the area near P will be swept out in *a positive sense if* O T *crosses from right to left*, otherwise it will be negative. Applying this rule to closed curves of any shape, it was shown that if T goes once round the boundary, any area outside the curve was necessarily swept over as many times in the negative sense as in the positive sense; therefore these areas cancelled, and also that the sense of any part of an area depends on the sense of its boundary. Passing on to the consideration of areas generated by a line (or rod) of fixed length, which moves anyhow in a plane, and returns to its initial position, Prof. Henrici showed, by taking instantaneous centres, that the same rule regarding the sense of the areas holds, and that the area generated by the rod is equal to the difference between the areas of the two closed curves traced by its ends. In the particular case where one end of the rod moves forwards and backwards along the same path, the area swept out by the rod is equal to that of the closed curve traversed by the other end.

This is the theory of Amsler's planimeter, for the area of the curve whose boundary is traversed by the tracer is the same as that swept out by the rod carrying the tracer when the pole is outside the closed curve. By resolving small motions of the rod in two component parts, a translator parallel to itself, and a rotation about the point in which the plane of the registering wheel cuts the rod, the author showed that the areas swept out by the translations were registered by the wheel, whilst the sum of those generated during the rotations cancel. Cases where the pole is inside the curve were next considered, and the constant then to be added to the wheel reading determined.

Instead of registering the translation by a wheel whose axis is parallel to the rod, a knife-edged wheel which slides and turns freely on an arm perpendicular to the rod would serve the same purpose. This is the principle of Hine and Robertson's planimeter.* In the actual instrument, however, the arm is inclined at about 10deg. to the rod, and is therefore inaccurate. In the "Hatchet"† planimeter a bent rod terminates at one end in a tracing point and at the other in a convex knife edge or "keel" whose plane contains the point. The area of the curve whose boundary is traversed by the point is approximately equal to twice that of the sector included between the initial and final positions of the rod. The approximation results from the fact that the area of the curve traced by the keel is not zero. At the meeting the question of reducing the area of the keel curve was discussed at some length, the author showing that in the case of a curve symmetrical about a line, it was possible to reduce this area practically to zero. Even for unsymmetrical curves one could obtain a symmetrical one of double the area by drawing a line cutting the curve, and supposing the area turned over about this line.

Prof. PERRY inquired if the author's conclusion was that the Hatchet planimeter and the Hine and Robertson instrument were inaccurate? If so, he was at a loss to understand why the latter gave results more nearly correct than Amsler's.

Mr. BLAKESLEY pointed out that if both arms of a jointed planimeter be simultaneously moved over curves, the total reading should give the sum of the two areas traced out, if taken in the proper senses.

Mr. A. P. TROTTER directed attention to an article by the inventor of the "Hatchet," in the current number of *Engineering*.

Dr. MACFARLANE GRAY said he had examined the proof given in *Engineering* and found no error. He then showed how the Amsler planimeter could be explained in a simple geometrical manner by drawing radial lines through the pole and intersecting the curve. Moving the tracer along these radii added nothing to the area; motion along the arcs was the important component.

Mr. O. G. JONES and Prof. THOMPSON also took part in the discussion.

Mr. F. W. HILL made a communication on

"The Hatchet Planimeter."

In this Paper the author takes a point within the area to be measured and divides the area into elementary triangles, with this point as apex. The tracing point of the planimeter is then supposed to start from the apex, and trace out one of the triangles. The inclination between the initial and final positions of the Hatchet is then expressed in terms of the angle at the apex, the radius sector, and the length of the planimeter. By expanding and integrating the expression it is shown that twice the area between the initial and final position of the planimeter, after tracing all the triangles, is represented by an infinite series of terms, the first of which is the area of the curve, the second is proportional to the moment of inertia of the area about the point, the third proportional to its first moment about the same point. The higher terms are usually small enough to be neglected. Starting the tracer at the centroid of the area causes the third term to disappear and the second has its minimum value, so that this is the starting point recommended. The magnitude of the errors caused by neglecting the various terms are discussed in some detail. In the author's opinion the instrument can never be strictly accurate, but usually the errors are within the limits of observation.

Prof. HENRICI did not agree with the statement that the instrument was necessarily inaccurate, and thought geometry might aid analysis to find the proper starting point. For a symmetrical curve he had shown that a point existed, starting from which the area traced by the hatchet-end was zero.

Dr. MACFARLANE GRAY thought Prof. Henrici's latter argument was vitiated by his figure not being correctly drawn; but this Prof. Henrici disputed.

Mr. O. G. JONES said Prof. Henrici's construction was not obvious, for the crisp curves traced by the hatchet-end depended on the starting point.

Mr. YULE suggested that by shortening the planimeter it might be possible to bring the third and second terms of Mr. Hill's formula into greater prominence, and, by going round the curve more than once, determine the first and second moments.

A Paper on

"A New Integrating Apparatus,"

by Mr. A. SHARP, B.Sc., was taken as read. The Paper describes an improved form of harmonic analyser, giving the amplitude and epoch of each constituent term, the mechanism of which is an inversion of that described in a communication made to the Society on April 13th; numerous drawings accompany the Paper, showing the various parts in detail. The mechanism is also shown to be applicable for integraphs, and by suitable modification may be employed for mechanically integrating differential equations of various forms.

A Paper on "Magnetic Shielding by a Hollow Cylinder," by Prof. Perry; and another on "Clark's Cells," by Mr. S. Skinner, were postponed.

Before adjourning, the CHAIRMAN announced that in future the meetings would be held in the rooms of the Chemical Society, Burlington House.

* *The Electrician*, Vol. XXVI., p. 432.

† *The Electrician*, present Vol., p. 137.

Platinised Glass Resistances.—In a recent discussion at the Société Française de Physique on a method proposed by M. Mergier for measuring the resistance of the human body, M. Ducretet pointed out what a convenient form of high resistance could be obtained by using platinised glass. A sheet of platinised glass 75 mm. by 110 mm. (3in. by 4¼in.), enables one to get a resistance varying from 25 to 100,000 ohms. The best way to mount these sort of resistances is to place them in a closed bottle containing purified petroleum, a layer of mercury at the bottom of the bottle enabling the resistance in circuit to be brought to any desired value.

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The Electrician.

(The Oldest Electrical Journal, 1861—1878.)

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CATALOGUING SCIENCE.

The peculiar peril to which modern science is exposed, that of being buried beneath its own accumulations, has long been dimly perceived by the more prescient, and to-day the possibility of such an eventuality is only scouted by a small but vigorous minority, who hold that the whole duty of scientific man is to go about his own business, untroubled by the reflection that the soil which he is tilling with so much labour may have been long ago exhausted by another. Recognition is one thing, counteraction is another. The world of science has for some time past fully recognised the evil, and it is satisfactory to find evidence in the Presidential address to the Chemical Society delivered last May by Prof. ARMSTRONG and in the recently-issued circular of the Royal Society, that the leaders are ready to take the lead in this matter, and are prepared with some not totally inadequate proposals.

Prof. ARMSTRONG, we are glad to note, sees clearly that this "remorseless cataract," as someone has termed it, "which thunders over the remnants of the past, as if it were a fresh impediment to the men of our day in the way of systematic knowledge and consistent powers of thought; as if it were destined one day to overwhelm the great inheritance of mankind. . . . ," is not only such, but may, even if it fail to overwhelm, have nevertheless a decidedly deadening influence; no effort, says Prof. ARMSTRONG, should be spared "to prevent our being split up into factions and becoming narrow-minded specialists." On the other hand, the Royal Society, it would appear, sees its way to a remedy as clearly as Prof. ARMSTRONG sees the necessity for remedial measures; though it may be remarked, in passing, that the compilers of the circular in question are evidently of opinion that a little confession is remarkably good for the soul, since they devote the first half of it to a minute catalogue of the deficiencies of the existing "Catalogue of Scientific Papers." It is limited, we are told, to periodical scientific literature, no account being taken of monographs, such, for instance, as that by Prof. FERRARIS on rotating vectors, which has lately appeared in our columns, or of

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independent books, such, we will say, as HELMHOLTZ's "Physiological Optics." But even as regards periodical literature, the present catalogue is said to be "confessedly incomplete," Papers which have the misfortune to appear in unimportant or somewhat inaccessible publications being omitted. Finally, the Papers that do appear on the list are arranged solely according to the authors' names. However faulty the Catalogue itself may be, this catalogue of failings is remarkably complete.

The disagreeable duty of making a clean breast of it once performed, the compilers of the circular proceed to make a series of well-considered suggestions. The great development of scientific literature, they urge, requires the compilation of a compendious international catalogue, published at short intervals by a central bureau in an agreed-upon language, and arranged in accordance with common sense; that is to say, the title, not the text, of a Paper settling its place in the ranks. As to the desirability of international co-operation there surely cannot be two opinions; as to its feasibility there surely cannot be any doubt. The undue multiplication of catalogues is not less to be deprecated than the undue multiplication of memoirs to be catalogued. A publication of the nature proposed and for the purpose proposed can only be expected to prove of real service and to remain the sole representative of its kind if it be subsidised, supported, and edited internationally; and that, not by learned professors in their leisure moments, but by the labours of competent and well-paid physicists, chemists, and geologists, devoting their whole time to the task, and reinforced at frequent intervals by vigorous recruits. Index-making and catalogue-compiling may in this year of grace be a work of necessity and an art of the utmost importance, but nothing can dissociate it from the attribute of deadly dulness. Yet nothing is more indispensable in the performance of such functions—that is to say, if the result is to be of genuine value—than a general mental alertness, and a guarding of oneself against the not unnatural supposition that the titles of Papers bear some relation to their contents. No more useless form of catalogue can be conceived than the Universal Index which it is proposed to publish weekly at Leipzig. Editors of technical and scientific periodicals are requested to send their publications to the editor of the Index and thus "secure a permanent advertisement." The specimen copy before us contains nothing more than the lists of contents of a number of journals arranged in the alphabetical order of the places of publication. Articles which are on their way round the world appear in the list of each journal that has copied them.

Whether such a comprehensive compilation as the one outlined by the Royal Society should be purely and simply a *catalogue raisonné*, or should add to its bulk and to its value by containing something in the nature of an abstract of each item catalogued, is apparently a matter upon which the Royal Society is in some doubt. If we consider, however, for a moment the chief use to which a compendium of this kind would in all probability be put, it would seem as if the balance must inevitably turn in favour of greater bulk and greater value. A research likely to involve many months, it may be years, of thought and experiment suggests itself to a physicist or chemist. He may, indeed, possess a tolerably wide acquaintance with previous work in the same field; but no man, no, not even an editor, is omniscient. A necessary and useful preliminary to such a piece of research is, therefore, a glance backward into the past. At present there is not even so much as a reliable well-arranged catalogue to assist that glance, although it is possible that the scientific world may, from the first day of the twentieth century onwards, be so far blessed. But the labour and money required for a mere catalogue would, with modest additions, suffice for compiling under each of the more important entries a twelve-line *aperçu*—we will not call it abstract—adorned if need be with one of those diagrams which tell so much in so little space; each epitome stating, with rigid condensation, the object of the research, the method employed, the result obtained. To place a bald catalogue in the hands of an investigator will be to tantalise and exasperate him. It will not bring him appreciably nearer to getting a sight of Papers he thinks he wants, or enable him to assure himself that similarity of title does not perchance mean similarity of text. As to the language in which this portentous work should be published, it might be fairly argued on the ground of approximate universality that it should be English, whilst the Germans might urge their extraordinary scientific activity and the French might claim that what is the language of diplomacy all the world over might well serve as a medium for conveying scientific information all over the world. There is, it must be admitted, a certain crisp precision about the French language that neither our own rich native tongue nor the cumbersome German one can hope to attain to.

Such is the complaint, and such is the cure proposed; the one is heroic in its dimensions, the other in its laboriousness. But as we live in an age of preventive medicine, would it not be well to attack the evil at its origin? Diffuseness of style, and over-eagerness to publish, must share the blame between them. We print too soon, we print too much, we print too long. A scientific Tacitus is needed to bring conciseness and compression once more into fashion.

REVIEWS.

The Steam-Engine and other Heat Engines. By Prof. J. A. EWING, M.A., B.Sc., F.R.S., M.Inst.C.E. (Cambridge: University Press, 1894.)

The volume before us is a treatise based upon, and constituting an extension and amplification of, the article by the author in the *Encyclopædia Britannica* on the same subject. When, some years ago, Prof. Ewing compiled that encyclopædic article, it seemed to him that the most appropriate mode of treatment consisted in following, though with considerable compression, his course of lectures to students of engineering. The amplification of this article has therefore led most naturally to the publication of a treatise which is in every sense to be regarded as a students' textbook. Prof. Ewing's book must be regarded in this light, as well for its academic style and scope as for its main purpose, the inculcation of the theoretical principles of thermodynamic machinery. It is a book which will take its place beside the student's "Rankine" and "Cotterill," and in many respects it carries on the useful work begun in them. There is progress in theory as well as in practice; and the engineering student requires not only that the underlying principles of his science should from time to time be edited and presented in a more modern dress, but that accurate account should be given to him of progress in machine construction and practice. It is rarely, if ever, that a textbook satisfactorily combines these two duties; nor is it always desirable that it should endeavour to do so. Prof. Ewing's book is an able exposition of the former—the theoretical—side of engineering studies.

To the issue of a new work on the thermodynamics of heat engines it is possible that objections may be raised. It will probably, on the one hand, be urged, as it is so often urged, that thermodynamics have done nothing to forward engineering; and, on the other hand, it may be objected that all these things are written in the works of Clausius and Rankine, of Maxwell and Cotterill, which are in the hands of every engineering student with any true pretensions to the name.

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Neither of these objections is valid. Even though it were true that the progress of engineering has not been directly aided by theoretical investigations in thermodynamics, it would still be a fact that indirectly a great deal of assistance to practical progress has been rendered by the insight which the study of this science has afforded to engineers. But it is not true; direct aid has over and over again been given. The introduction of the separate condenser, of high pressure steam, of compound and multiple expansion, of high-speed pistons, the revival of super-heating, are instances of progress in steam practice which has been initiated by a true insight into thermodynamic principles; while it is inconceivable that any inventor could have intelligently devised the Atkinson cycle for gas engines had he not been guided by thermodynamics. The mistaken ideas which are held by some engineers in regard to thermodynamics arise from the erroneous notion that the principles of the science are identical with complex mathematical analysis. We feel sure that if such engineers were aware of the close relation which exists between this science and every item of economy in the working of their engines, there would be a higher and more adequate appreciation of its value.

That there is not in Prof. Ewing's book anything of the nature of a discovery or advancement of new thermodynamic principles is not, on the other hand, a fact which should make it any the less useful to the student. Prof. Ewing has exercised the most commendable judgment and care in his selection of subject matter. The details of thermodynamics with which he deals are just such as are essential to a broad-minded knowledge of engineering; nothing that can be considered as such has been omitted, while nothing of a purely physical nature irrelevant to engineering has been introduced. It is chiefly in this respect that the student will value Prof. Ewing's book, as compared with the more comprehensive and less strictly engineering treatises of Clausius, Cotterill and Maxwell. Then again, Prof. Ewing exhibits a clear and easy style, avoiding wherever possible the higher mathematical walks, and he considerately assumes that his reader is one who does *not* know all that he is reading rather than one who does. Finally, the treatment of well-established thermodynamic principles has received considerable development of late; and Prof. Ewing has not failed to bring his treatise up to date in this respect. Thus we find a full account of the graphic methods of studying the functions of entropy and temperature, and some recent graphical constructions dealing with valves. In connection with the former of these instances, we cannot refrain from expressing our regret that the classic symbol, θ, for absolute temperature, should have been abandoned. We were all learning to speak of "the θ ϕ diagram" as an established mathematical instrument.

The work commences with a chapter on "The Early History of the Steam Engine," which passes in brief review the various ancient engines, from the Egyptian dodge for impressively opening a temple door before an astonished crowd down to the inventions of Watt and Stephenson. In our opinion, considering the fact that the subsequent parts of the book are not devoted to the structure of engines as a whole, as well as the fact that only a single chapter is devoted to "Air, Gas and Oil Engines," this chapter might well have been omitted or compressed to within a much smaller compass. In the next chapter the elementary principles of thermodynamics are considered, the reader being introduced to the two laws of thermodynamics and their relation to physics, and to the action of any working substance. Chapter III. deals with the production and thermodynamic properties of steam. It is regrettable that the table of the properties of saturated steam on page 65 is not presented in a more handy form. It is evidently compiled from a similar table which contained a temperature column in centigrade degrees, for the temperature column on page 65 consists of intervals of 9° F. throughout, a by no means convenient interval. In Chapter IV. some of the most important thermodynamic problems, such as the relations of entropy to temperature under various operations, are considered. The next chapter, on the "Actual Behaviour of Steam in the Cylinder," is one of the best in the book, and is remarkable for the masterly way in which the bearing of the various theoretical deductions upon actual practice is developed. In this chapter the influences of wetness, wire-drawing, clearance, compression, jacketting, superheating, various cut-offs, &c., &c., are very clearly discussed. The chapter on "The Testing of Steam-Engines," which follows, is brief and complete; and, though accurate as far as it goes, it is not one which will prove of much practical value to the engineer. Fourteen pages are quite inadequate to the proper treatment of such an important subject. Chapter VII. deals briefly with "Compound Expansion," and is devoted to considerations of the behaviour of steam in Woolf and receiver engines, and to the combination of indicator cards taken from these engines. The next two chapters are the only ones which are devoted to considerations of mechanical details of steam engines. The former of these is on "Valves and Valve-Gears," and the latter on "Governing." The simple slide valve comes in for a large share of attention, and is discussed by several graphic methods, including the well-known Zeuner polar curves and the oval diagram. As a variant upon the latter, a graphic construction involving the plotting of sine curves on rectangular axes is given and recommended as "a much more useful diagram." Undoubtedly it is a very interesting diagram, but we are inclined to think that steam engineers are not so fond of plotting sine curves as are their electrical brethren, and that they would prefer less mathematically elegant but more handy methods of determining valve quantities. As a classroom device for explaining valve relations, however, the construction might be found useful. Chapter X., on "The Work on the Crank-Shaft," discusses the variations of crank effort, the influence of the fly-wheel, and balancing. The treatment is on the orthodox lines of rigid dynamics, and somewhat *doctrinaire.* Not until Chapter XI. is reached is there any attempt to discuss the practical generation of steam in boilers; and we think that the student must be placed at a disadvantage in his study of the foregoing chapters from the tardiness with which he is informed of the action of boilers in producing steam, and of the character of the steam they are liable to produce. Some of the most important boilers are described, and the chapter is well illustrated.

A good practical chapter follows, on "Forms of the Steam Engine." It is scarcely necessary to say that only a very few forms are described, because in a work having so great a scope it would be impossible to give an exhaustive account of even the most important types. The beam engine is the first described, followed by a summary of the advantages and characteristics of direct-acting engines. Single-acting high-speed engines are represented by the Brotherhood 3 cylinder engine and the Willans engine. Vertical non-rotative pumping engines and the pulsometer are briefly described; and a short account is given of the Davey safety motor, or the "kettle engine" as someone has aptly called it. Rotary engines and steam turbines are represented by the Tower spherical engine, of which one hears so little now, and the Parsons engine, the latter being very fully discussed. Marine and locomotive engines complete the chapter, and receive brief description. A short concluding chapter on "Air, Gas, and Oil Engines" may perhaps be considered to justify the use of the phrase "other heat engines" in the title of the book. This chapter upsets the balance of the whole book; for, from a theoretical point of view, the "other heat engines" deserve far better recognition; and if, from the practical point of view, the steam engine is worthy of so great a share of consideration, it must be objected that Prof. Ewing's treatment of the steam engine is not at all from the practical point of view. There can be no excuse, therefore, for crowding the account of the non-steam heat engines into one short chapter. The hot-air engines of Stirling, Ericsson, Robinson, and Buckett, are discussed. Then follows some account of the work of Beau de Rochas and Otto, in connection with gas engines; trials of modern gas engines and the use of cheap gas fuels are next considered; and the chapter concludes with a page or two on oil engines.

The engineering student has cause to be thankful to Prof. Ewing for this book. It is one that cannot fail to take its place among standard educational works that every student of theoretical engineering should possess.

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The Art of Soldering. By William Probert. (Municipal Technical School, Birmingham.)

It is impossible to discuss the whole art of soldering in a little pamphlet of 22 pages, but the author has put together some very useful notes on the chemistry of fluxes, the composition of hard and soft solders, and gives a few practical hints about their use. The dodges peculiar to electrical work are not mentioned; but even those electricians, and there are many, who can handle a bit or blowpipe in a way that astounds an ordinary tinsmith, and can achieve feats of soldering which no workman would have believed possible a few years ago, will find something worth knowing in Mr. Probert's little book.

THE WORK OF HERTZ.

CORRECTIONS AND EXPLANATIONS BY DR. OLIVER LODGE.

In connection with the illustrations to a lecture of mine at the Royal Institution, recently reported in *The Electrician*, June 8th, 15th, 22nd, there are some misapprehensions which it may be well to set right for the benefit of students and others who may wish to repeat some of the experiments. Many of the experiments lend themselves to easy repetition, since they involve nothing novel in the way of apparatus except what is quite easily constructed; many of them can be performed with the ordinary stock apparatus of an amateur's laboratory.

Figs. 2, 3, and 4 (page 154) are curves obtained by Bjerknes with the apparatus depicted in Fig. 14, which is intended to show:—

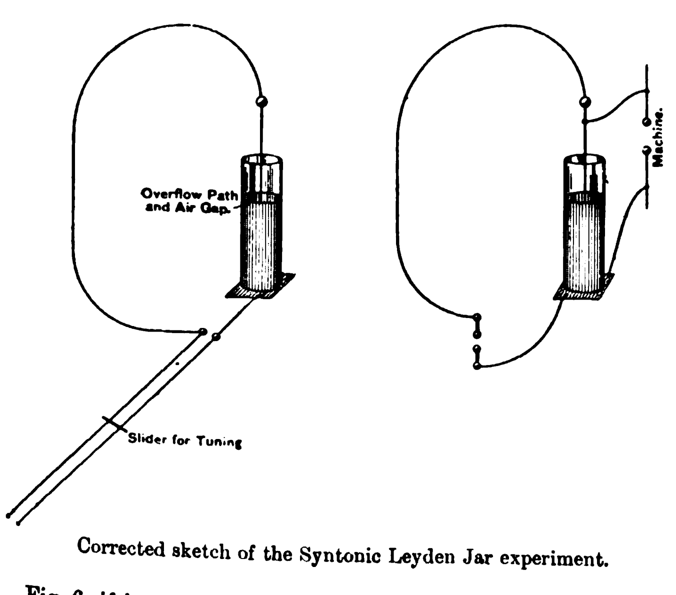
(1) A Hertz vibrator connected to an induction coil;

(2) A nearly-closed-circuit receiver properly tuned with the vibrator; and

(3) A one-sided electrometer for inserting in the air-gap of 2.

The receiver is not provided with knobs, as depicted in Fig. 14, but its open circuit is terminated by the quadrants of the electrometer, which is shown on an enlarged scale alongside. The needle is at zero potential and is attracted by both quadrants. By calculation from the indication of this electrometer Bjerknes plotted the curves Figs. 2, 3, and 4. Fig. 2 represents the oscillations of the primary vibrator, rapidly damped by radiation of energy. Fig. 3 represents the vibrations thereby set up in the resonating circuit when the two are accurately in tune; and which persist for many swings. Fig. 4 shows the vibrations excited in the same circuit when slightly out of tune with the exciter. A receiver of this kind makes many swings before it is seriously damped.

In Fig. 5 the emitting circuit is properly shown, but the receiving circuit is not shown properly. The following sketch is correct.



Corrected sketch of the Syntonic Leyden Jar experiment.

Fig. 6, if its plates and rods are magnified enormously without magnifying the knobs, may serve to represent the gigantic vibrator mentioned on pages 186 and 187; whereas the ordinary-size Hertz vibrator is shown in Fig. 10, on a scale of about an inch to a foot.

A new figure, Fig. 22, may be added instead of the last footnote on page 155, to illustrate the arrangement by which I showed the effect on one spark of the light from another. It will be observed that with this arrangement the B knobs are at the same potential up to the instant of the flash, and in that case the ultra-violet portion of the light of the A spark assists the occurrence of the B spark. But it is interesting to note, what Elster and Geitel have found, that if the B knobs were subjected to steady strain instead of to impulsive rush—*e.g.*, if they were connected to the inner coats of the jars instead of the outer coatings—that then the effect of ultra-violet light on either spark gap would exert a deterrent influence, so that the spark would probably occur at the other, or non-illuminated, gap. With the altered connections it is of course not feasible to illuminate one spark by the light of the other; the sparks are then alternative not successive.

The work of Elster and Geitel ought to have been mentioned in the penultimate paragraph of p. 155, but the omission is repaired in a separate article which is shortly to appear in *The Electrician.*

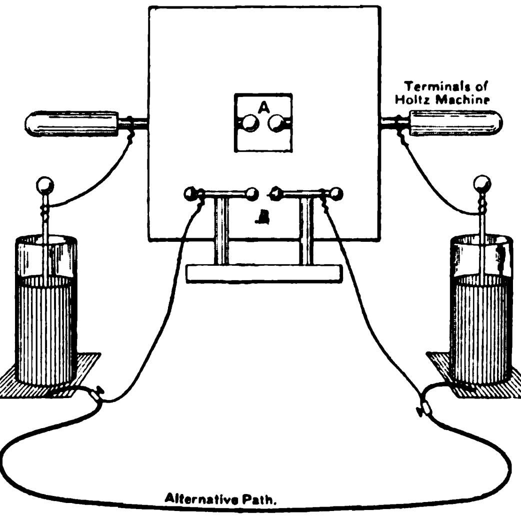


Fig. 22.—Experiment arranged to show effect on one spark of light from another. The B spark occurs more easily when it can see the A spark through the window, unless the window is glazed with glass. A quartz pane transmits the effect.

With reference to the silent discharging power of light for negative electricity from clean metallic surfaces, Fig. 6 is drawn much as the experiment was shown; it being understood that the lenses are of quartz, not glass. But there is no need to condense the beam at all in this experiment, the naked arc acts powerfully on clean zinc or aluminium, or, indeed, on most metals. But if there be a few minutes' delay after sandpapering the surfaces the effect is very noticeably diminished. In Fig. 8 all the optical parts are of quartz, and the position of the zinc sphere indicates its position in the most effective region of ultra-violet light.

A few lines below Fig. 9 the references in the text have got mixed; the reference to Fig. 9 should be to Fig. 10, and the reference to Fig. 10 should be deleted. The knobs of Fig. 11 should be nearly in contact. Fig. 12 is not a resonator or receiver, but an emitter; it emits a long series of 3in. waves at each spark, and it was arranged against the *outside* of a tinfoil-lined box containing battery and induction coil for exciting it. Alongside of it and outside the same box was arranged the larger radiator, Fig. 20, the wires from which pass into the box through glass tubes, and are there connected with the terminals of the secondary coil. The object of this metal-lined box or packing-case is to keep in all the stray waves, which else are liable to start from any part of the circuit; *i.e.*, to insure that the ostensible source shall likewise be the real one. The sending arrangement shown in Fig. 21 would do very well, but the box should be of metal. The wires of the receiving circuit are screened from direct radiation by being inclosed in a compo pipe.

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Fig. 18 does not represent what I have called a coherer, but a simple tube of iron borings or filings, as used by me following M. Branly. Fig. 17 is the coherer, though the spiral should be longer to give elasticity enough, and no "stop" is desirable as the pressure has to be regulated by trial. The contact best adapted for sensitiveness is one with quite appreciable pressure. Some practice is needed to work with these things.

The spherical radiator shown in Fig. 19, which was at pleasure either two inches or five inches in diameter, though it could excite the filings tube Fig. 18 when 60 yards away in the open air, yet could not excite it perceptibly when screened off by so many walls and metal surfaces as exist between the Library and Theatre of the Royal Institution. It could, however, still easily excite the coherer, which is immensely more sensitive, and also more troublesome and occasionally capricious than is a tube of iron filings.

In Fig. 16 the handle should be shown of ebonite too, to permit a delicate adjustment without discharge. The instrument is intended to be placed on, or otherwise connected with, the cap of an electroscope, while the left hand terminal is connected to its sole or outer case. Any electrification then given to the right hand screw soon causes overflow at the excessively minute spark-gap inside. The leaves only diverge a little way and then suddenly collapse.

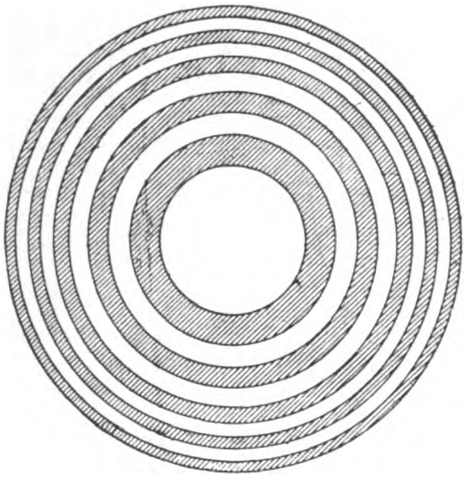

Fig. 23.—Zoneplate of Tinfoil on Glass.

A zone plate or series of rings of equal area, made of tinfoil pasted upon glass with alternate spaces bare, is shown in Fig. 23 herewith, and is intended to act as a diffraction lens, concentrating to a focus the 3in. waves from the radiator Fig. 12.

Lastly, a table of numbers interpolated in the second column of page 204, beginning "with reference to the reflecting power. . . ." and ending "up against stops," is seriously out of its place, since it interrupts the sense of another paragraph. It belongs properly just above the first italic heading on page 205.

The account of the "optical experiments" given towards the end of the lecture is very compressed. It may be well to give a few additional remarks on this subject in another article.

ARC LIGHTING AT HASTINGS.

On Saturday last the occasion of the first lighting up by arc lamps of the entire length of the Hastings and St. Leonards sea front and promenade, extending from the extreme easterly point, known as the Fish Market, to the west end of the Marina, was appropriately celebrated. After a banquet, given by the Hastings and St. Leonards Electric Light Company, at which the Mayors of Hastings and Winchester and a number of other gentlemen were entertained, the invited company proceeded to the end of Hastings Pier, where the Mayor of Hastings formally switched on the long line of arc lights. The company then made a closer inspection of the lighting by driving along the sea-front.

For many years a certain amount of arc lighting has been done at Hastings by Brush continuous-current lamps, supplied in series from Brush dynamos, and the ordinary house lighting has been worked on the alternating-current transformer system. This practice entailed the use of two distinct sets of plant at the generating station, and rendered it impossible to combine the two loads, at least as far as the engines and dynamos were concerned. Upon the extension of the public lighting from the original 15 lamps, occupying little more than half a mile of sea-front, to the present 52 lamps, extending some two and a-half miles, it was very wisely determined to so arrange matters that the steady arc light load might be put on the same generators as would be used for the house supply, thereby materially improving the load factor and economy of the station. The work of carrying out these alterations and extensions was undertaken by the Brush Electrical Engineering Company, who have succeeded in turning out the work in an effective and thoroughly satisfactory manner. Contrary to the teachings of those who maintain that the continuous current arc in-invariably gives the best results in street lighting, the conditions on the sea-front seem to be such as are favoured by the use of the alternate current arc. The light, which is thrown upwards, strikes pleasantly against the upper portions of the houses which skirt the sea-front, and in this way an effect more generally resembling the even distribution of daylight is produced.

Each lamp is fed from a separate transformer, this latter taking the primary power at 2,000 volts and transforming it down to 50 volts. A small choking coil placed in the lamp circuit serves to regulate the voltage on the arc. The transformers of the 52 lamps are grouped in parallel on two pairs of mains, the connections being so made that the failure of either main will extinguish only alternate lamps. These two mains are switched on to the station bus bars, being fed at 2,000 volts from the Mordey-Victoria alternators, which also supply the house mains. The alternators are rope-driven by Raworth steam engines. The contracting company have been ably assisted in carrying out this work by Mr. M. G. Ross, the engineer and manager to the local company, and by Mr. E. Geipel, the resident outside engineer, and all parties connected with the enterprise are to be congratulated on this successful piece of work.

HEINRICH HERTZ.*

The first day of this year took away from us a fellow worker whose loss affects us most deeply. If, after a long career of discovery and a life rich in achievements, one of the old masters of science passes to his rest, we lament his death but we bow to the inexorable laws of nature. In Heinrich Hertz a discoverer of the first rank has been torn away from us in the middle of his work, and almost at the commencement of the prime of life. The sad news has spread far and wide, and so it is very fitting that we also should pay a tribute to his memory. Let us first glance over the development of the external events of his life during the short space of time allotted to it.†

Heinrich Rudolf Hertz was born at Hamburg on February 22, 1857, and was the eldest son of the then attorney (and later Senator) Hertz. His mother was a native of Frankfort-on-Main. After having attended a city school until his confirmation, he studied privately at home during the years 1873-4, and at Easter, 1874, he entered the highest class of the upper school of the Johanneum in his native town. At Easter, 1875, he left school, in his eighteenth year, with a certificate of fitness for the University.

Even as a boy he displayed great talent, but more especially a strong liking for, and an uncommonly great interest in, the exact sciences. As a scholar of twelve years of age he attended Sunday classes in geometrical drawing held at the Technical School. In addition to his scholastic studies he industriously practised the use of tools, and he went through that course of practical training in carpentry and lathe-work which is of so great importance to the physicist; his skill enabled him to construct quite serviceable instruments from the simplest materials, and, among other things, he once made for himself a spectroscope.

* Memorial Address by Prof. Hermann Ebert, delivered at the meeting of the Physical Society of Erlangen, March 7, 1894. Translated by James L. Howard.

†For the following biographical notice the author acknowledges his deep indebtedness to Frau Prof. Hertz.

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When he left the Gymnasium it became necessary for him to choose a profession. His desire to construct something useful and permanent and his innate modest temperament, which at that time caused him to doubt greatly his ability to accomplish anything satisfactory in pure science, as well as his newly-awakened joy at the prospect of making a practical trial of his powers, all these led him to choose the profession of an engineer, and, indeed, that of a civil engineer. As a preparation for this calling he served during the year 1875-6 as an apprentice in the city engineer's office at Frankfort-on-Main, such preparation being at that time a necessary preliminary before entering the profession. After this he went during the Summer Semester of 1876 to the Technical High School at Dresden. During the twelve months subsequent to October, 1876, his studies were interrupted by his year of military service, which he passed at Berlin in the Railway Regiment. In the autumn of 1877 he went to Munich. This was the most remarkable turning-point in Hertz's career, which converted him from a man of practice to one of learning. Here he recognised that his nature could only find full satisfaction in dealing with science, and he applied himself in Munich specially to mathematics and physics.

After only a year, in the autumn of 1878, he removed to the University of Berlin, where he entered the laboratory of Von Helmholtz. His progress was unusually rapid. In 1879 he gained a prize offered by the Philosophical Faculty for a research on extra currents induced in coils and wires, a work which presented difficulties both of theory and experiment. In 1880 he graduated as doctor, and in the same year Von Helmholtz chose him as assistant in the Physical Institute, only three years after he had first devoted himself to the study of physics.

At Easter, 1883, when in his twenty-sixth year, he became Privat-Docent at Kiel, acting on the advice of Von Helmholtz, and he immediately obtained a commission to teach theoretical physics from the Prussian Minister of Instruction. At Easter, 1885, when twenty-eight years of age, he received a call as ordinary Professor of Physics at the Technical High School at Karlsruhe. From this place originated his epoch-making experimental researches. In 1886 he married Elizabeth Doll, daughter of the Professor of Geodesy at the same High School.

When in the year 1889 death took away from Bonn Clausius, the founder of the mechanical theory of heat, there was no hesitation in conferring upon Hertz, although only thirty-two years of age, the honour of succeeding a Clausius; and at Easter, 1889, he was called to Bonn.

Having thus succeeded to a secure and honourable position, respected and admired both in Germany and abroad, at an age when the power of research usually first begins to make itself manifest, he was soon visited by the insidious enemy which was destined to bring so brilliant a career to such a tragic close. In the middle of the year 1892 a chronic blood-poisoning, originating, probably, from a gathering in the jaw cavity, had already begun to undermine his hitherto excellent health. The crisis, which occurred in November, 1892, was passed by a successful operation, and he was able to continue his lectures throughout the Summer Semester of 1893, and (although with great effort) until December 7th of the same year, only a short time before his decease. His malady then returned, and in a few weeks proved fatal; he died on New Year's Day in the 37th year of his age. According to the testimony of those who were near him, and particularly of his wife, who nursed him faithfully to the last, his sufferings were indescribable. In him there passed away not only a man of great learning, but also a noble man, who had the singular good fortune to find many admirers, but none to hate or envy him; those who came into personal contact with him were struck by his modesty and charmed by his amiability. He was a true friend to his friends, a respected teacher to his students, who had begun to gather round him in somewhat large numbers, some of them coming from great distances; and to his family he was a loving husband and father.

The course of events in the external life of Heinrich Hertz was simple and plain. But what a world is opened before us when we consider his scientific life, which was bound up within such narrow limits of time! To give a condensed sketch of its development is the object of the present address.

We generally speak only of his later epoch-making researches; they alone have become known far and wide. But it is very instructive to glance once more over the earlier researches from the higher standpoint reached by the later ones. Further, we perceive how the later discoveries, which have transformed the whole subject, were originated and developed from the former, these being in a certain restricted sense stepping-stones to the latter series of experiments, for Hertz was not led by mere accident to his investigations on the propagation of electric waves; it was a comprehensive and well-arranged process of argument which was crowned by those researches, even if a happy chance often furnished him with the means of more quickly reaching the goal. I shall confine myself to the electrical researches, and therefore merely mention Hertz's work on the evaporation of liquids and in particular of mercury in vacuo, on the pressure of saturated mercury vapour, his meteorological investigations, his researches connected with elasticity, and the theory of solids; these all show the many-sidedness of his work.

His scientific activity began, as we have already seen, with the solution of a prize problem. The research proposed by the faculty of the University of Friedrich Wilhelm at Berlin for the students of 1879 was the experimental investigation of the intensity of induced electric currents. The problem, the solution of which was intended to be advanced by this research, was an old one, and for the older theories of electric phenomena a very important one. These theories were based on the assumption that electricity was a fluid which moved through the conductor conveying it. If anything of the nature of matter was concerned in electric phenomena this hypothetical something must possess *mass*, even if only in a small degree. If it had mass it must possess inertia when subjected to "electromotive forces," and must therefore, when once set in motion, contain a certain amount of kinetic energy by virtue of its mass and velocity. This kinetic energy would manifest itself if the current in a coil were alternately suddenly made and interrupted; because "extra-currents" are then set up in the coil in consequence of the mutual inductive action of the separate parts on each other, and the energy of these extra-currents would represent that of the moving electrical masses. An exact numerical estimate of this energy, and hence of the quantity of electric fluid, say, in a cubic millimetre of a wire traversed by a current, was hardly to be expected because of the difficult nature of the measurements; one had to be content with seeking an upper limit for the quantity of energy and thus furnishing an answer to the question "How great can this quantity of energy possibly be?"

The first considerable experimental investigation of Hertz was devoted to this problem. It appeared with the title "Experiments to determine an Upper Limit for the Kinetic Energy of an Electric Current." The result of the experiments was negative; since the upper limit became smaller and smaller the more exactly the experiments were performed, it was necessary to conclude that the quantity looked for would also eventually become zero if all errors of experiment could be successfully eliminated. But it was certainly a matter of great importance for Hertz that in his first research in the domain of electricity he already convinced himself that assumptions as to the material nature of electricity were untenable, and that the postulated fluid vanished just as he sought to detect it with more accurate means of observation.

In this first work, published when he was only twenty-two years of age, great experimental skill was displayed. We find him working with long stretched wires and large wire rectangles which he stretches in the cellar of the laboratory, pieces of apparatus which he was destined to use later in such a masterly fashion as his tools. One particularly clever device was the arrangement of a commutator by the simple rotation of which a complicated system of conductors could be automatically and quickly inserted in the circuit, cut out or reversed, in regular order. That Hertz was even then master of the mathematical theory, that most important adjunct to his work, is shown by his calculation of the action of the various turns and layers on each other; that is to say, by his calculation of the self-induction of his coils.

Hertz returned to the same subject again at the end of a year ("Upper Limit for the Kinetic Energy of Electricity in Motion"), when he employed a method which was not only more direct and more sensitive, but at the same time more perfect in its theory. A very thin silver film deposited chemically on glass was traversed by a strong current in one direction; the current-density, or, according to the older theory, the amount of moving electricity in each cubic millimetre of silver, was in this case as great as possible. If this moving electricity was only subjected to the electromotive force of the voltaic cell driving it, the plate was traversed by it symmetrically from anode to cathode; and if two wires leading to a sensitive galvanometer touched the plate at points on a line perpendicular to that joining the electrodes, no current would pass between these wires. The plate was now fixed on a whirling-table and rapidly rotated about an axis through its centre perpendicular to its plane. If moving electricity possessed any property analogous to inertia the current would be deflected by this rotation out of its original path, just as currents of air moving over the surface of the earth from the equator to the poles are deflected by its rotation from their south-to-north direction and strike the meridians at an angle. In this case a component of the current would pass between the two transverse electrodes, and this would be indicated by the galvanometer, even though only small in amount. Numerous sources of error, thermal currents caused by unequal heating of the two electrodes by the air currents, alterations in the rotating plate due to centrifugal force, &c., all these were encountered and to some extent masked the effect looked for. But Hertz knew how to reduce these sources of error to a minimum by a judicious combination of separate experiments under varying conditions. In spite of this, 320 separate observations failed to give any positive result; the upper limit so determined is that the kinetic energy of an electric current whose density (measured electromagnetically) is

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unity is, per cubic millimetre of a silver film, not so great as that of $\frac{1}{50000}$th of a milligram moving at the rate of a millimetre per second. At the end of this Paper he points to the possibility of obtaining positive results in the case of electrolytes, in which the motion of the electricity is bound up with that of the material ions. This conjecture of Hertz has been confirmed by later researches of Colley and Descoudres. Here, however, it is not the inertia of electricity itself, but that of the bodies carrying it, by which the phenomena are brought about.

His thesis for the degree of Doctor in 1880 treats of induction in rotating spherical conductors or hollow spheres between magnets according to the theory of Neumann.

(*To be continued.*)

DIRECT-READING APPARATUS FOR THE DETERMINATION OF THE MAGNETIC QUALITIES OF IRON.*

BY DR. A. KOEPSEL.

The author, who is the designer of the apparatus described, having set out with the idea that for a direct-reading instrument an incomplete magnetic circuit must necessarily be employed, began by the investigation of two points: first, whether results could be obtained with an incomplete magnetic circuit which could

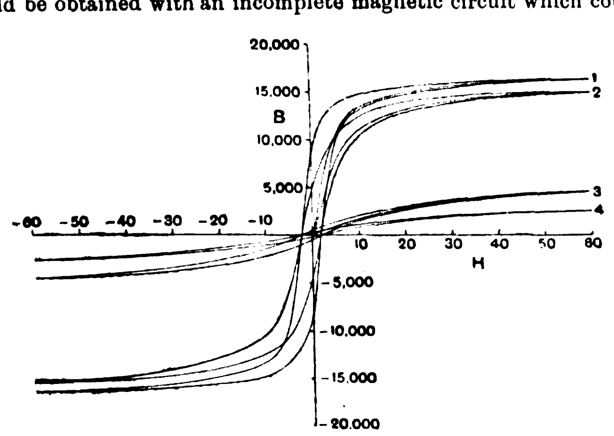

Fig. 1.

be definitely referred to those obtainable with a closed circuit, so that the latter could be easily deduced from the former; and, secondly, whereabouts in an incomplete circuit is the best position for the division, with the object in view of getting the magnetisation curves as correctly as possible. A division in the sample itself was found to be out of the question, as even when the pieces were pressed tightly together a considerable alteration of the curve of magnetisation was observed. Fig. 1 shows in curves 1-4 the

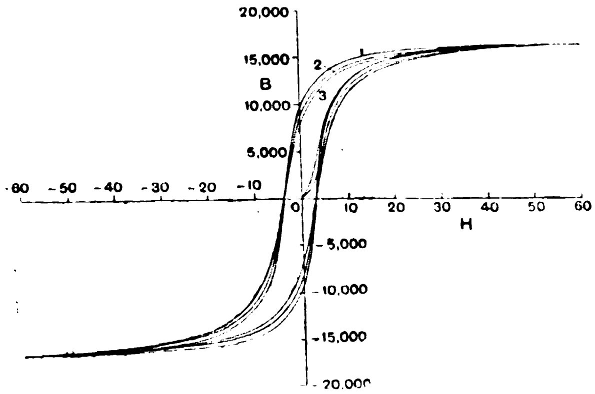

Fig. 2.

curves of magnetisation obtained by the ballistic method from a bar of soft iron 6mm. in diameter, the return being by a large yoke, the curves referring to the following cases:—(1) The bar whole and undivided; (2) The bar cut in two, and the surfaces pressed tightly together; (3) The surfaces 1·3mm. apart; (4) The surfaces 2·5mm. apart.

On the other hand, a division in the yoke itself had comparatively little effect, as shown in Fig. 2, curves 1-3, which represent the curves of magnetisation of a similar bar under the following conditions:—(1) With an undivided yoke; (2) Yoke divided, and the surfaces pressed tightly together; (3) The surfaces 1mm. apart. As the yoke had 100 times the surface of the sample, the magnetic resistance of the division was 100 times as small as in the first case. It is then of great importance to get the yoke as large as possible, which was done in the author's case by making the yoke a solid of rotation, which one can imagine formed by rotating the yoke

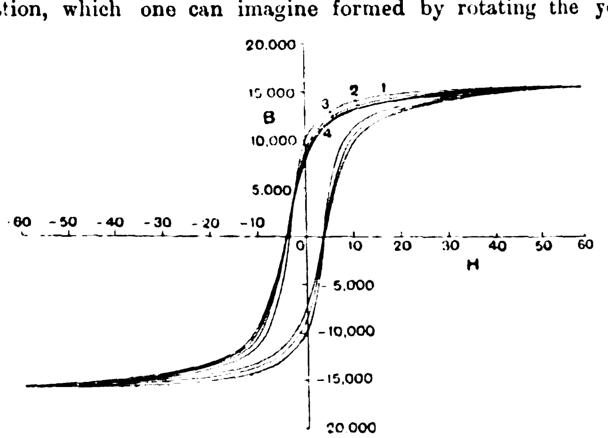

Fig. 3.

about the test bar as an axis, the bar and the magnetising coil being thus completely enclosed. It was then found that, although the curve obtained by pressing the half cylinders together (No. 2, Fig. 3) was not the same as that obtained with an undivided yoke (No. 1), yet the latter could be obtained from the former by the shearing process; and, further, the experiments showed that a gap of 1·5mm. between the cylinders did not very much alter the form and position of the curves (Nos. 3 and 4).

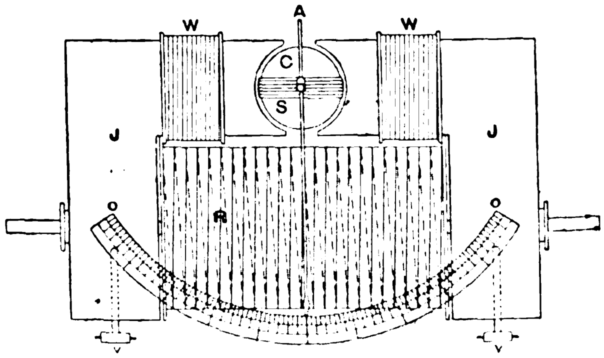

Fig. 4.

A gap of 5mm., however, was enough to afford room for a flat-wound coil carrying a current and controlled by a torsion head, the amount of whose rotation to bring the coil to zero is a measure of the field. This coil, however, had to be made very small, and had, consequently, a very small torque; and therefore a design had to be evolved which, while not increasing the air space, should allow of a larger area of coil. This object was attained by return-

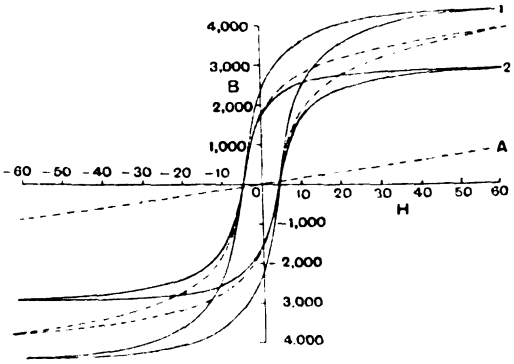

Fig. 5.

ing to the simple form of yoke shown in Fig. 4. The yoke J is bored out at A like the pole pieces of a dynamo, and the piece bored out is replaced by a soft iron cylinder, C, having a diameter 2mm. less; and in the cylindrical air space so made a coil is placed, working on pivots, and capable of rotation, and which is traversed by a current of about 0·01 ampere led in by palladium springs. The openings *o o* of the yoke serve for the introduction of the

* *Elektrotechnische Zeitschrift.*

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samples, which may be bars or sheets. These are fastened by means of the screws r, and suitable clamping pieces. The test piece is completely surrounded by the magnetising coil R, which is so wound that the magnetising force is exactly one hundred times the current in amperes. In order to counteract the effect on the swinging coil of the induction produced in the yoke by the magnetising coil when no test piece is in place, the coils W W are wound on to serve as compensating coils. Another simple method is to magnetically short circuit the magnetising coil by a suitable iron covering.

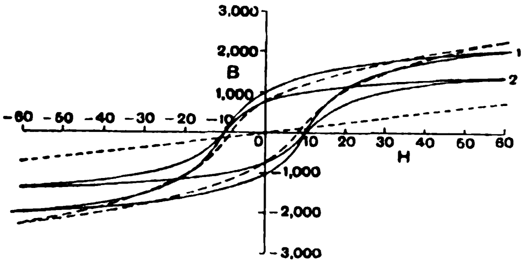

Fig. 6.

The apparatus was then carefully calibrated by ballistic measurements in the centre of the bar and the centre of the yoke (*see* Fig. 5), and it was found that Curve 1 (obtained on the bar) could be deduced from Curve 2 (obtained at the yoke) by simple multiplication of the ordinates by the factor 1·47, the coefficient of leakage, with a considerable degree of accuracy. The dotted curve shows the values obtained actually in the middle of the yoke when the effect of the coil on the yoke itself is not deducted. This coefficient of leakage was the same for wrought and cast-iron

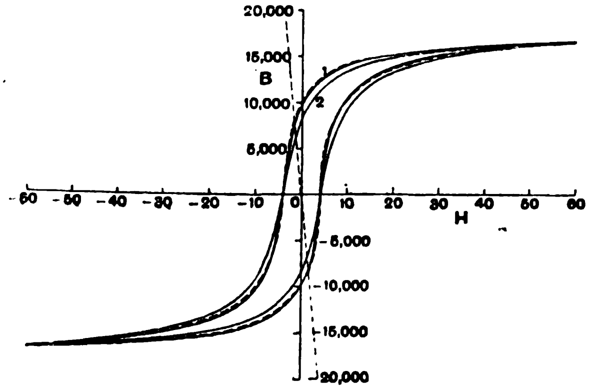

Fig. 7.

(Fig. 6), and it was, therefore, possible to calibrate the apparatus so that the pointer indicated directly the value of the induction density for different kinds of iron. It will be noted that it is unnecessary even to have test bars always of the same section, for the current in the swinging coil may be adjusted for any required section so that the scale is direct reading, and this operation has only to be performed once, before the determination of the curve is begun. It is, of course, assumed in doing this that the resistance of the yoke is negligible compared with that of the bar, which is

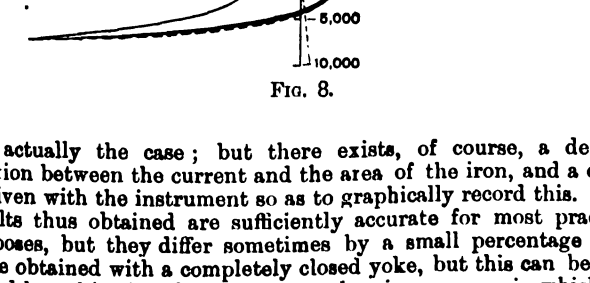

Fig. 8.

not actually the case; but there exists, of course, a definite relation between the current and the area of the iron, and a curve is given with the instrument so as to graphically record this. The results thus obtained are sufficiently accurate for most practical purposes, but they differ sometimes by a small percentage from those obtained with a completely closed yoke, but this can be corrected by subjecting the curves to a shearing process, in which the line of shearing may be taken as straight up to about 12,000 C.G.S. units of induction. For higher values the line of shear is curved, and can be determined once for all for every instrument. This curve may be rendered approximately a straight line by somewhat under-compensating, but this only has the right effect if the sectional area of the iron bar be kept constant.

The author is making further experiments in which the coil is replaced by a notched-armature, so as to reduce the air-space to half a millimetre, and the induction is to be measured by rotating the armature at a given speed and observing the volts on the armature.

The Figs. 7, 8, and 9 show the agreement of the curves obtained with those obtained by ballistic measurements. In each case Curve 1 is the ballistic curve, Curve 2 the one obtained from the under-compensated apparatus, and the dotted curve is the latter corrected by shearing with a straight line as the line of shear. Fig. 7 refers to wrought-iron bars, Fig. 8 to cast-iron, and Fig. 9 to charcoal iron plates.

The ballistic measurements were carried out by the aid of an astatic mirror galvanometer, whose constant was controlled before every experiment by means of a standard condenser. For if a condenser be discharged through a galvanometer, the deflection

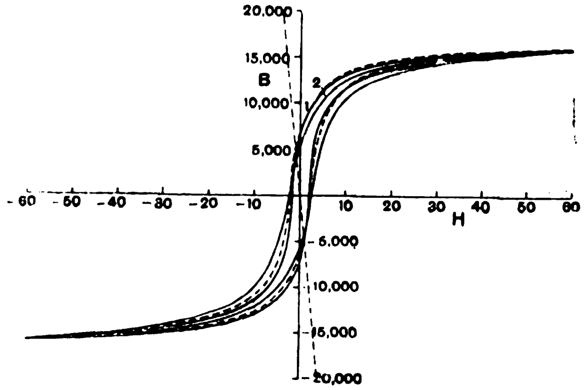

Fig. 9.

$\delta = a \cdot K V$, where K is the capacity, V the electromotive force with which it is charged, and a the galvanometer constant. If the ends of a coil of wire of one square centimetre area be connected to the terminals of the same galvanometer, and B lines of induction be sent through the coil, the deflection

$$\delta_1 = a \, B / W,$$

where W is the resistance of the circuit. Combining these equations the constant disappears, and we have

$$B = K V W \delta_1 / \delta.$$

If expressed in the practical units, this must be multiplied by 10^2. Damping may therefore be neglected so long as the deflections remain proportional to the electromotive force of the condenser. The self-induction introduces an error, and it is well to take a galvanometer of small number of turns, or to put a large inductionless resistance in the circuit. In conclusion, the author remarks that apparently the same idea has occurred to Mr. L. F. Robinson, who speaks of it in the *Electrical World*, February 24, 1894; but the latter gentleman does not appear to have ever made the apparatus.

A COMPARISON BETWEEN AMERICAN AND GERMAN CENTRAL STATION STATISTICS.*

The value of reliable statistics properly classified and digested is too well known to require special pointing out; but it is sometimes forgotten that they are especially valuable when relating to new industries, such as electric lighting and power distribution. Various attempts have been made by the National Electric Light Association to supply this very necessary data, but the work thus far accomplished must be regarded as but a tithe of that necessary to enable the central station manager to compare the operation of his own station with that of others. Thus, at the last Convention held in Washington the statistics submitted were limited practically to the consumption of coal per horse-power hour in central stations. This was good enough in itself, but manifestly it covered but a part of the working of a central station.

In marked contrast to the American lack of data in this respect are the statistics from Germany. We have before us two statistical compilations, one embodying the work of the German Elektrotechnischer Verein and the other that of the "Free Association of Electric Light Station Representatives." Naturally both sets of statistics cover much of the same ground, but they differ somewhat in their modes of tabulation and each has a distinct value of its own.

* Abstract from the *Electrical Engineer* of New York.

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That of the Electrotechnischer Verein gives the tabulated results of central stations in 24 cities, including four having over 250,000 inhabitants, seven between 75,000 and 250,000, seven between 10,000 and 75,000, and six under 10,000. These stations employ probably all the various ordinary methods of generation and distribution, and allow some quite definite conclusions to be reached on hitherto doubtful points.

Comparing the cities for current capacity installed per 1,000 inhabitants, we find it to vary considerably, and, as would hardly be expected on first consideration, to average higher in the smaller cities than in the larger ones. It amounts in Berlin to 5·81 kilowatts per 1,000 inhabitants. A glance at the cities of the third group shows that the consumption of current is largely increased by the adoption of a sliding scale. The proportional distribution of lighting in hotels, dwellings, theatres, &c., varies, of course, with the character of each city. Thus, whereas in Berlin the percentage of current furnished to dwellings and hotels is only 19·9 per cent. of the total consumption, it amounts to 38·7 per cent. in Hamburg. A greater constancy in this respect is shown in store illumination, at least in the larger cities, where 30 per cent. of the total is about the average of current consumed in such places. This is in marked contrast to the figures in the United States, in which hotels and private dwellings represent but a small fraction of the current consumed, by far the largest percentage being devoted to store and office illumination. This fact is due, in part, probably to the larger number of isolated plants in the United States. Factory lighting represents but a small fraction of the whole, which is easily accounted for. Unfortunately, the data on street illumination is incomplete, so that no comparison can be made in this respect.

The amount of electric power consumed in German cities is of special interest. From the tables it would seem that the cities of medium size employ but very small quantities, whereas the larger cities take proportionately more current for this purpose. Thus Berlin and Vienna employ, respectively, 8·6 and 6·8 per cent. of the total current generated for power purposes. Glancing at the actual electrical energy consumed we note that Berlin stands at the head with 6,700,000 kilowatt hours per annum, followed by Vienna with 1,300,000; then comes Hamburg with 500,000, and Dusseldorf and Elberfeld with 300,000 each.

The charges for current in Germany show a most varied practice. A fixed charge per lamp installed is exacted in Berlin and Innsbruck. In Vienna-Mariahilf this charge is waived beyond 100 lamp hours per lamp. In Heilbronn a charge is only made for the first 10 incandescent lamps or the first 2 arc lamps; in the first case $1. 87c. (about 7s. 6d.), and in the latter $10 (£2). A sliding scale is in vogue in several cities. The cheapest rates are to be found in Triberg, where the lamps are divided into three groups. The first group includes such lamps as are burnt in winter and summer at definite times; the second, lamps which are burnt only in winter or only in summer; and third, lamps which are used temporarily only. The prices are also graded according to whether the lamps are used in hotels, dwellings, stores, or factories. There result from this no fewer than 12 different rates of charge, varying from $9 (£1. 16s.) to $90 (£18) per kilowatt per annum.

The average price of current in stations selling by meter is a little over 18c. (9d.) per kilowatt hour, the highest being 22½c. (1s.); but the discounts vary considerably in different localities. The rates for electric power are arranged on a variety of plans. In Düsseldorf and Hamburg each case is treated individually and a special price fixed. In other cities there are flat rates without discount, as in Barmen, Berlin, Stockholm, and other cities. The highest price is that in vogue at Gummersbach, namely, 13c. (6½d.) per kilowatt hour. In Berlin, however, the low price of 5c. (2½d.) obtains, while at Triberg power is actually sold at 2½c. (1¼d.) per kilowatt hour. It goes without saying that current for power purposes can be furnished at a lower cost than for lighting, but one is hardly prepared for such generally low prices as these statistics show. For those who argue that the electric light and electric power are luxuries, the German statistics will prove a revelation. They show, in fact, that in the larger cities electric light is but slightly dearer than gaslight; but that electric motive power is still considerably dearer than gas-engine power, leaving out of consideration, of course, the question of convenience and considering merely the relative cost of gas and current. On the other hand, it is shown that in many of the smaller cities the electric light is far cheaper than gas, and electric power much cheaper than gas power. In several instances the electric light is successfully competing with petroleum. The results here shown would indicate that the Germans are just waking up to the fact that there is a profitable business to be done in small towns, as has been proved to be the case in this country when the stations are properly managed.

Of the cities tabulated, the large majority are operated on the continuous-current plan, and of these a large percentage are equipped with storage batteries. The figures show that all these stations exhibit by far the greatest economy in fuel consumption. The best result thus far obtained is that recorded of the storage battery station at Altona; namely, 0·413 kilowatt hour of current delivered to mains for one kilogram of coal; that is, close to 4lb. of coal per horse-power hour, or 5·3lb. per kilowatt hour delivered. The Table of the National Electric Light Association submitted at the last meeting showed an average of 91·7 watt hours per pound of coal, and a maximum of 208; while in the case of Altona the economy is 190 watt hours. But the point to be considered is that while the 208 watt hours per pound of coal was obtained with a station having a capacity of 8,000,000 watt hours per day, the 190 watt hours per pound of coal at Altona were obtained at a station of only 468,000 watt hours capacity per day. There is food for thought in this showing, and it ought to have some influence on future work in America.

THE EFFECT OF MECHANICAL STRESS AND OF MAGNETISATION ON THE PHYSICAL PROPERTIES OF ALLOYS OF IRON AND NICKEL AND OF MANGANESE STEEL.*

BY HERBERT TOMLINSON, F.R.S.

The author has examined the principal physical properties of three alloys of nickel with iron and of the non-magnetic manganese steel of Mr. Hadfield, together with the effects of mechanical stress and magnetisation on these properties. The three nickel-iron alloys contain 22, 25, and 30 per cent. of nickel, and are designated Specimens D, E, and F respectively; they are in the form of thin wires, and similar specimens have been previously tested by Dr. John Hopkinson for the effect of change of temperature on their magnetic properties.† Specimen F practically loses its magnetic susceptibility at a temperature below 100°C., but regains it again on cooling to the temperature of the room. Specimens D and E are magnetic in the hard-drawn condition, but become non-magnetic when heated above 600°C. They do not, however, like Specimen F, regain their magnetic susceptibility when cooled to the ordinary temperature of the room; but can be made to do so, either by the process of wire-drawing, or by cooling them a few degrees below 0°C. The density of all the specimens is diminished by wire-drawing, the simple rigidity is also diminished, and the internal molecular friction, as inferred from the logarithmic decrement of arc of torsionally oscillating wires, is considerably increased. On the contrary, whilst the specific resistance of iron, nickel, and manganese steel is increased by wire-drawing, that of the iron-nickel alloys is largely diminished. Again, whilst wire-drawing largely decreases the magnetic permeability of iron, nickel, and iron alloyed with 30 per cent. of nickel, it makes the alloys containing 22 and 25 per cent. of nickel to considerably appreciate in permeability, and, in fact, in a great measure transforms them from the almost non-magnetic to the magnetic condition. Dr. John Hopkinson has shown that a similar result can be obtained by cooling the alloys several degrees below 0°C. The magnetic properties of manganese steel cannot, however, be restored by the process of wire-drawing.

As regards the physical properties themselves, apart from the effects of stress or strain on these properties, all the nickel-iron alloys here examined have considerably less longitudinal and torsional elasticity than the pure metals nickel and iron; they also have considerably less internal friction. This last is very conspicuously the case with the alloys containing 25 per cent. nickel, which in the annealed non-magnetic condition has an internal molecular friction less than one-fourth of that of iron or nickel. For magnetising forces extending from 0·8 to 2 C.G.S. units, the alloy containing 30 per cent. of nickel is possessed of much greater magnetic permeability than iron, but for large forces the iron is superior. The other two nickel-iron alloys are, when in the annealed condition, almost as non-magnetic as Hadfield's manganese steel.

Longitudinal traction produces on both the specific resistance and the thermo-electric height of the alloys of nickel with iron, an effect which is intermediate to that produced on the pure metals nickel and iron. The magnetising forces employed ranged for the most part between 40 and 80 C.G.S. units, and the results obtained refer only to the elastic effects of the force, which effects are approximately proportional to the force itself. These elastic effects are much greater in proportion to the change of magnetic induction than are the residual effects. The change of both specific resistance and thermo-electric height produced by a C.G.S. unit of magnetic stress, is in all cases enormously greater than that produced by a C.G.S. unit of mechanical stress.

The effects of mechanical stress on the magnetic permeability of all the different iron-nickel alloys are fully exhibited in this Paper. Speaking roughly, they lie between the corresponding effects for the pure metals iron and nickel.

* Abstract of a Paper read before the Royal Society.
† Roy. Soc. *Proc.*, Vol. XLVIII., pp. 1—13.

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AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *June* 22, 1894.

The United States Patent Office.—In the argument last week of Counsel for the Government in the suit to annul the Berliner telephone patent some severe charges were made against employés of the Patent Office, and against the administration of that important bureau. It was charged that there was collusion between the Bell Telephone Company and the Patent Office officials, or at least a tacit agreement between them, the result of which was to delay the issue of the patent fourteen years. The fact is referred to as suggestive that two examiners of the Patent Office, who left the employment of the Government to enter that of the Bell Company, have since testified eagerly to the great anxiety shown by Counsel for the defence to hasten the issue of the patent. This somewhat singular arraignment of one department of the Government by another is rendered more notable by the extreme severity of language in which the action—and non-action—of the Patent Office is referred to.

The Buffalo Cataract Construction Company.—Messrs. Houston and Kennelly have been appointed engineers to the Buffalo Cataract Construction Company. This firm has also been retained as experts by one of the two large storage battery companies of this country that are now in litigation.

CORRESPONDENCE.

CURRENT-RUSHES INTO TRANSFORMERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the introductory portion of Mr. Hay's Paper on the above subject, which you published in last week's *Electrician*, the writer makes the remark that he is not aware of any experimental evidence for these current-rushes. As this effect was first pointed out by me in a Paper read before the Institution of Electrical Engineers in 1892, perhaps you will permit me to draw Mr. Hay's attention to the fact that about eight pages of the *Journal* of the Institution of Electrical Engineers, Vol. XXI., 1892, are occupied with a detailed account of the experimental evidence on which I based my conclusions. Mr. Mordey afterwards repeated most of the experiments and added some further observations, which he describes in his remarks on my Paper. Mr. Hay will find on investigation that the experimental evidence I adduced was very complete. Any additional observations which Mr. Hay may make will be valuable, but he will find that any theory, to be satisfactory, must take into account all the facts already accumulated. Much other information I have collected on the above subject was not referred to in my Paper, but was gathered from extensive observations of the behaviour of transformers on commercial circuits. It is, perhaps, premature to criticise a Paper not completely published; but I may mention that one of my experiments was directed to determine whether the rush was unidirectional or alternating. Mr. Hay will find that the experimental evidence is not quite in accord with his simple theory of the matter. At a very early stage of my study of these effects, I adopted, but subsequently abandoned as an explanation, the theory now proposed by Mr. Hay, as it in no way appears to explain certain well-ascertained facts on the method by which these current-rushes take place or can be invariably prevented. Mr. Hay will see that I considered very fully not only the disease, but the cure, for an effect which had sometimes very disastrous results. I have not the smallest desire to claim finality for any of my conclusions; but Mr. Hay is probably not aware that those who are interested practically in transformer systems have had abundant opportunities, and, indeed, compulsion, to investigate experimentally in the fullest possible manner a subject which he appears to think has been incompletely examined.—Yours, &c., J. A. FLEMING.

University College, London.

LEGAL INTELLIGENCE.

Re Woodhouse and Rawson United (Limited).

THURSDAY, JUNE 28TH.

After Mr. M. Dundas had been further examined, as stated last week,

Lord ABERDARE was called, and in reply to the Official Receiver stated that he was one of the original Directors of the United Company. He had a considerable interest in the Company, to the extent of something like £4,000. He had actually invested £3,600, and there was a further liability of £700. He could not say that he was consulted about the amalgamation, but he was informed of it, and was asked to become a Director. At that time he understood that the enterprise was to be wholly an industrial one. He refused for a long time to become a Director, on the ground that he could not accept such a position unless he was able to take an active part in the work, and he felt that that, as he was living in South Wales, would be impossible. Mr. Rawson, however, suggested that, as he could not attend personally at the meetings of the Board, his son-in-law, Mr. Whately, in whom he (witness) had the utmost confidence, should attend in his behalf. Upon that condition he accepted. Just about the time the Company went to allotment he fell ill (in July), and did not recover sufficiently to take any interest in the business until the end of October; he attended a meeting in December, but he was still suffering from the effects of his severe illness, and was again absent until February. In the July following he came to the conclusion that he was unable to do the work of a Director; and, whilst he had every confidence in his colleagues, and knew that his son-in-law had some influence at the Board meetings, still he had no vote, and he (witness) decided to retire. He would have retired at once, but that he feared his doing so might be misinterpreted and injury be caused to the Company; consequently he resolved to postpone his withdrawal until he had had an opportunity of meeting the shareholders, and for various reasons that did not occur until October. He was not present when the report of the auditor regarding the nature of the profits made by Woodhouse and Rawson (Limited) was produced, and it was not until a period much later that he become aware of the existence of such a report. It was explained to him that it was produced at a meeting of the Directors at a time when he was conducting an inquiry for the Government, and that it was then carefully considered; but he was not quite satisfied, because he thought it ought to have been communicated to him. He thought he must have been aware of the nature of the Woodhouse and Rawson profits before the prospectus of the United Company was issued. All these things were threshed out with extraordinary minuteness and care at the Board meetings. The Directors were men of high and unblemished character, and a solicitor was in regular attendance to advise them upon every step. That gentleman said that in the whole of his long experience he had never known Directors take so much pains to be satisfied about everything.

The OFFICIAL RECEIVER: If I put it to you that that £21,440 was principally made up of the successful flotation of the Elmore Copper Company, would that surprise you? Would it have been in your knowledge at the time?—I think it must have been in my knowledge at the time the prospectus was issued; it was not at the time I consented to become a Director.

A very large sum was paid for goodwill—£75,000, and £85,000 for patents, in addition to stock and so on. Did you look into the question of the value of those things?—I have not the slightest doubt I did. Doubts were constantly thrown by one or other of the Directors as to the trustworthiness of the valuation, and the utmost pains were taken to secure an accurate valuation. I believe that the valuations were made with perfect honesty, and the Directors were ultimately satisfied that that was so. Everything was very thoroughly gone into, and nothing was decided at but one sitting.

Did you look at Mr. Edmunds as being a thoroughly independent valuer?—I must have done so; but I cannot recollect all the circumstances that influenced me in accepting Mr. Edmunds' valuation.

Mr. Edmunds was valuing these patents at £159,000; the Managing Director tells me they were worth a much higher figure. Mr. Edmunds says he was paid £25 in cash, and was to receive £25 more if the Company went to allotment. I think that would strike you as rather an inadequate fee, would it not?—It certainly would.

If a man was going into it as a thoroughly independent man, with the view of advising a purchaser whether those patents were worth the money, it was a small fee?—It depends upon the amount of consideration necessary. I do not know what was submitted, or what amount of inquiry was necessary. I doubt whether I was consulted as to the amount of consideration. I have no doubt he would take care that he had a sufficient payment.

The REGISTRAR: If I remember aright, there were two valuations?

The OFFICIAL RECEIVER: Yes, one in 1887. But it would take the same work two years later to be properly done. (To witness) As regards the goodwill did you form an independent judgment?—All I can say is, this, like everything else, was carefully threshed out by competent men. Beyond that I cannot say.

Whose judgment did you rely on amongst the Directors?—I cannot exactly apportion that. I looked on Sir Albert Cappel and Mr. Philip Rawson, who was entirely unconnected with the promoters, as men of great experience; Sir John Coode seemed to me a man of great business faculty. I forget who the others were; but they all seemed to me men not only fully awake to their responsibilities, but also quite competent to see that what was proper was done.

Of the original Directors those three who retired, Sir John Coode, Sir Albert Cappel and Col. Howard Vincent, were entirely unconnected with

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any of the Woodhouse and Rawson Companies?—They had no shares?—I cannot say. All I know is they were fully persuaded of the honesty and completeness of this valuation, and it was not on that ground that they ceased to belong to the Company. That was entirely due to what they regarded as the inadequacy of the subscription.

At the same time they said they were not quite satisfied with the way things were conducted.—Well, that could not apply to this valuation.

WITNESS, continuing, said he was not present at the meeting at which they actually resigned, and he had no knowledge of the circular sent out after their resignation. The knowledge of the existence of Mr. Pixley's report of 1889 on the accounts of 1888 must have been communicated to him by Mr. Whateley, and he wrote somewhat strongly about its not having been communicated to him and to the shareholders, and requested that a meeting should be held to discuss that matter, and also the financial position of the United Company generally. At that meeting he was informed that the report had been fully discussed, and that all the Directors, including those who had retired, were quite satisfied with the explanations given. The whole matter of the financial position of the Company was gone into at that meeting, and the result was the institution of a monthly audit.

A number of letters which passed between Lord Aberdare and Sir Rawson Rawson were here read by the Official Receiver, from which it appeared that Lord Aberdare was dissatisfied with reference to numerous points, and that, even after counsel's opinion was obtained, he was opposed to the payment of dividend out of profits obtained by the sale of land to the Kensington Stores.

The OFFICIAL RECEIVER: Was your managing director benefitted considerably by the regarding of this £17,000 as revenue?—He received 25 per cent.—Was that discussed?—I cannot say whether it was or not. But this I venture to say: No doubt Mr. Fred. Rawson had his deficiencies as a managing director, and in me he had a severe critic; but I think him a perfectly upright and honourable man.

Were you aware that on five out of six departments there was a considerable loss, and that on only one department, the Works department, was there a profit?—I knew some of them were worked at a loss. I was under the impression that they were all good, sound businesses, but that through exceptional circumstances they were not paying then.

Mr. PILLING: Had you ever it on your mind at the time of the amalgamation that you were going to get your capital in Woodhouse and Rawson (Limited) back four times over?—No.

If I say that the balance-sheet of Woodhouse and Rawson (Limited) shows those figures, would that be correct?—I suppose so, but I do not think there is any such statement.

If the figures in the books relating to the assets had worked out according to the papers put before the shareholders you do not know that your share would have been £14,000 in place of your £3,600?—No such vision ever presented itself to my mind.

Mr. MUIR MACKENZIE: I object to such a statement going upon the notes. The gentleman is putting forward a purely fabricated statement.

The REGISTRAR said Mr. Pilling was conducting his examination in a manner which was not at all discreet.

Mr. PILLING: I am going by the balance-sheet of June, 1889. There is shown a surplus of £97,800, and reckoning the amounts paid for goodwill and patent rights, there should be four times the original capital, as I have said. I do not care whether that is right or wrong.

Mr. MUIR MACKENZIE: I know you do not care whether that is true or false.

The REGISTRAR: I think Mr. Muir Mackenzie is fully justified in making that statement.

Mr. PILLING: I ask is this an open Court?

The REGISTRAR: You may ask any fair question, but you may not make statements.

The OFFICIAL RECEIVER: I think Mr. Pilling is right in the point he is trying to make. There is a surplus shown of so much, and Mr. Pilling says the assets of goodwill for which the United Company paid this large sum should be added to that surplus.

Mr. PILLING: I have not been an accountant for 20 years without knowing what figures are.

The REGISTRAR: I desire to give you every fair chance.

WITNESS, further examined by Mr. Pilling, said all he did with regard to his shares in Woodhouse and Rawson (Limited) was to transfer his interest in the United Company to an exactly equivalent amount. He had never trafficked in the shares, and never received a single penny by way of bonus, or in any other way than as dividend. He participated in no distribution of assets of the Limited Company.

Examined by Mr. H. G. Rawson, WITNESS said Sir Rawson Rawson always gave him information, in replying to his letters, to the fullest extent possible, and even in the light of later knowledge he had never had occasion to doubt the *bona fides* of the statements which he made. Sir Rawson sent him, at his request, a full analysis of the balance-sheet for the year 1889-9, and also a statement explaining the way in which the profits had been arrived at.

Some point has been made of the industrial and other operations of the business, and you have replied that when first asked to become a Director you understood the business to be purely industrial. Is it present to your mind that the sale of the Elmore patents to the Foreign Elmore Company took place on or about June 11, 1889, the date of that prospectus?—You must not confound two things. When I was asked to become a Director—it may have been my fault—it never entered into my mind that it was anything more than the amalgamation of these various companies, and it was only slowly and by degrees that it was borne in upon me that there was other business, when I found the Elmore, which seemed to me a very valuable property, in the hands of the Company. I certainly should never have dreamt of joining this Company if I had supposed it was for the purpose of promoting other companies. Beyond question that was part of the reason for my subsequent retirement; not from want of confidence in the proficiency of the Directors, but the business was new and strange to me, it took me out of my depth, and I did not like it.

Am I right in stating that the only salary of the Managing Director was his commission?—I think so.

Did you do your utmost as a prominent member of the Board to hold even the scales as between his interests on the one hand and those of the shareholders on the other?—I am sure I must have done so, but I cannot give any particular case.

Would not such a case be when you were endeavouring to carry to reserve sums of money which counsel had the opinion should be divided. It was a question between justice to your Managing Director and considerations of prudence?—I may say that was not in my mind. I was merely considering what was fairly divisible and what was not divisible.

The REGISTRAR: How were you introduced to the Company?—I knew Mr. Rawson's family, and was very much interested in these electrical works, and consequently I invested some money in the works, which I thought among the best of the day. On this interest Mr. Rawson, thinking, no doubt, that my name and my work as a Director might be of use, asked me to join. As I have said, I refused over and over again at first: then came the offer of my being represented by Mr. Whateley, and I accepted.

Examined by Mr. Muir Mackenzie: Mr. Whateley held 789 Ordinary shares in the Company, and 351 Preference shares. They were in constant correspondence respecting the affairs of the Company.

Mr. A. HOSTER, one of the liquidators of Woodhouse and Rawson (Limited), in reply to the Official Receiver, said a certain proportion of the shares he had held in that Company really belonged to Mr. F. L. Rawson. He was unable to say precisely what he as liquidator was able to get from the Manufacturing and Supply Companies as representing the debts of those Companies to the Limited Company; he got all there was. The shares in those Companies were to a great extent taken over by the Limited Company. He could not say whether they ever realised more than 10s. in the £ in respect of those debts. All the rights and interests of the Company in the Automatic Machines Company were sold to Mr. F. L. Rawson for 1s., and that sum was expended in stamps for use in the liquidation. But it was not fair to let that statement go by itself without an explanation. The stock and everything that was valuable in the Automatic Machines Company was in the hands of a receiver on behalf of the debenture holders, but in order to close the liquidation of the Limited Company it was necessary to dispose of the rights of that Company, although they were not worth anything, and Mr. F. L. Rawson offered 1s. merely to facilitate the liquidation. He promised, however, to pay over anything which he might realise in excess of the 1s. There were arbitration proceedings going on between them and the Automatic Company, and the officials of the latter were acting scandalously in his opinion in allowing the stock to lie idle and spoiling. He himself had a claim of several thousand pounds against the Limited Company, but that did not appear in the accounts or in Mr. Pixley's report of June, 1890. It was only ascertained through the liquidation two years later. He received a very small amount in cash, and practically the whole in shares of the United Company and the Schulke Gas Company.

By Mr. F. L. Rawson: In the beginning of 1889 he had charge of the negotiations for the sale of the Foreign Elmore patents in Paris. He sold those patents for £700,000, and the contract was signed; but difficulties arose, and it was never carried out. All the debts of the manufacturing Company were collected and handed over to the Limited Company. The United Company refused to have anything to do with the lamp business until the legal difficulties were cleared up; and, in consequence, the Limited, Manufacturing, and Supply Companies were put to considerable expense. If the arrangement made in the middle of 1889 as regards the British licence had been carried out it would have been of immense value. He should say an output of 50,000 lamps would have been a small amount by this time; the profit on each lamp, at the old price, would have been between 1s. 6d. and 2s. So far as the filament was concerned, the Woodhouse and Rawson lamp was the best he knew. He had even had complaints that it lasted too long. He had had considerable experience as a lamp manufacturer in France. He did not recollect Mr. Rawson complaining at meetings of the Limited Company that the subsidiary Companies were sacrificed for the Limited Company; but there were a good many observations of a similar kind made. When the Limited Company was formed a guarantee from Messrs. Woodhouse and Rawson was insisted upon; by subsequent arrangements that guarantee was changed from time to time; but still they had a substantial guarantee. He conducted the negotiations between the British Electric Light Company and Woodhouse and Rawson (Limited). In 1891 they anticipated making a large number of lamps under that agreement, which was signed and approved by the Chairman of the British Electric Light Company. Then when the subsidiary Companies entered upon liquidation they went back upon their agreement and consequently those large profits were lost. The licence was granted to the British Company in 1831 by Edison and Swan at a 10 per cent. royalty. The Edison-Swan Company refused to allow the Woodhouse and Rawson Manufacturing Company to manufacture the lamps on a royalty of 1s. 6d. per lamp. Then they (Woodhouse and Rawson) found that this licence had been granted to the British Company, and they resuscitated it: and an arrangement was made whereby the United Company was to manufacture for the British Company, and the British would sell to the public, the profits to be divided between the two companies. Mr. Vernon Harcourt had reported that the Schulke gas lamp was the best ever made. He (Mr. Rawson) wanted the Schulke Company to amalgamate with the Welsbach, and the Schulke refused. Such an amalgamation would have been very valuable. Mr. Rawson was Chairman of the Welsbach Investigation Committee, and made the offer on behalf of that Company. The Welsbach Company had this year made a profit of £25,000.

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By Mr. Jenkins: The arbitration with regard to the Automatic Company took up the greater part of three years, and the result was that the arbitrator's award was in Woodhouse and Rawson's favour. A receiver was put in for the debenture-holders, and he personally objected to the Woodhouse and Rawson taking up the arbitrator's award, as there were expenses to the amount of £700.

By Mr. H. G. Rawson: The Automatic Company complained that the machines were not properly made, and that they could not use them. As a matter of fact, they never tried, and £70,000 worth of machinery was improperly stored and allowed practically to fall to pieces, when they might have been earning large profits. When the Company commenced operations the earnings were sufficient to pay for a box in one week. He was aware that under the estimate he had made of an output of 50,000 lamps the profits would amount to £250,000 a year. He carried to a conclusion the agreement between the British Company and the Edison-Swan Company, and had gone carefully into the probable profits to be earned under those patents.

By the Registrar: As much as 100 and even 200 guineas were sometimes paid for valuations of patents; but the fee depended upon the amount of inquiry and consideration necessary, and upon the importance of the patents.

Mr. F. L. RAWSON: The Directors chose Mr. Edmunds. He had valued the patents before, and could do it quickly.

Mr. EVE said he would respectfully ask, through the Registrar, that the Official Receiver would do all he could to shorten the examination. He had so far put a lot of gentlemen into the box who knew very little about the affairs of the Company. If he really wished to get at the facts he would have called the Managing Director at once. He would ask the Registrar to say that Mr. F. L. Rawson must now be called.

The REGISTRAR said he did not think he should interfere with the Official Receiver's discretion as to the witnesses he should call.

Mr. EVE said it was an injustice to his clients to be kept there day after day unnecessarily.

Mr. JENKINS supported Mr. Eve's protest, and repeated that if Mr. Stewart wanted the facts he would call Mr. Rawson.

The REGISTRAR said Mr. Stewart would probably consider the matter by the time of the next sitting.

THURSDAY, JULY 5TH.

The OFFICIAL RECEIVER said, whilst desiring as far as possible to shorten the proceedings, he could not see his way to acceding to Mr. Eve's request by examining Mr. F. L. Rawson next.

Mr. T. H. LAMBERT, a Director of Woodhouse and Rawson (Limited), and one of the liquidators, agreed with the statement of Mr. Hoster that no cash was realised upon account of the shares held by the Company in the subsidiary companies. He was under the impression that the valuer of the patents was appointed by the Directors of the Limited Company, or by Mr. Hoster and Mr. F. L. Rawson on behalf of the Board.

By Mr. Pilling: When the Limited Company took over the partnership of Messrs. Woodhouse and Rawson, there were certain book debts against which a guarantee was given by the partners. The book debts were never paid, and there was some arrangement with regard to the guarantee, but he did not recollect how it was wiped out. £10,000 remuneration was voted to Mr. F. L. Rawson by the Limited Company for his services in promoting several companies, but he did not think that had any reference to the promotion of the United Company.

By Mr. F. L. Rawson: He regarded the manufacturing business as likely to become a very profitable business. Mr. F. L. Rawson usually took the part of the United Company, and Mr. Hoster that of the Limited Company in the negotiations, and there were frequent disagreements between those two gentlemen, because Mr. Hoster said Mr. Rawson wanted too much for the United Company. Mr. Hoster had also said in his presence that Mr. Rawson was not acting fairly to his family or to himself by sacrificing himself in the interests of the shareholders of the United Company.

Mr. PHILIP RAWSON, the next witness, said he was not related to Mr. Frederick Rawson or his father in any way; but as far back as 1885 he lent the firm of Woodhouse and Rawson £2,000, and that was his first connection with the Company. He was to have the option of taking shares, and he afterwards did take shares. He eventually put another £2,000 into the business. He had never sold a share. He became a Director of the Manufacturing Company, and subsequently of the United Company. He had had a serious illness, and his recollection of what took place at the time of the formation of the United Company was very defective. He regarded the circular sent out upon the withdrawal of three of the original Directors, although he did not recollect having seen it before, as a quite sufficient intimation that applicants might withdraw their applications for shares, although it did not specifically say so. He did not think that Baron Albert Grant was consulted by Mr. F. L. Rawson with regard to the formation of the United Company. There was a minute showing that the Managing Director was to be instructed that any relations with the Phœnix Trust, or with any financial adviser other than those which might be approved by the Board, should cease with all convenient speed. He remembered that resolution being passed, but was not aware that Baron Grant was connected with the Phœnix Trust. He supposed he must have known that a circular was sent out, puffing the Elmore shares after they had been sold to the Phœnix Trust; but he had no recollection. It had escaped his memory that Mr. F. L. Rawson and himself were appointed a finance committee, and he did not recollect attending a meeting of such committee. He did not think the extension of the financial accounts to thirteen months, whilst the industrial accounts were made up for eleven months in 1891, was done for the purpose of including the supposed profit on the formation of the Epstein Company. He eventually resigned on account of ill-health.

Sir LEOPOLD M'CLINTOCK stated that he was asked to become a Director of the United Company in place of one of the gentlemen who resigned, and he consented; but soon found that he had too many other duties to permit of his giving close attention to the business, and also that the financial part of the business was taking him out of his depth. He wished to resign in August, but was induced to remain a little longer as a matter of courtesy. He had no mistrust of any kind, and did not doubt the accuracy of any of the statements made to him respecting the Company's affairs; he did not make any thorough investigation, as he regarded it as a going concern.

Mr. A. L. FOLEY, for some time secretary, was examined, but gave no material evidence.

Mr. W. T. STUTCHBURY, who became secretary in 1891, and afterwards manager, said within two or three months of his joining the Company he told Sir Rawson Rawson he thought they were making a mistake in not trying to develop the resources of the Company. Sir Rawson admitted that perhaps it had been neglected; but at the same time the Directors looked for the greater part of the profit to the development of the financial side of the business, and he agreed with his son that where they had brought out one Company they would bring out ten, not with so much profit, probably, but still with a fair margin in each case.

The further examination was adjourned until to-morrow (Friday).

Winnipeg Street Railway Company v. Winnipeg Electric Street Railway Company and the City of Winnipeg.

Before the Judicial Committee of the Privy Council last week an appeal from a judgment of the Court of Queen's Bench in Manitoba was heard.

The case was recently argued before a Board consisting of the Lord Chancellor, Lord Watson, Lord Macnaghten, and Sir Richard Couch, when judgment was reserved, and

Lord WATSON, in now delivering judgment, went fully into the question at issue between the parties. The action was originally brought to secure certain rights claimed by the appellant Company under a deed of indenture executed in July, 1882, between the appellants and the authorities of the city of Winnipeg for the construction and working of street railways within that city. Having very exhaustively reviewed the evidence, his Lordship said that the privileges conceded to the appellant Company were to endure for 25 years from the date of the deed of indenture executed in July, 1882, it being in the option of the city to acquire the Company's undertaking at the expiry of that period upon their giving five years' previous notice to that effect. The Company at once proceeded with their tramway enterprise, in accordance with the terms of the said deed, which gave the appellant Company powers to use and occupy such parts of the streets of the city as were necessary for the use and working of their railways. Before 1892 they had completed and were in course of working upwards of nine miles of street railways. In February, 1892, the Mayor and Council of Winnipeg passed a bye-law authorising James Ross and William M'Kenzie to construct railways upon the streets of the city. The respondent Company in April, 1892, obtained an Act of the Provincial Legislature, incorporating them for the purpose of their taking over the rights acquired by Ross and M'Kenzie, and carrying out the scheme sanctioned by the bye-law of February. The respondent Company's Bill was opposed by the appellant Company, who alleged that they were entitled to a monopoly for the period of 25 years from the date of their agreement of all those streets in which their railways had already been opened for traffic, and also of certain other streets in which they had intimated that they were willing and ready to construct and operate railways. This right was (the appellants contended) specifically safeguarded by a clause in the Company's Act. It was (said his Lordship) unnecessary to criticise the enactments of this clause, because it was not disputed that these would be sufficient to protect any such privilege as that which was claimed by the appellant Company in the appeal. The appellants commenced the present suit by presenting to the Court of Queen's Bench a bill of complaint against the respondent Company and also against the city of Winnipeg. The appellants craved a declaration of the exclusive rights which they claimed against both respondents, and an injunction restraining the respondent Company from constructing or operating railways in any street occupied by the appellants, or in any street not then occupied by them until an offer had been made to them of the privilege of constructing a railway upon it and had not been accepted by them within two months. In defence to the suit the respondents maintained, in the first place, that the appellant Company were not possessed of any exclusive privilege, and that the city had therefore power to sanction the construction of railways by the respondent Company, in any street of the city, whether it was already occupied by the Company or not; and, in the second place, that, if the city had in fact agreed to give the appellant Company a monopoly of the railway traffic in certain streets, the agreement was *ultra vires* and void. The original action had been decided against the appellants, as had also an appeal before a full Court. In the full Court both points were decided against the appellants. Their Lordships did not find a single expression tending to show that the Legislature either intended that no tramways other than those of the appellant Company were to occupy the streets of Winnipeg or had it in contemplation that the appellants were to obtain a monopoly from the Council of the city. If such a claim were valid, the right must be derived from the indenture of 1882; but the only authority there given was expressly limited to the construction, maintenance, and operation in each street which the Company might select for that purpose, of a railway consisting of a single or double line of rails, with needful appurtenances; "and such railway shall have the exclusive right of such portion of any street or streets as shall be occupied by the said railway, and shall be worked under such regulations as may be necessary for the protection of the citizens of said city." The appellant Company argued that the

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words last quoted ought to be construed as a declaration that the Company's railway was to be the only railway permitted to occupy any part of those streets into which it might be introduced by them. In their Lordships' opinion, any such construction would be contrary to the plain meaning of the words of the agreement, which in substance implied that the Company were to have no use or occupation of, and no concern with, those portions of any street which were not actually occupied by their double or single line of rails. The only clause at all bearing out the appellant's contention ran thus:—"In the event of any other parties proposing to construct street railways on any of the streets not occupied by the parties to whom the privilege is now to be granted, the nature of the proposal thus made shall be communicated to them, and the option of constructing such proposed railway on similar conditions as are herein stipulated shall be offered; but if such preference is not accepted within two months, then the Corporation may grant the privilege to any other parties." Their Lordships did not think that it was going too far to say that, laying aside the terms of that stipulation, there was not a single expression in the deed of agreement which gave the least countenance to the suggestion that the Municipal Council intended to grant to the appellants an exclusive right to use and occupy any street for railway purposes. Those clauses of the deed which dealt directly with the use and occupation of the streets which were to be enjoyed by the Company were not only silent upon the question of exclusive right, but were conceived in terms which it was exceedingly difficult to reconcile with the theory of an intention to create such a right. Had there been any such intention, nothing would have been easier than to indicate its existence, in the proper place, either expressly or by implication. Their Lordships were therefore of opinion that the leading clauses of the agreement which defined the Company's rights of user and occupation, could not be qualified by a subsidiary clause, such as that upon which the appellant Company relied, unless its terms were clear and coercive. They were unable to hold that the terms of the clause in question were in themselves sufficient to control the plain meaning of the previous stipulations and to constitute the right of monopoly which the appellant company claimed. The clause could not imply an undertaking on the part of the council that in the event of a rival company obtaining statutory powers, and desiring to compete with the appellant Company in those streets in which their system had already been established, the Council should be bound, although against the interest of the community which it represented, to refuse its assent to the new scheme and to allow the Company to remain in the enjoyment of a monopoly. Their Lordships' decision, therefore, was that the judgments appealed from ought to be affirmed, and the appellant Company must pay one set of costs to the respondents.

Brasyer v. Harness and Another.

This action came on for hearing on Tuesday before Mr. Justice Charles and a Special Jury in Queen's Bench Court III. In this action Colonel Jeremiah Brasyer, the plaintiff, sued the defendant, Cornelius Bennett Harness, the manager of the Medical Battery Company, and James Montgomery M'Cully, a surgeon, to recover damages for alleged negligence and fradulent misrepresentation in connection with their advertised cures by electrical process. The defendant Harness denied the alleged misrepresentations and also that the plaintiff had been induced to pay the £52. 10s. he had paid by any such misrepresentations. He further denied that the applications and methods adopted by him for the cure of the plaintiff were to his knowledge valueless. This defendant counter-claimed for damages in respect of a malicious prosecution, which the plaintiff had commenced against him in November, 1893, and which was dismissed on January 31, 1894, after numerous remands. The defendant, J. M. M'Cully, in a separate defence, denied all the allegations of fraudulent misrepresentation, and also that he had, by his negligent treatment of the plaintiff, injured the plaintiff's arm as alleged. He also counter-claimed for damages for malicious prosecution. The plaintiff joined issue upon both the defences, and pleaded to the counter-claim that in prosecuting the defendants he had acted without malice, and that there was no absence of reasonable and probable cause. Mr. Witt, Q.C., Mr. T. Terrell, and Mr. H. C. Gollan were for the plaintiff; Mr. Jelf, Q C., and Mr. H. Avory were for the defendant Harness; and Mr. Abinger and Mr. W. Campbell appeared for the defendant M'Cully.

The hearing of this case was resumed on Wednesday. Mr. HARNESS, cross-examined by Mr. Witt, Q.C., said that in 1872 he stated a wholesale business on his own account. In 1870 he became bankrupt. After obtaining his discharge he was connected with the Xylonite Company up to 1880. In 1880 he went in for electricity. Up to 1885, when the Electrical Battery Company was established, he never studied medicine, electricity, anatomy, or anything of that kind. The various books published in connection with his business had been written by competent gentlemen. He believed that the electric treatment would cure various diseases, but did not personally himself pretend to cure these diseases. His Company had, it was true, gone back to the "connected" type of belt, but that was against his own opinion. Referring to the various libel actions, Mr. Harness stated generally that his reasons for either compromising them or not continuing them was the fact that he was a ruined man. He had no doubt made mistakes, but maintained most emphatically that all the gross charges, insinuations, and accusations in articles published against him were absolutely false.

Re-examined by Mr. Jelf, Q.C., WITNESS stated that the statements in the various libels as to the profits made on the sale of belts were absolutely false. The expenditure of £200,000 in five years in advertising was necessary, and not at all too high or unusual for the legitimate purposes of such a business.

M. LOREAU (called and examined by Mr. Avory) said he was acquainted with electro-therapeutics, and had worked under the well-known Dr. Charcot. In June, 1888, he was introduced to Mr. Harness, and came after and assisted him to manage his Oxford-street establishment, where he remained until March, 1892, at a salary of £400 a year. During that period he introduced a number of novelties in electrical appliances, such as were found in use at the Salpêtrière. He had visited the various London hospitals, and did not consider their electric equipments so complete as that of Mr. Harness's establishment. As an expert it was his opinion that the belts without any connection were electrical appliances. He remembered Dr. Vigoroux being appointed as consulting medical adviser to Mr. Harness.

At this stage the hearing was adjourned until Thursday.

On the hearing of this action being resumed yesterday, Mr. S. J. MACKAY, formerly science correspondent of the *Standard*, said he had experimented with one of the Harness belts. He had worn one for nine months. He did not form any permanent opinion of the belt.

Cross-examined by Mr. WITT: Did an article or report, purporting to be from your pen, on Harness's establishment appear in the *Standard*?—I think not.

Was there not an article in the *Standard* on Harness's establishment?—I do not remember it.

Was it in the *Westminster Gazette*?—It might be.

Did it purport to be signed by you?—It did.

Did the same article, or substantially the same, appear in the *St. James's Gazette*?—It appeared in several papers; whether in the *St. James's Gazette* or not I do not know.

Purporting to be signed by you?—I said purporting to be signed by me.

Was it signed by you?—No.

How did it get into the paper with your signature?—I really don't know.

Cannot you help me?—Witness hereupon related the story of how he had gone away from London, and on his return in July purchased a paper, and was astounded to see the article and his signature attached. He saw the editor, who showed him the manuscript and his signature to it, which was his in appearance. He supposed they had got hold of his signature at Harness's establishment. It was an electrotyped signature, and it was a good imitation of his. Witness never gave authority to Harness or anybody else to put his signature to the article. In the main, it contained opinions expressed in a report in course of preparation. The more florid part of it was inspired by Harness. The interlineations sprang from Harness's editorial department.

Mr. WITT: Did your resign your position on the *Standard* in consequence of the matter?

WITNESS: The tension between me and the *Standard* became so strained that I thought it incumbent upon me to resign.

A considerable volume of expert electrical evidence followed.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

The 1894 Edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK IS NOW READY. This valuable book contains 1,000 closely-printed pages, and several new and useful features have been added. The price of the Directory and Handbook is 7s. 6d. Postage in the United Kingdom, 9d.; abroad, 1s. 4d.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," being four Lectures delivered before the Royal Institution in April-May, 1894, by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is in preparation, and will shortly be published.

"ELECTROMAGNETIC THEORY," by Oliver Heaviside, is now ready, price 12s. 6d. (abroad 13s.). Prospectus on application.

"THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application to the Publisher.

"DRUM ARMATURES AND COMMUTATORS."—This book, written by Mr. F. Marten Weymouth, is also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"INVENTIONS, RESEARCHES AND WRITINGS OF NIKOLA TESLA," by T. Commerford Martin, may be obtained from the Publisher of *The Electrician*, and a copy will be forwarded post free on receipt of 16s. 6d.

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. (abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application to the Publisher.

TENDERS INVITED.—The London County Council invite tenders for the construction of the generating station buildings in connection with the electric light installation for the Victoria Embankment and Westminster and Waterloo Bridges. Specifications, &c., can be obtained at the Engineers' Department, County Hall, Spring Gardens, London, S.W., and tenders must be sent in to Mr. H. de la Hooke, Clerk to the Council, before 10 o'clock Tuesday, the 10th inst.

——— The Southport Corporation invite tenders for electric wires, switchings, fittings, &c., required in the lighting of the Town Hall and Cambridge Hall at Southport. Further particulars will be found in our advertisement columns, and copies of the specification and other particulars may be obtained of the Town Clerk, Mr. J. Davies Williams, Town Hall, Southport.

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Tenders Invited.—Tenders are invited for a suitable plant for lighting a foundry and engineering works. Apply, Stewart; Blackwood, Mon.

——— The Wolverhampton Corporation require tenders for wiring and the erection of selected fittings for the lighting of the Town Hall, Art Gallery, School of Art, Free Library, and Market Hall. Particulars can be obtained of the Borough Electrical Engineer. The same Corporation also invite tenders for the supply of electric fittings suitable for the above installation.

Tenders Accepted.—The following tenders have been received by the Bedford Corporation for buildings, machinery, and plant required in connection with the electric lighting scheme :—

	£	s.	d.
Mains and Transformers.			
Pritchetts and Gold	3,465	10	0
Porter and Harrison	3,350	0	0
New and Mayne	3,282	2	6
Brush Electrical Engineering Company	3,C68	0	0
Electric Construction Company	2,780	0	0
British Insulated Wire Company	2,686	10	5
India Rubber, Gutta Percha, and Telegraph Works Company	2,598	0	0
J. Fowler and Co.	2,560	0	0
W. T. Glover and Co.	2,520	15	0
Henley's Telegraph Works	2,463	16	8
Hooper's Telegraph and India-rubber Works	2,450	0	0
Johnson and Phillips	2,416	4	0
Crompton and Co.	2,333	0	0
Telegraph Manufacturing Company, Helsby (accepted)	2,271	5	2
Siemens Bros. and Co. (incomplete tender)	2,215	0	0
Plant.			
Baily, Grundy and Barrett	9,320	0	0
Siemens Bros. and Co.	6,290	0	0
J. Fowler and Co. (Leeds)	6,123	0	0
Brush Electrical Manufacturing Company	5,890	0	0
Crompton and Co.	5,791	0	0
Allen, Son and Co.	5,731	0	0
Electric Construction Company	5,317	0	0
Johnson and Phillips, London (accepted)	4,888	0	0
Travelling Crane.			
Bedford Engineering Company	120	0	0
Messrs. Grafton and Co., Bedford (accepted)	85	0	0
Buildings and Shaft.			
G. E. Fathers	2,022	13	6
J. J. Potter	1,911	0	0
T. H. Coleman, Bedford (accepted)	1,565	0	0

Tenders Accepted.—The Worcester Corporation have accepted the tender of the New British Electric Installation Contractors (Limited) for wiring and fitting up the Guildhall Police Station and chief constable's house, and the house in the station yard, in accordance with the specifications prepared by Mr. Preece. The wiring tender is £556. 2s. 6d., and fittings £243. 9s. 1d. The same Company's tender has been accepted for wiring the public hall, small hall, &c., at £177. 19s. 2d., and the tender of Messrs. Verity and Sons for the fittings in these latter buildings at £154. 1s. 4d.

——— The Cheltenham Corporation have accepted the tender of Messrs. Malvern for the erection of the central electric lighting station, at a cost of £1,790 ; and the tender of the Callender Company has been accepted for the supply of cables for £1,031. 8s. 4d. (subject to the high-pressure mains being guaranteed for 10 years).

Vacant Appointments.—The Technical Education Board of the London County Council is prepared to receive applications for the appointments of Inspector of Science Schools and Classes, and Inspector of Art Schools and Classes. The stipend is at the rate of £400 per annum for each appointment. Further particulars are given in our advertisement columns. Applications must be made on or before the 21st inst., on forms to be obtained of Prof. Wm. Garnett, Secretary of the Technical Education Board, 13, Spring-gardens, London, S.W.

——— The Staffordshire Technical Instruction Committee require a lecturer in metallurgy at a salary of £250 per annum. Particulars can be obtained of Mr. T. Turner, Director of Technical Instruction, County Offices, Stafford ; and applications must be in by July 14th.

——— The Corporation of Wolverhampton require a working foreman engineer for their electric works at a commencing salary of £2 per week. Applications have to be sent in by noon on July 14th.

——— The Battersea Polytechnic Institute have a vacancy for an assistant lecturer in mathematics and physics. Particulars can be obtained of Mr. J. Harwood, secretary.

New Firm.—Mr. G. E. Piggott, who was for some years with Mr. R. Applegarth, has started business at 110, Cannon-street, E.C., under the style of Piggott and Co.

Dissolutions of Partnership.—The firm of Burbey, Williamson, and Joseph, electrical engineers, of Queen Victoria-street, has been dissolved so far as regards Mr. W. S. Burbey. The business will be carried on by Messrs. Williamson and Joseph.

——— Mr. Herbert Nalder has retired from the firm of Nalder Bros. and Co., of 16, Red Lion-street, Clerkenwell. The business will be continued under the same style by Messrs. F. H. Nalder, C. W. S. Crawley, and Alfred Soames.

Warning.—Several cases have occurred recently in which goods have been obtained by a person who passes as representative of well-known electrical firms, but who possesses no authority. Messrs. Edmundsons (Limited), of Great George-street, S.W., inform us that they have had several such cases brought to their notice, and desire us to warn firms not to supply goods without their official order.

Edison and Swan United Electric Light Company.—Owing to the great increase of business the City show-room and warehouse premises of this Company in Cannon-street are altogether too small for immediate requirements, and it has been decided to erect entirely new premises at 36 and 37, Queen-street, Cheapside, where the head office, warehouses, and City show-rooms will, early in August, be removed. It is doubtless the success which has attended the opening of the Cannon-street show-rooms that has now necessitated the erection of specially-arranged premises of sufficient magnitude to meet the immediate and growing wants of the Company's business. The new premises, which will be well situated in the very centre of the City, are to be called "Ediswan Buildings."

Messrs. Swinburne and Co.'s Supplementary Catalogue.—We have received a list in which motor-alternators, dynamos, switch-board instruments, transformers, reducers for arc lamps, choking coils, and high-tension switches are illustrated and described. A new insulating flux for soldering is offered. It is claimed that it is a perfect insulator, is waterproof, non-corrosive, and improves the insulation of cotton or silk, and, unlike rosin, which merely keeps the metal clean, it is said to be a real flux. It is called "Scalpa."

Messrs. Baxendale and Co.—This firm send us lengthy particulars of installation work recently completed, including the telephonic work required at the Denbigh Lunatic Asylum, the electric lighting work at the North Pier, Blackpool, for which concentric wiring has been adopted, the cables being supplied by the British Insulated Wire Company, of Prescot, and the arc lamps are of the Brockie-Pell standard type, attached to ornamental standards. The list also contains a number of telephonic and electric lighting installations carried out by the firm in the Manchester and Oldham districts.

English-made Telephones.—The Consolidated Telephone Construction and Maintenance Company (Limited), of Farringdon-road, E.C., send us their new circular, illustrating the latest make of Gower-Bell telephones, the new Post Office telephone, and the new form of transmitter now supplied by the Company, of which they are the original manufacturers.

Messrs. J. P. Hall and Co.—We have received from this firm their new price list of dynamos and combined engine and dynamo sets, which is fully illustrated and well arranged.

Manganese.—It is stated that immense quantities of manganese have been discovered in the Caucasus Mountains between the Black and Caspian Seas, and European capitalists affirm that they will be able to deliver manganese into Baltimore, U.S.A., at $9 per ton.

Canadian Customs Dues.—Under the new Canadian Tariff Law, which took effect from March 27th last, alterations are made in the customs dues on the following articles :—For insulators of all kinds, arc and incandescent lamps, side and head lights, gas and electric light shades and globes, the duty is now 30 per cent. *ad valorem* ; copper wire, 15 per cent. *ad val.* ; wire covered with cotton, linen, silk, or other material, 30 per cent. *ad val.* ; brass wire, 10 per cent. *ad val.* ; galvanised iron wire, 25 per cent. *ad val.* ; telephone and telegraph instruments, telephone, telegraph, and electric light cables, electric and galvanic batteries, electric motors, generators, dynamos, and electrical apparatus generally, 25 per cent. *ad val.* ; electric light carbons or carbon points not exceeding 12in. in length $2·50 per thousand, and proportionately for greater or less lengths. Considerable alterations are also made in the duties on metals, engines, tubes and tubing, castings, and acids. A full list of these alterations will be found in the *Board of Trade Journal* for June and July.

Commercial Education.—The fifth examination for junior commercial certificates in connection with the London Chamber of Commerce, under its commercial education scheme, has been held during the present week. The proceedings started at King's College on Monday with the examination in practical chemistry ; and other examinations include book-keeping, writing and arithmetic, proficiency in modern languages, mathematics, mechanics and hydrostatics, electricity and magnetism, sound, light and heat,

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natural history, shorthand, and drawing, for which various prizes, ranging from £20 to £2, are given to candidates under 17 years of age at the date of the commencement of the examination. The Chamber of Commerce undertakes to find employment for all candidates succeeding in gaining a certificate. Only one reward can be obtained by any candidate.

Telegraphic Addresses.—Mr. Sell has just issued the June Supplement to his "Directory of Registered Telegraphic Addresses," which contains some thousands of new registrations, cancellations, and other alterations effected during the quarter. The Supplement is sent free to all subscribers; and firms who have purchased the Directory through local booksellers or otherwise than direct from the publishing offices, are requested to send their names and addresses.

Catalogue.—We have received a copy of Messrs. J. Davis and Son's new section "B" catalogue, specially devoted to electrical plant for transmission of power, including pumping, hauling, coal cutting, drilling, &c.; electric lighting; special electric light fittings for out-door and damp and exposed situations; electric blasting apparatus, and electric signals for collieries.

"Annuaire de l'Électricité," 1894.—This Directory, published by M. Camille Rousset, 114, Rue et Place la Fayette, Paris, is just issued, and includes a list of the members of the British Institution of Electrical Engineers corrected up to January, 1893, together with a variety of lists, home and foreign.

"Gas, Water, and Electric Lighting Companies' Directory."—This useful annual, which in addition to a carefully-compiled Directory of gas and water works contains a mass of gas and waterworks statistics, is just issued by Messrs. Hazell, Watson and Viney, of Creed-lane, London, E.C. This is the eighteenth issue, and the book is revised up to March 31st last. In addition to the statistics referred to, a careful summary is made of the principal events of the previous year of interest to all concerned in the gas and water industries, as well as to many engaged in the electrical trades. The price of the book is 10s., bound in strong cloth.

Electrical Stores.—We have received a copy of the July price sheet of electrical stores and apparatus issued by the Electrical Plant and Sundries Company, of 10, Laurence Pountney-lane, E.C. A large quantity of material is included in the list.

Asylum Lighting.—The Cheshire County Council have decided to make extensive additions to the Upton Lunatic Asylum from plans prepared by Messrs. Grason and Ould. The additions are intended to accommodate 416 additional patients, and will cost £76,200, the allowance made for the electric lighting of the new building being £2,000.

Athletic Sports.—The Arc Works Athletic Club, composed of the members of Messrs. Crompton's works at Chelmsford, held their fifth annual bicycle and athletic races on Saturday last. The Company included Mr. R. E. Crompton, Miss Crompton, Mr. J. F. Albright, Mr. F. R. Reeves, and many others well known in electrical circles. Mr. W. Woodward, who was first prize winner in the one-mile flat championship last year, again proved victorious, and retained the silver challenge cup presented by Messrs. Crompton and Albright. The various events were well contested, and at the conclusion Miss Crompton distributed the prizes.

Baslow and Burnell (Derbyshire).—The Local Board decided some time back to postpone the consideration of an electric lighting scheme for the district until the new Parish Council was formed. At the last meeting correspondence was read in reference to the scheme, and an offer was received for advancing the necessary money at 3½ per cent.

Bedford.—The list of tenders received by the Bedford Corporation will be found in a previous column. At a meeting of the Corporation, at which the tenders were considered and accepted, Mr. Blaydes, the Chairman of the Electric Lighting Committee, explained that the Committee considered it essential that no time should be lost in selecting and accepting tenders for the electric lighting work, and they had therefore recommended the acceptance of tenders as indicated in the list. It was originally recommended to accepted the tender of Messrs. Siemens Bros. and Co. for mains and transformers; but upon going through the tender the Committee found that the price per yard, multiplied by the number of yards, would give a total in excess of the amount of the tender, and, as the next tender (that of the Telegraph Manufacturing Company, Limited) was only £56 more than the original tender of Messrs. Siemens Bros. and Co., the Committee recommended its acceptance. The Mayor, before taking the vote, asked Mr. Medhurst, the Corporation's Consulting Engineer, whether he considered the Telegraph Manufacturing Company a reliable firm and one upon which the Council could thoroughly rely to carry out the work, to which Mr. Medhurst replied that he was quite satisfied that the Company, who had carried out large contracts, would do the work to the Corporation's satisfaction. He had used a great deal of the cable manufactured by the Company, and had always found it up to specification. Some other slight modifications of the original tenders having been explained, the offers of Messrs. Johnson and Phillips for the plant, and of Mr. Coleman and Messrs. Grafton for the buildings and shaft and travelling crane were accepted. Mr. Blaydes then moved that it be an instruction to the Electric Lighting Committee to carry out the work of the electric lighting scheme, subject to the approval of the Local Government Board and the Board of Trade. An inquiry was to be held to empower the Corporation to borrow £12,000 to carry out the work, and he hoped there would now be no hitch to prevent their proceeding rapidly with the work.

Belfast.—Mr. M'Cowen, the resident engineer, has submitted to the Electric Lighting Committee of the Corporation a report of the progress of the electric lighting works since the Committee's last meeting. Mr. M'Cowen reports that a large number of persons outside the prescribed area have applied for the electric light.——The Young Men's Christian Association have decided to erect a large block of buildings, from the designs of Messrs. Young and Mackenzie, at a cost of £12,000, the whole of the buildings to be lighted by electricity.

Bolton.—At the meeting of the Town Council on Wednesday Alderman Myles stated that the electric lighting works, which had cost the Corporation nearly £40,000, were approaching completion, and in a few weeks the Corporation would, he hoped, be in a position to supply electric current to intending consumers.

Bournemouth.—Permission has been given to the Brush Company to fit three or four of the existing street lamps with glow lamps of various candle-powers, to be supplied with current from the transformer station near the Bournemouth Arcade. An experiment is to be made with low-tension current, and is intended for inspection by the Winchester Town Council, with whom the Brush Company are negotiating for lighting that city.

Boscombe.—The Bournemouth Electric Light Company are making extensions into this district which, when completed, will reach to the junction of Christchurch-road with the Ashley-road.

Bradford.—The Bradford Bowling Club have now lighted their bowling greens by electricity. Four 3,000-c.p. arcs are used. The lamps are provided with reflectors, and all parts of the green are by this means well lighted, enabling play to be carried on to a late hour.

Brechin.—At the annual meeting of the local gas company amongst the subjects discussed was the advisability of the Company supplying electric light within the district, with special reference to the application to Parliament by the Aberdeen Gas Company for a Provisional Order to supply electric current within the town of Brechin. No decision on the matter was arrived at.

Burton-on-Trent.—A grant of £100 has been voted to Mr. Ramsden, the Corporation's gas manager, for his services in designing and constructing the electric lighting works, and it is proposed to make him manager of the latter at a salary of £50 per annum, dating from February last.

Canterbury.—A public meeting was held at the Guildhall, Canterbury, last week, to consider the proposals of the County of London and Brush Provincial Electric Lighting Company, and to decide definitely whether the electric light should be introduced into the city. The Mayor explained that the Corporation had obtained a Provisional Order at a cost of about £450, and had offered the same to the Brush Company on certain conditions. Mr. R. Percy Sellon said there had been considerable delay since the Corporation and the Brush Company first entered into negotiations, the Company from the first assuming that local support would be readily forthcoming if a local company were formed. He thought much apathy had been shown towards the undertaking by the citizens, and they had experienced difficulty in obtaining the services of local gentlemen to form a Board of Directors. This had caused some delay, but the Corporation met the Company generously, and gave them an extension of time, which had nearly expired, and the matter must at once be definitely settled. It had been clearly shown from the experience of the past ten years that electricity could not pay, when all the necessary expenses had been met, unless the demand reached between 3,000 and 5,000 8-c.p. lamps. If the Company had a demand for 4,000 lamps the undertaking would just pay. They (the Company) were prepared to come forward with two-thirds of the necessary capital, provided the other third was subscribed locally, the total required being between £15,000 and £20,000. It was necessary that the inhabitants should show goodwill towards the undertaking, and this could be done by subscribing the necessary £6,000 towards the capital expenditure. He calculated that the charge for current would be between 7d. and 8d. per unit, and electricity at that price would be equal, light for light, to gas at 3s. per thousand. He thought they need fear no diminution of the gas company's dividends, as it had been found that the introduction of the electric light had had an opposite effect. Alderman Mason said the scheme had met with a considerable amount of opposition from gas share-

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holders, who were receiving 8 or 8½ per cent. dividends; but it must be remembered that these shares sold at twice their nominal amount, which would bring the dividends down to about 4 per cent., and this was what they might reasonably expect from the electric lighting undertaking. A resolution was ultimately adopted that "it was the opinion of the meeting that the electric light should be introduced forthwith into Canterbury," and a committee was appointed to carry this resolution into effect.

CAOUTCHOUC.—It is stated that new clusters of *ficus elastica* have been discovered on the Rivers Verde, Tarvo, Itenes, San Martin, Paragua, and their tributaries in the Bolivian Republic.

CENTRAL LONDON RAILWAY BILL.—The Royal assent was given on Tuesday last to the Central London Railway (Extension of Time) Bill.

CHATHAM.—The Highway and Works Committee of the Town Council have recommended that the Local Electric Light Company be called upon to at once remove their overhead wires, and, failing compliance, that the Board of Trade be consulted on the matter.

CHURCH AND CHAPEL LIGHTING.—At a meeting of the Electric Lighting Committee of the Hull Corporation last week, Dr. Holder, the Chairman, stated that the result of the negotiations with the representatives of Waltham Chapel was indicated by the following resolution. He moved: "That, inasmuch as the Sunday demand for electricity will, when winter approaches, require a Sunday shift of workers at the station, and as such a shift can work the whole number of machines as easily as it can one, it is desirable to foster the demand for light for illuminating churches and chapels. As an inducement this Committee recommends the Council to supply places of worship requiring it at a charge of 5½d. per unit for such electricity as they may use in such places, or in class-rooms attached thereto." The motion was carried, although Councillor Millington took exception to the resolution on the ground that it would necessitate Sunday labour on the part of Corporation officials.——The Church of St. Mary Redcliff, Bristol, which is considered the finest parish church in England, is about to be lighted by electricity. The Lady Chapel at Bristol Cathedral is now lighted electrically.——The Roman Catholic Church of St. Mary's, Barrow, to which extensive alterations are now being made, is to be lighted throughout by the electric light.——St. Peter's Church, Lancaster, is lighted by electricity.——The parish church at Eastbourne, which dates back to the twelfth century, is now being fitted for lighting by electricity.

EDINBURGH.—It has been decided by the Cleaning and Lighting Committee of the Town Council to recommend that George-street, St. Andrew-square, Charlotte-square, and the streets leading from these main thoroughfares into Princes-street be lighted by electricity.

ELECTRICAL ENGINEERING IN SOUTH AFRICA.—It is reported that Messrs. Siemens and Halske, of Berlin, intend to establish an electrical plant in the Witwatersrand mining district of South Africa, to supply electrical energy for pumping, boring, and other purposes.

ELECTRIC TRACTION IN GERMANY.—At the annual meeting of the Union Electrical Company of Berlin, held a few days ago, it was stated that the Company, which exploits the Thomson-Houston system in Germany, had, during 1893, completed electric tramways on that system at Bremen and Remsteid. During the same year work was also commenced of a similar character at Hamburg, Erfurt, and Gotha. The Company had recently received a further contract for converting an additional 70 kilometres of tramway at Hamburg for electric traction, the commission including the supply of 105 motor cars.

ELECTRIC TRACTION IN FRANCE.—The French Thomson-Houston Company has secured the contract for the construction of an electric tramway at Montpellier, and also the contract for converting several of the horse-car lines at Roubaix into electric tramways. The Lyons-Oullins electric tramway is to be extended to Saint-Genis, Laval.

ELECTRICITY IN MINES.—The Cowpen Coal Company are introducing at their Cambois Collieries a system of electric pumping, and electric pumps are to entirely supersede those at present driven by rope. About 20 miles of cable will be used.

FAREHAM.—A petition has been presented to the Board of Trade against the purchase of the Fareham Electric Light Company's undertaking by the Local Board.

FLEETWOOD.—The Improvement Commissioners have discussed the Electric Lighting Committee's report just presented. The report deals with the visit of the Fleetwood deputation to Coatbridge and other towns, and describes the nature of the works adopted. The system adopted for Fleetwood is on exactly the same lines as those at Coatbridge, with the exception of the gas tank, which at Fleetwood is to be increased, and made capable of holding a large supply of gas for engines during the hours of light and heavy loads. Tandem type engines, made by Messrs. Dick, Kerr and Co. are to be used, and rope-driving has been selected. The Brush Company have prepared the plans for the works. Mr. Kirkbride's tender for the buildings, &c., has been provisionally accepted; and Mr. C. Drummond has been appointed clerk to the works and engineer to superintend the building, &c. The total estimated cost is £11,819, which includes £500, which the Committee propose shall be expended for the purchase of electric fittings for sale to intending consumers. If this latter suggestion is approved it is proposed to fit up a show room in the central part of the town for displaying the fittings. The Committee anticipate no difficulty in obtaining approval from the Local Government Board for borrowing the necessary money. The report was unanimously approved.

GLASGOW.—At the last meeting of the Lighting Committee of the Town Council the report showed a steady increase in the demand for electric lighting for domestic purposes. All available plant is now fully employed, and considerable extensions are taking place with a view to meeting the coming winter's demands.

HAMPSTEAD.—The Electric Lighting Committee of the Vestry, having considered the applications sent in for the vacant post of Electrical Engineer, have selected six candidates who are to appear before the Vestry at its next meeting.

HOSPITAL LIGHTING.—The New Park Hospital at Hither Green, to be built for the Metropolitan Asylums Board from designs by Mr. E. T. Hall, F.R.I.B.A., is to be fitted throughout for the electric light, telephones, fire appliances, and with hydraulic lifts for the patients.

ILFRACOMBE.—The Local Board have received an intimation from the Great Western Electric Light Company of their intention to apply to Parliament for a Provisional Order for lighting the district by electricity.

ISLINGTON.—The Electric Lighting Committee of the Vestry have decided to recommend that the designs for the electric lighting central station sent in by Mr. A. Hessel Tiltman, F.R.I.B.A., be accepted. The cost of the works is estimated at £17,540.

LARNE.—The Town Commissioners have for the second time entered into a contract with the liquidators of Messrs. J. E. H. Gordon and Co. for the lighting of the town by electricity.

LONDON COUNTY COUNCIL.—The Works Committee decline to undertake the electric lighting installation works for Westminster and Waterloo Bridges and the Victoria Embankment on the ground that the Highways Committee's estimate for the work is much too low. The Highways Committee at the last meeting of the Council proposed that the work be offered to tender, and this proposal is to be considered at the next meeting.——The Highways Committee at the last meeting of the Council recommended that machinery and plant for the electric lighting station required for the installation for the Victoria-embankment and the Waterloo and Westminster Bridges should be immediately obtained, and that tenders asking for the supply of the machinery and plant be invited by public advertisement. It was suggested that as the designs for the lamp-posts proposed to be used had been generally condemned, premiums should be offered for good designs. After some further discussion the subject was adjourned until next meeting.

LYONS EXHIBITION.—During his visit to this Exhibition the late President Carnot was much interested in the exhibit of M. Croizier, the agent in France of Messrs. Willans and Robinson (Limited). There are on view a Willans-Siemens and a Willans-Crompton compound engine and dynamo, each producing 900 amperes at a potential of 120 volts, and generating three-fourths of the current used for lighting the cupola.

OLDHAM.—The Oldham Central Electric Supply Station has just been completed by Messrs. J. P. Hall and Co. The same firm have also lately completed contracts for electric light installations for the Manchester Ship Canal Company for the locks at Barton, Irlam, and Latchford, the plants for which comprise arc lamps, dynamos, steam engines, boilers, &c.

PADDINGTON.—The Vestry have received a request from a prominent ratepayer asking them to ascertain from the Metropolitan Electric Supply Company and other companies if they are prepared to enter into arrangements for lighting the streets of Paddington, either partially or otherwise, by electricity, and at what cost.

PROVISIONAL ORDERS.—The Royal assent has been given to the Provisional Order for the electric lighting of St. Austell.

SHOP AND WAREHOUSE LIGHTING.—The extensive new premises recently opened by Mr. Clark at Bayswater, W., are to be lighted electrically throughout by Messrs. John Bowling and Sons (Limited).

SHOREDITCH.—The Electric Lighting Committee have applied to the London County Council for a loan of £12,300 for sixty years.

SOUTHAMPTON.—Notice has been received by the Town Council from the Southampton Electric Lighting Company of their intention to apply for a Provisional Order in the ensuing session.

SOUTH SHIELDS.—A visit has been paid by the Mayor of South Shields, accompanied by two Aldermen, the Town Clerk (Mr. Moore Hayton), and Mr. Joseph Jeckell, the electrical engineer, to

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Bristol, for the purpose of inspecting the electric light works in that city.

THEATRE LIGHTING.—The electric lighting at the Theatre Royal, Bradford, is used for the auditorium, entrance corridors, bars, and footlights. There is sufficient plant and power to supply in addition the stage, dressing-rooms, scene-dock, and workroom in the rear. 454 16-c.p. incandescents have been provided for the auditorium. In the covered space in front of the theatre 56 incandescents and three arcs are used, while a 3,000 c.p. arc is placed on the top of the building. The central electrolier in the auditorium is provided with incandescents equal to 1,000 c.p.

TORQUAY.—The Holloway Electricity Supply Company have notified the Torquay Corporation of their intention to apply for a Provisional Order for lighting the district by electricity. The matter has been referred to the Electric Lighting Committee. The Corporation themselves possess Parliamentary powers.

WALTHAMSTOW.—At the last meeting of the Local Board a letter was read from Mr. Jerram, notifying the Board that a syndicate had been formed for supplying electric current in the district, and asking the Board's permission for opening the roads and laying down the necessary mains. The writer also inquired if the Board were willing to take electric current for street lighting at the same cost, or less, than they now paid for gas lighting. The letter was referred to the Lighting Committee.

WREXHAM.—The Town Council has affixed the Corporate Seal to a joint memorial from the Wrexham and District Electric Supply Company (Limited) and the Corporation to the Board of Trade, in reference to the proposed acquisition by the Corporation of powers, under Provisional Order, licence, or otherwise, for supplying electric current within the borough, and asking that the Corporation may become the undertakers for such supply in place of the Company. The memorial states that the price to be paid by the Corporation to the Company is £350.

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

June 11, 1894.

11,276. R. LANGHANS. London. Improvements in and relating to electric incandescent lamps.

11,280. W. GEIPEL. London. Improvements in jointing electric conductors.

11,286. H. C. L. HOLDEN. Woolwich. Improvements in electric arc lamps.

11,312. H. H. LAKE. London. Improvements in electric accumulators or secondary batteries. (La Société Electrogénique, France.)

11,320. H. H. LAKE. London. Improvements relating to telegraphic and telephonic transmission. (M. J. Pupin, United States.)*

11,323. A. MUIRHEAD and A. FRASER. London. Improvements in apparatus for the automatic transmission of signals through telegraph lines and cables.

11,338. C. M. HOUGHTON. Cheltenham. System of electric signalling. (L. F. C. Rich, United States.)

June 12, 1894.

11,339. L. HOFFER. London. Improvements in cigarette paper and in holders therefor.

11,364. W. LOWRIE. London. Improvements in dynamo electric machines.

11,418. J. E. KINGSBURY. London. Improvements in telephone transmitters. (The Western Electric Company, United States.)

June 13, 1894.

11,439. H. J. WAGG. London. Improved electric indicator.

11,452. R. E. B. CROMPTON and H. J. DOWSING. London. Improvements in connectors for conductors used with electrical apparatus.

11,483. J. E. LIARDET. London. Improvements relating to the generation of electricity.

June 14, 1894.

11,559. H. LÜDEKE, E. L. A. LÜDEKE, A. J. THORMAN, E. DE BUNSEN, and E. M. HORE. London. Improvements in magneto-electric motors.

11,587. L. P. HULIN. London. Improvements in the process of and apparatus for the electrolytic decomposition of solutions, and for the immediate separation therefrom of the liquid or dissolved electrolytic products. [Date applied for under Patents, &c., Act, 1883, Sec. 103, November 25, 1893, being date of application in France].

11,601. O. L. KLEBER. London. Improvement in printing telegraph instruments.*

June 15, 1894.

11,606. F. R. DAVENPORT. Eastbourne. Improvement in separators for electric storage cells.

11,613. H. W. ROWLAND. Liverpool. An electrical minnow for fishing purposes.

11,628. F. HEWITT. Birmingham. Improvements in the mode of and means for suspending electric lamps, lanterns, shades, and other such articles.

June 16, 1894.

11,684. A. MARR. Manchester. Improvements in and connected with electrical safety fuses.

11,701. G. R. NEILSON and A. C. BROWN. London. Improvements in electric fire-alarms.

June 18, 1894.

11,733. R. ALTSCHUL. Liverpool. Improvements in or appertaining to electrical railways or tramways.

11,780. D. COOK. Richmond. Improvements in the means of distributing alternating electricity.

June 19, 1894.

11,809. J. B. ROLFE. London. Electrical life-preserving fire alarm.

11,813. F. WOILLIARD-RIGG and H. E. SCARBOROUGH. Halifax. Improvements in photographs.

11,814. W. G. MARTIN. London. Automatic auxiliary electric block, and engine distance caution signal for railways.

11,815. A. ECKSTEIN and A. E. MITCHELL. Manchester. An improved electrical indicator.

11,822. A. MARSDEN. London. A new attachment for hanging electroliers and other electric fittings.

11,840. J. W. MEARES. Chelmsford. An instrument for finding the direction of induced current, rotation, or magnetisation in an electric generator or motor.

11,843. C. GILLARD. Somerset. To illuminate by electricity castings of flowers, fruits, and foliage taken from nature for the purpose of decoration in plaster, either cornices, centre ornaments, entablature, &c.

11,861. H. H. LAKE. London. Improvements in electric belts. (E. M. Miles, United States).*

June 20, 1894.

11,903. A. A. GOVAN. Glasgow. Improvements on conduit electric systems for supply of current to tramway, rail, or other motors.

June 21, 1894.

11,979. W. VON BRAUCKE. Stockton-on-Tees. Improvements in or relating to metal brushes for dynamos.

11,995. W. THOMSON (BARON KELVIN). Glasgow. Improvements in testing and working electric telegraphs.

12,006. C. BISHOP. Liverpool. Improvements in iron clips for fixing electric light casing, and other purposes.

12,009. W. R. V. MARSHALL. London. An automatic electrical switch.

June 22, 1894.

12,099. H. F. JOEL. London. Improvements in the construction of armatures for dynamo-electric and electric motors.*

12,100. J. W. SUNDERLAND and G. BILLROUGH. London. Improvements in, or connected with, signalling electrically to locomotives or trains in motion.

12,131. L. E. FREEDLEY. London. Improvements in electric brake-operating mechanism for vehicles. (Date applied for under Patents, &c., Act, 1883, Sec. 103, December 29, 1893, being date of application in United States.)*

12,137. H. NEWBOLD. London. Improvements connected with a combined walking stick and electric lamp appliances.*

June 23, 1894.

12,140. A. A. C. SWINTON. London. Improvements in electric igniters.

12,147. W. B. SILVERLOCK. London. An improved electrical gripper bar, applicable to printing machines.

12,151. C. LANGSTONE and B. YOUNG. Birmingham. Concentric lever switch.

12,183. J. E. PARKER. New York. Underground electrical propulsion.

12,221. P. M. JUSTICE. London. Improvements connected with electrical furnaces. (E. G. Acheson, United States.)

June 25, 1894.

12,241. J. PERRY and T. TOMLINSON. London. Electro-magnetic traction.

12,253. H. POWIS and G. EVANS. Shrewsbury. Electric staff and tablet detector.

12,283. E. LANGEN. London. Improved block system on electric railways and apparatus therefor.

12,304. H. N. FRENAY-OLYFF. London. Improvements in and relating to electric telephone systems.

June 26, 1894.

12,313. F. M. LEWIS. Leeds. Improvements in or in connection with arc lamps.

12,345. P. WRIGHT. London. Improvements in transformer systems of electrical distribution.

12,349. W. P. THOMPSON. Liverpool. Improvements in, or relating to, heating metals electrically. (C. L. Coffin, United States.)*

12,400. F. SUISSE and P. E. HENNEQUIN. London. Improvements in regulators for electric arc lamps or lighting apparatus.

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12,406. T. E. Waltham. London. Improvements relating to electric and other motors.

12,411. F. W. Schindler. London. Electric igniting device suitable for lighting tobacco pipes and cigars.

June 27, 1894.

12,476. J. S. Raworth. London. Improved system of switching and regulating apparatus for central stations for the generation and distribution of electrical energy.

12,483. C. P. Shrewsbury, F. L. Marshall, J. Cooper and J. L. Dobell. London. Improvements in or connected with electric batteries.

12,492. W. U. Hilliar. London. An improved construction of holder for incandescent electric lamps.

12,505. J. J. Rathbone and A. Chester. London. Improvements connected with arc lamps.

12,510. E. Chabeault. London. Improvements in apparatus for supplying electricity to electrically-propelled vehicles.

SPECIFICATIONS PUBLISHED.

Note.—All Specifications can now be obtained at the uniform price of 8d. each.

1893.

10,597. Sluce. Adapting electric lamps to candle fittings, &c.

10,772. Cutting. Ceiling roses, &c., for electric connections.

11,168. Death. Arc Lamps.

11,294. Pippette. Electric exchange.

12,785. New and Mayne. Electric switches.

13,217. Lithanode and General Electric Company (Limited) and Niblett. Electric batteries.

13,749. Smith. Electric elevators.

14,271. Bertram and Hope-Johnstone. Distributing electricity.

14,533. Siemens Bros. and Co. (Limited) (Siemens and Halske). Supplying electrical energy to motor vehicles on electric railways, &c.

14,562. Ravenshaw and Atkinson. Alternate-current dynamos, &c.

14,715. Harcourt. Electric bell pulls and pushes.

14,969. Newton and Hawkins. Dynamos, motors, &c.

15,073. Cooper and others. Electric arc lamps.

15,510. Brockie. Electric arc lamps.

16,025. Siemens Bros. and Co. (Limited) (Siemens and Halske). Electromotors.

16,026. Siemens Bros. and Co. (Limited) and Holmes. Regulator for dynamo-electric machines.

1894.

1,849. Taylor. Arc lamp.

3,072. Woolverton. Arc lamps.

4,429. Metzger. Electrical switches.

6,947. Gülcher. Plates for accumulators.

7,239. Coerper. Electric motors.

8,587. Lake (Purvis and another). Electric railways.

8,835. Still. Electrical propulsion of cars.

8,917. Alexander. Electro-deposition of metals.

COMPANIES' MEETINGS AND REPORTS.

Oriental Telephone and Electric Company (Limited).

The first ordinary general meeting of this Company was held on Wednesday at Winchester House, Old Broad-street, under the presidency of Mr. W. Addison.

The SECRETARY (Mr. Alex. B. Chalmers) having read the notice convening the meeting,

The CHAIRMAN said : Gentlemen, the Directors of the newly-constructed Company have the pleasure of meeting you to-day at what is termed the "statutory general meeting," which by Act of Parliment is required to be held within four months from the formation of the Company. The meeting has not been held earlier because we were desirous of being able, when it was held, to inform you that the reconstruction arrangements had proceeded satisfactorily. This, we are glad to inform you, has, in all respects, been the case. The new Company was registered on the afternoon of the same day on which the resolutions were passed by the shareholders of the old company, and the business has been continued by the new Company without drawback of any kind, nor is any anticipated. In order to obviate, as far as possible, inconvenience to shareholders, the application for a quotation on the Stock Exchange of the shares in the new Company was pressed forward as much as possible, and, with the assistance of the representatives of the Stock Exchange, the necessary arrangements were concluded promptly and satisfactorily. Few transfers of shares have taken place, from which it may be inferred that the shares are well and firmly held. I am also pleased to inform you that the Company's business is showing fair progress. The reports from its various agencies and from the affiliated Companies are satisfactory. As regards India, the volume of business transacted shows a satisfactory increase ; but it is only right that I should remind you that the depreciation of silver may affect the net revenue. We can only hope that silver has already reached its lowest price, and that any movement in the future may show an upward tendency. The new Company having only been formed on March 12th, we cannot at this meeting bring before you the usual annual report and balance-sheet, but will do so at the earliest opportunity next year, which will probably be, as usual, in April, when the results of the Company's operations to the end of the present year will be laid before you. As there is no special resolution to put before the meeting I shall be happy to answer any questions that may be asked.

No questions being asked,

The CHAIRMAN (after a pause): Well, gentlemen, this is only a formal meeting, as you are aware, and that concludes the business.

The meeting then separated.

The India-Rubber, Gutta-Percha, and Telegraph Works Company (Limited).

A half-yearly general meeting of the Company was held at the Cannon-street Hotel yesterday for the purpose of obtaining the sanction of the shareholders to the payment of an interim dividend of 5 per cent., or 10s. per share, free of income-tax. Mr. S. William Silver presided.

The SECRETARY (Mr. W. J. Tyler) having read the notice calling the meeting,

The CHAIRMAN said : Gentlemen, the books are made up, as I think you are aware, only once a year. I have no hesitation in recommending for your adoption

"*That an interim dividend of 5 per cent., or 10s. per share, free of income-tax, be payable on the 6th inst.*"

When we last met I referred to the considerable difficulty we experienced in securing contracts and works generally owing to the depression in trade that exists. This state of things has increased. Notwithstanding, I think that we get our share. This is to be accounted for by the efforts used to make known, both at home and abroad, the excellency of the work turned out at Silvertown, and the efficiency of the machinery, which is quite up to the requirements of the hour—so much so that I may say that we have the first offer of most improvements introduced into this country. Now, here let me say that I would ask you all who are interested in this concern to use any and every opportunity of bringing business that may present itself to you. As regards submarine cable work we have done very little besides laying a short length for the Spanish Government ; but we have had a fair share of land work, including orders from our own and foreign Governments. The works at Silvertown are in a very efficient state, and I think I may say that the same remark applies to those at Persan.

Mr. SCOTT seconded the motion.

Mr. M. GRAY said that he had recently visited the works at Persan, and found them in very good order ; and he was in every way satisfied with the manner in which the business was being conducted, not only there, but at Silvertown.

The motion was carried unanimously.

Dr. SMALL proposed, and a SHAREHOLDER seconded, a vote of thanks to the Chairman and Directors ; and,

The CHAIRMAN having expressed his acknowledgment, the proceedings ended.

Eastern Telegraph Company (Limited).

The following is the report for the half-year ended March 31, 1894, to be presented to the forty-fourth half-yearly ordinary general meeting, to be held at Winchester House, London, E.C., on Thursday next, the 12th inst., at one o'clock :—

The revenue for the six months ended March 31, 1894, amounted to £389,314. 2s. 3d., from which are deducted £102,218. 18s. 6d. for the ordinary expenses, and £49,660. 6s. 5d. for expenditure relating to repairs and renewals of cables, &c., during the half-year. After providing £3,219. 14s. 8d. for income tax, and £401. 12s. 6d. due to re-valuation of currency, balances at stations, &c., there remains a balance of £233,813. 10s. 2d., to which is added £86,252. 13s. 11d. brought from the preceding half-year, making a total available balance of £320,066. 4s. 1d. From this balance there have been paid—

Interest on Debentures and Debenture Stock.....	£27,680	4	0
Dividend on Preference shares	20,384	11	11
An interim dividend of 2s. 6d. per share on the Ordinary shares	50,000	0	0
	£98,064	15	11

Leaving a balance of £222,001. 8s. 2d., from which £110,000 has been carried to General Reserve Fund.

The Directors now recommend the declaration of a final dividend for the year ended March 31, 1894, of 2s. 6d. per share and a bonus of 3s. per share, amounting together to £110,000, both payable on the 12th instant, free of income-tax, and making, with the three previous payments on account, a total distribution of 13s. per share or 6½ per cent. for the year on the Ordinary shares. The balance of £2,001. 8s. 2d. shown at the foot of the revenue account is proposed to be carried forward to the next half-year.

The revenue includes £32,791. 12s. dividends and bonus for the half-year upon the Company's investments in the Eastern and South African, the Black Sea, the Direct Spanish, and the African Direct Telegraph Companies.

West African Telegraph Company (Limited).

Report of the Directors for the year ended December last, to be presented to the ninth ordinary general meeting to be held at Winchester House, E.C., on Thursday, the 12th inst., at 2:30 :—

The Company's revenue for the period amounted to £61,847. 1s. 5d., against which £18,828. 19s. 1d. is charged for ordinary expenses, and £20,492. 5s. 11d. for expenditure relating to repairs to cables, &c. After

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providing £1,020. 6s. 1d. for Income-tax, and £214. 8s. 3d. due to revaluation of currency balances at stations, there remains a balance of £21,285. 2s. 1d., to which is added £2,410. 9s. 10d. brought forward from the preceding year, making a total balance of £23,695. 11s 11d. From this balance there is deducted £12,495. 11s. 11d. for interest on debentures, and £11,200 for sinking fund.

The total expenses attending repairs and renewals of cables, &c., amounted to £31,233. 17s. 6d.; but the Directors, after careful consideration, have decided to apply from the general reserve fund the sum of £10,741. 11s. 7d. to meet the deficiencies which would otherwise have appeared after providing for the ordinary expenses, interest and sinking fund for debentures, as well as for the expenses incurred in repairing the cables.

A loss has been made on exchange of £7,751. 2s. 10d., against £8,044. 10s. 1d. last year. The depreciation of Portuguese currency continues to seriously affect our remittances from abroad.

The Directors who retire by rotation are Sir John Pender, G.C.M.G., M.P., and Mr. Thomas Fuller, who, being eligible, offer themselves for re-election, as do the auditors, Messrs. Deloitte, Dever, Griffiths and Co.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1894, pages 274-300, *&c., &c.*]

BELCHER'S PATENT SMOKE PREVENTER COMPANY (LIMITED).—This Company was registered on July 2nd with a capital of £1,000 in £1 shares, to acquire letters patent, No. 9,340, of May 17, 1892, for improvements in or connected with the furnaces of steam boilers, and to carry on the business of manufacturers of boilers, furnaces, and engines of any description, and general engineers.

COMMERCIAL ELECTRICITY SUPPLY COMPANY (LIMITED). — This Company was registered on June 30th, with a capital of £2,000, in £1 shares, to carry on the business of an electrical company in all or any of its branches, in particular to supply electricity for use in the production of light and power, and to carry on the business of electrical and mechanical engineers and manufacturers of and dealers in electric, magnetic, telegraphic, telephonic and other appliances, and steam, hydraulic, pneumatic or other engines. The subscribers (with one share each) are: Arthur E. Cosson, 96, Hillfield-road, West Hampstead, N.W.; Arthur J. McGrath, 70, Victoria-road, Kentish Town, N.W.; George W. Whitton, 60, Queen Victoria-street, E.C.; Robert A. Daniell, 20, Bucklersbury, E.C.; Frederick G. Nash, 73, Salcott-road, Wandsworth Common, S.W.; Edward L. C. Bauman, 67, White Horse-lane, Mile End, E.; Samuel G. Tripp, 28, Wilberforce-road, Finsbury Park, N.

CROPPER-MINERVA MACHINES COMPANY (LIMITED).—This Company was registered on June 28th with a capital of £10.000 in £1 shares, to acquire by purchase or otherwise, and carry on the business of machine builders, engineers, and to carry on the business of an electric light company in all or any of its branches, to construct, lay down, establish, fix, and carry out all necessary cables, wires, lines, accumulators, lamps and works; to generate, accumulate, distribute, and supply electricity, and to carry on the business of electricians, suppliers of electricity, manufacturers of electrical apparatus, &c.

DALZIEL'S NEWS (LIMITED).—This Company was registered on June 30th, with a capital of £150,000, divided into 60,000 £6 per cent. cumulative Preference and 90,000 Ordinary shares of £1 each, to acquire as a going concern the business of a news agency carried on by Dalziel's Cable News Agency (Limited).

GREAT WESTERN ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—This Company was registered on June 29th with a capital of £1,000 in £10 shares, to produce and supply electricity or electrical currents and force, to undertake public or private lighting, to supply light, heat, motive power, or telegraphic, telephonic, or other means of communication, to make applications to Parliament, the Board of Trade, or any Municipal, or other authorities or persons for powers, grants, or concessions for public or private lighting, and to manufacture, provide, sell, deal in or let for hire any engines, machinery, wires, plant, instruments, fittings or apparatus for producing, storing, supplying, transmitting or using, or for regulating and measuring the supply or consumption of, or for facilitating the use of, electricity. The subscribers (with one share each) are:—H. G. Simmonds, 73, St. George's-avenue, N.; William Farrant, 7, Vincent-square, S.W.; R. Bridges-Molesworth, 34, Victoria-street, S.W.; Arthur H. Witham, 49, Crewdson-road, Brixton-road, S.W.; Erasmus A. Watts, 74, Offord-road, Barnsbury, N.; Edward L. Russell, 2, Thornford-road, Lewisham, S.E.; Arthur G. Defries, Rose Bank, Bulwer-road, Leystonstone, E.

ALFRED HERBERT (LIMITED).—This Company was registered on July 2nd, with a capital of £25,000 in £5 shares, to acquire the business of a mechanical engineer and manufacturer of boilers, engines, tools, and implements carried on by Alfred E. Herbert, at the Butts, Warwick, and to carry on the business of mechanical engineers, machine and engineering tool makers, fitters, boiler makers, iron and brass founders, millwrights, steel converters, plate makers, electrical engineers, suppliers of electricity for all purposes, wire drawers, tube makers, &c.

NON-CORRODING SILVER METAL SYNDICATE (LIMITED).—This Company was registered on June 20th, with a capital of £20,000, in £1 shares, to acquire, use and operate an invention or process for a silver metal having a greater tensile strength than that of steel, capable of taking and maintaining a high polish, and not susceptible to corrosion or tarnish; and to carry on the business of manufacturers of machinery, engineers, mechanics, machinists, iron founders, &c.

ABRAM PULMAN AND SONS (LIMITED).—This Company was registered on June 28th, with a capital of £12,000 in £5 shares, to acquire and take over as a going concern the business carried on by Abram Pulman and Sons, at Halifax, to carry on the business of iron and steel merchants, bolt and screw manufacturers, metal workers, iron and brass founders, coppersmiths, machinists, metallurgists, &c., and to construct, equip, and supply electric motive power, and all kinds of machinery, appliances, apparatus, and things of every description in connection therewith.

PUTNEY ELECTRIC SUPPLY COMPANY (LIMITED).—This Company was registered on June 27th, with a capital of £1,000 in £2 shares, to enter into contracts for electric lighting, and for the supply of electric energy for power and transmission, and for fixing, maintaining, selling, hiring, or otherwise dealing with wires, lamps, secondary batteries, and all other electrical appliances and equipments, and to supply, or manufacture, purchase, hire, take in exchange, or otherwise acquire, sell, and supply all machinery, motors, generators, lamps, and materials connected with, or necessary to, the business of the Company. The subscribers are:—John S. Sayer (50 shares), Samuel Legg (1), William Goodridge (1), Ernest R. Smith (1), Herbert A. Hughes (1), Thomas C. Cleary (1), and William B. Ducket (1).

THOMAS RICHARDSON AND SONS (LIMITED).—This Company was registered on June 21st, with a capital of £250,000 divided into 20,000 Ordinary, and 5,000 £5 per Cent. Cumulative Preference shares of £10 each, to acquire and carry on the business of marine engine builders, mechanical engineers, founders, smiths, machinists, manufacturers, and patentees, carried on at the Hartlepool Engine Works, Hartlepool, in the County of Durham, by the firm of Thomas Richardson and Sons. The first Directors are Thomas Richardson (Managing Director), and William J. Richardson (Chairman).

TANDEM SMELTING SYNDICATE (LIMITED).—This Company was registered on June 28th with a capital of £5,000 in £1 shares, to acquire the business of dealing in Tandem-bearing and other anti-friction metals and alloys carried on under the style of "Hoveler and Dieckhaus," at 3, Stockwell-avenue, London, S.W., including the right of manufacturing such metals and alloys within the United Kingdom, and to carry on the business of analytical chemists, metal workers, smelters and manufacturers, brass founders, engineers, &c.

WINDERMERE AND DISTRICT ELECTRICITY SUPPLY COMPANY (LIMITED).—This Company was registered on June 27th, with a capital of £50,000, in £5 shares, to carry on the business of electrical engineers, electricians, engineers, and contractors, suppliers of electricity, manufacturers of and dealers in electrical apparatus, mechanical and chemical engineers, water power engineers, tramway proprietors, &c., and the business of producing, storing, distributing and supplying light, heat, sound and power by electricity, galvanism, magnetism or otherwise. The subscribers (with one share each) are: Martin E. Sheerboom, Arthur Barrenger, Thomas T. Bickford, James Renwick, Archibald Hair, H. E. Shaughnessy, and Frederick Hodson, all of London.

WIMSHURST, HOLLICK AND CO. (LIMITED).—This Company was registered on June 27th, with a capital of £40,000, divided into 4,000 £5 per Cent. Cumulative Preference and 4,000 Ordinary shares of £5 each, to acquire as a going concern a business of electrical and general engineers and boilermakers now carried on in Commercial-road, London, E., to manufacture and deal in all apparatus used in connection with the generation, distribution, supply, accumulation, and employment of electricity, and to carry on the business of electrical and general engineers, boilermakers, manufacturers, and electricians. The first Directors are: Thomas D. Hollick, Thomas P. Hollick, and Frederick W. Drake, the first mentioned being Managing Director.

CITY NOTES.

AFRICAN GOLD RECOVERY COMPANY (LIMITED).—Lord Kelvin, Sir Henry E. Roscoe, Prof. W. Crookes, F.R.S., and Mr. Le Neve Foster are, it is stated, to be witnesses in the action brought by the above Company against Messrs. Lake and Thompson in regard to the Company's gold recovery patents. The action is to be tried at Pretoria, but the evidence of the above gentlemen will be taken on commission.

CENTRAL CHILI COPPER COMPANY (LIMITED).—This is the title of the reconstructed Panulcillo Copper Company, with a capital of £255,000 in 30,000 Six per Cent. Cumulative Priority Shares of £1 each, and 225,000 Ordinary shares of £1 each. The Priority Shares are now offered for subscription to the shareholders of the old Company in the proportion of one Priority for every eight shares held in the old Company. Shareholders of the old Company subscribing for shares in the new are also entitled to receive two Ordinary shares of the new Company of £1 each fully paid in exchange for each share they hold in the Panulcillo Company. The Directors consist of Sir John Pender, G.C.M.G., M.P., and Messrs. Goldschmid, of Paris, and J. H. Collins, F.G.S., formerly of the Rio Tinto Company. Subject to conditions explained in the prospectus the Priority Shares will have preference both as to capital and interest. Copies of the prospectus can be obtained at the offices, St. George's House, Eastcheap, E.C.

CHILIAN MANGANESE MINES (LIMITED).—This Company, which has an authorised capital of £125,000, invites applications for £50,000 Seven per Cent. First Debentures, of which £17,200 has already been subscribed for. The debentures are in £100. The property of the Company consists

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of valuable manganese mines in Chili. Mr. Joseph Wilson Swan is Chairman of the Company.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended July 1st were £1,020, as against £811 in the corresponding period of 1893, being an increase of £209. The total receipts for the half-year amount to £23,636, as against £22,610 for the corresponding period of 1893, an increase of £1,026.

CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).—The warrants for the interest due on this Company's debenture stock to June 30th have been posted. The transfer books and register of members of the Six per Cent. Cumulative Preference Shares of this Company are announced to be closed from July 9th to 19th inclusive, to enable the preparation of the interim dividend warrants.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the month of June are £3,350, as compared with £3,233 in the corresponding month of last year.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—This Company's estimated traffic receipts for the month of June amounted to £1,617, as against £1,730 in the corresponding period of last year.

EASTERN TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of June amounted to £53,752, against £62,564 in the corresponding period of last year, being a decrease of £8,812.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of June, 1894, amounted to £44,244, and to £45,443 in the corresponding period of 1893.

EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY (LIMITED). An extraordinary general meeting of this Company was held on Tuesday, at the Cannon-street Hotel, Mr. J. S. Forbes in the chair. On the motion of the Chairman, seconded by Major Flood Page, a resolution approving of the provisional agreement of June 5th last between the Swan United Electric Light Company (Limited) and this Company for the sale of the Swan Company's undertaking to this Company for debenture stock, was passed. The Chairman said that when the two companies originally came to terms there were "two Richmonds in the field," the Edison and the Swan, both with patents of a useful character, that might have led to litigation; but instead of fighting they amalgamated, and did pretty well under that amalgamation. But, whereas the Swan had patents in Great Britain, all Europe, and some other places, the Edison Company had only the British patents; therefore, all the Edison Company put into the pot as the Swan Company was the British patents, and kept the outlying business as a separate matter, and that was now represented by a business in Germany, certain advantages there, by an investment in the French Edison Company, and so forth. Now they proposed to bring it in. The patent period was now over. They were the subjects of active competition, and, this being so, came to the conclusion that it was very desirable to join forces, so as to present a united front to the enemy, not only in Great Britain, but also on the Continent, and for that residuum the Swan Company had agreed to accept £100,000 of debentures. The question to determine that day was whether the Edison and Swan Company was willing to give that for it. The Boards of both companies had agreed to the scheme, but preferred to have the approval of the Edison and Swan proprietors. Major Flood Page said that every single Director and every official connected with the management of the organisation was in accord in thinking that if they were to make a success of that undertaking they must have this fusion, in order to show a united front against all the rivals they now had in this business. Col. Stroud asked when the meeting for the presentation of the accounts would take place. And the Chairman (Mr. J. S. Forbes) replied that it would be held on July 26th.

SWAN UNITED ELECTRIC LIGHT COMPANY (LIMITED).—An extraordinary general meeting of this Company was held at the Cannon-street Hotel, on Tuesday, Mr. J. S. Forbes presiding, when the special resolution passed at the extraordinary general meeting held on the 14th, and published in *The Electrician* on June 8th (page 169), was, on the motion of the Chairman, seconded by Major Flood-Page, confirmed. Colonel Wallace Stroud inquired in what way the £100,000 of Debentures to be given to the Swan Company were to be secured, and what would be their value, and in reply the Chairman stated that the £100,000 of Four and a-Half per Cent. Debentures would be secured on the property of the Edison and Swan United Electric Light Company, and, of course, would be a preference charge on the profits of that undertaking. What would be the worth of such debentures he could not say but he believed they would be a gilt-edged security. No doubt the patents were gone—and they cost a considerable portion of the capital—but the business remained, which, if properly administered, would return good profits from year to year.

ELMORE'S PATENT COPPER DEPOSITING COMPANY (LIMITED).—The Directors of this Company summoned a meeting of the shareholders at the Cannon-street Hotel, yesterday (Thursday), for the purpose of receiving their resignation, and appointing new Directors. The Directors in their circular say:—"It will be in your recollection that the investigation committee recommended, in the first instance, that local Directors should be selected; but, that being impossible at the time, the present Directors were appointed. Their work has been done at much inconvenience to themselves, to the best of their ability in the interests of the shareholders; but they feel it most difficult to exercise a proper control over the business without a sacrifice of time which their other occupations render most inconvenient. They are desirous, therefore, of placing their resignation in the hands of the shareholders, and are, they believe, fully justified in so doing under the conditions which are such as will enable them to present to the meeting the names of local gentlemen of position and ability who are now willing to take over the direction of the Company's affairs. It will be evident that the position of the business and condition of the works must be greatly improved, or the proposed new Directors would not have been induced to come forward and take a large pecuniary interest in the business, and place themselves in the responsible position of controlling the affairs of the Company. After the last meeting £10,000 of Six per Cent. Debentures were offered to the shareholders, but, as the issue met with little response, the deposits were returned. The want of capital caused again delay in developing the business, and it was only after some time that an arrangement was come to with our bankers (through the agency of Mr. William Elmore and the guarantee of Mr. A. S. Elmore) to the extent of £15,000. This provides for the purchase of ample supplies of copper and the completion of the needful plant; so that nothing should now be wanting for the accomplishment of profitable results. The Wire Company having obtained capital, an arrangement must now be made with them for the joint use of the furnaces, and, as other important agreements are waiting completion, the present Directors are desirous that they should be entered into by the new Directors, who would then commence their duties with a fuller control of the interests of the business."

At the meeting yesterday, the Chairman explained that the reason why the Directors wished to retire from the Board was that they were not sufficiently in touch with the business of the Company to effectively control it. Mr. Elmore had secured the services of three gentlemen who were willing to take over the direction of their affairs, and he was quite sure that the interests of the shareholders would be very much better looked after by them than could possibly be done by the existing Board, for the reason that they were more acquainted with the details of the trade. The new Directors lived near the works, and could, therefore, exercise the necessary control over the affairs of the Company which was absolutely required before economical and profitable results could be obtained from its business. Messrs. John Marshall (Sunderland), John North (Leeds), and Edward Reynolds (Sheffield) were then appointed Directors.

ELMORE'S GERMAN AND AUSTRO-HUNGARIAN METAL COMPANY (LIMITED).—It is stated that Mr. Rock, owing to continued ill-health, has resigned his seat on the Board of this Company, his place being taken by Mr. John Heel, of the firm of Bloor and Heel, of Snow-hill, E.C.

KENSINGTON AND KNIGHTSBRIDGE ELECTRIC LIGHTING COMPANY (LIMITED).—A dividend for the half-year ending June 30th on the Six Per Cent. First Preference Shares of this Company will be paid on and after the 13th inst.

LIVERPOOL ELECTRIC SUPPLY COMPANY (LIMITED).—It will be noticed from our share list that the stock of this Company is now all fully paid.

NATIONAL TELEPHONE COMPANY (LIMITED).—This Company announce a scheme of conversion and redemption of £1,000,000 Four and a-Half per Cent. Debenture Stock by the issue of £1,100,000 Three and a-Half per Cent. Debenture Stock, forming part of a total amount of such stock limited to £2,000,000. Holders of the Four and a-Half per Cent. Debenture stock are notified that unless presented for conversion under the present scheme, their stock will cease to bear interest and will be redeemed on December 31st next. Existing Four and a-Half per Cent. Debenture-holders will receive allotment in full at the rate of £110 of the new stock for every £100 of the old stock, and 6s. 6d. in cash (less tax) upon allotment, being the difference between the £110 stock of 3½ per cent. and the £100 Four and a-Half per Cent. Cash subscriptions for the remaining Three and a-Half per Cent. Stock will be received at par. The new Three and a-Half per Cent. Stock will constitute a first charge on the entire undertaking and property of the Company. The list for subscriptions will be closed at 4 p.m. on Wednesday, the 11th inst. The list for cash subscriptions opened on Saturday last and closed on Tuesday.

ST. JAMES'S AND PALL MALL ELECTRIC LIGHT COMPANY (LIMITED).—The Directors announce an interim dividend for the half-year ended June 30th at the rate of 7 per cent. per annum on the Preference shares, and at the rate of 4 per cent. per annum on the Ordinary shares.

WEST AFRICAN TELEGRAPH COMPANY (LIMITED).—Notice is given of the drawing of 116 Five per Cent. Mortgage Debentures of £100 each in this Company. The debentures will be paid off at par on September 1st next at the National Bank of Scotland, Nicholas-lane, Lombard-street, E.C.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended June 29th (after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited), were £2,370.

CRICKET.—EASTERN TELEGRAPH COMPANY—HEAD OFFICE *v.* COMPANY'S SHIPS.—A match was played on Saturday last on the West London Cricket Ground between teams representing the head office staff and the officers of the Company's ships now in London, resulting in a victory for head office by 43 runs.

Scores:—Head Office: H. J. Burke, b Bonitto, 38; W. M'Intosh, b Bonitto, 1; T. J. Palmer, b Drake, 13; G. C. Jack, c Denton, b Bonitto, 19; J. G. Macmillan, b Bonitto, 46; A. G. Macmillan, lbw, b Bonitto, 7; A. R. Hardie, b Bonitto, 4; P. G. Gale, not out, 39; T. Richardson, c Bonitto, b Denton, 5; J. Grigor, c Denton, b Bonitto, 1; S. Wells, b Bonitto, 1; extras, 8—total, 182.

Company's Ships: F. B. Miall, c Gale, b Macmillan, jun., 11; E. Lambert, b Hardie, 9; C. Allum, b Macmillan, jun., 13; A. Denton, b Macmillan, jun. 11; L. Drake, b Macmillan, jun., 21; Denton, c and b Hardie, 6; Capt. Pattison, c M'Intosh, b Hardie, 34; A. V. Bonitto, b Macmillan, jun., 9; V. F. Sparks, b Mmacillan, jun., 4; C. Guessant, b Macmillan, jun., 0; G. Pattison, not out, 6; extras, 15—total, 139.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, June 27.		Price Wednesday, July 4.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending July 4.	
			TELEGRAPHS.					£ s. d.		Highest	Lowest
£1,012,880	Stock	9 0	Anglo-American	37	40	38	41	6 4 0	Jan., Apr., July, Oct.	39½	..
£2,933,560	Stock	18 0	Do. Preferred	70	72	72	74	6 10 0	" "	77	71
£2,933,560	Stock	5/0	Do. Deferred	6½	6¾	6¾	7		.. ..	7 1/16	6¾
£184,500	100	4%	African Direct Teleg. 4% Deb. (Reg. & Bearer) xd	102	106	100	103	3 17 8	January and July	..	
130,000	£10	8/0	Brazilian Submarine xd	12	12½	12	12½	5 4 0	Mar., June, Oct., Dec.	12¾	12 3/16
£18,700	£100	5%	Do. 5 per Cent. Bonds	101	104	101	104	4 16 2	January and July	..	.
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906) xd	109	113	107	111	3 16 11	June and December		
10,000,000	$100	$1¼	Commercial Cable Capital Stock	139	143	139	143	4 17 11	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	12	13	12	13	6 3 1	February and August	..	–
6,000	10	10%	Do. Preference 10 per Cent.	18½	19½	18½	19½	5 2 7	" "	..	..
12,931	5	1/7½	Direct Spanish (fully paid)	4	4½	4	4½	4 8 11	April and October	.	..
6,000	5	10%	Do. Preference 10 per Cent.	9	9½	9	9½	5 5 3	" "	..	
60,710	20	2/0	Direct United States Cable, 1877	8	9	8½	9½	6 6 4	Jan., Apr., July, Oct.	9½	9
400,000	10	2/6	Eastern	15	15½	15	15½	4 5 3	" "	15½	15 1/16
70,000	10	6%	Do. 6 per Cent. Preference	15¾	16¼	15¾	16¼	3 13 10	" "	15 13/16	..
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	113	116	113	116	3 9 0	May and November	115	114
£102,100	100	5%	Do. 5 per Cent. Debentures, 1899	107	110	107	110	4 10 11	February & August	..	–
250,000	10	6/6	Eastern Extension	15½	15⅝	15½	15½	4 10 0	Jan., Apr., July, Oct.	15 7/16	15 5/16
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	114	118	114	118	3 7 10	February & August	–	..
£62,700	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900 xd	105	108	103	106	3 17 3	January and July	–	..
£95,100	100	5%	Eastern and S. African 5 p. Cent. Mor. Deb., 1900 xd	105	108	103	106	3 17 3	" "	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures, 1909 (regd.)	105	108	105	108	3 14 1	February & August	..	–
£200,000	£25	4%	Do. 4% Mauritius Sub. Debs.	107%	110%	107%	110%	3 12 9	May and November		–
180,227	10	2/6	Globe Telegraph and Trust	8⅛	8¾	8½	8½	4 14 0	Jan., Apr., July, Oct.	8½	8 7/16
180,042	10	6%	Do. 6 per Cent. Preference	15	15½	15½	15¾	3 18 0	" "	15⅝	15 7/16
150,000	10	5 0	Great Northern xd	21	21½	20½	21	4 0 0	Jan., April, and July	21	20½
£190,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	105	108	105	108	4 12 7	March & September	..	–
17,000	25	37/6	Indo-European	43	45	43	45	5 11 1	May and November	.	..
37,548	10	5/0	London Platino-Brazilian	5	7	5	7	..	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	107	110	107	110	5 9 1	March & September	..	–
£100,000	£100	4%	Pacific European Tel. 4% Guar. Debs. "Red" 1942 xd	103	103	101	104	3 16 11	.	–	..
11,839	8	4/0	Reuter's	5	6	5	6	..	April and October	..	..
3,381	£100 Cert.	35/0	Submarine Cables Trust 6 per Cent.	108	113	110	115	5 4 4	" "	..	..
15,609	10	5/0	West African Telegraph	3	5	3	5	..	January and July	..	..
£249,900	100	5%	Do. 5 per Cent. Debentures	102	105	102	105	4 15 3	March & September	..	..
30,000	10	2/0	West Coast of America	2½	3	2½	3	..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902 xd	100	105	96	101	7 18 5	June and December	..	..
88,321	10	9d.	West India and Panama	1½	1⅝	1	1½	..	..	1 7/16	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10	10½	10	10½	5 14 3	May and November	10½	10
4,669	10	6%	Do. 6 per Cent. 2nd Preference	9	10	9	10	6 0 0	" "	..	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917 xd	109	112	107	110	4 5 7	June and December	..	–
64,242	15	7/6	Western and Brazilian	6½	7	6½	7	..	May and November	7	6 7/16
33,129	7½	7/6	Do. 5 per Cent. Cumulative Preferred	5½	6½	5½	6½	..	..	..	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	2	2½	1¾	2½	.	..	2	..
£171,900	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	107	110	107	110	5 8 9	February & August	–	..
£214,800	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	107	110	107	110	5 8 9	" "	..	..
$1,211,000	$1,000	7%	Western Union 7% 1st Mort. (Building) Bonds	111	115	115	120	5 16 8	May and November	115	113½
£166,900	£100	6%	Do. 6 per Cent. Sterling Bonds	100	104	100	104	5 15 5	March & September	103¼	101½
			TELEPHONES.								
44,000	5	10/0	Chili Telephone (fully paid)	1½	2½	1½	2½	..	..	..	..
224,850	10/0	2½d.	Consolidated Telephone Const. & Maintenance	1/16	3/16	1/16	3/16	..	May and November	..	..
171,504	£1	6d.	Oriental Telephone and Electric (fully paid)	⅜	⅝	⅜	⅝	..	Yearly	..	..
484,597	5	2/6	National	4¾	5¼	4¾	5¼	4 17 7	June and December	5 1/16	4¾
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	15	16	15	16	3 15 0	" "	..	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	14½	15½	14½	15½	3 17 5	" "	15	..
119,234	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	5⅛	5⅜	5⅛	5⅜	4 5 1	..	5⅜	5⅜
1,000,000	Stock	4½%	Do. Debenture Stock, 4½% xd	112	115	109	112	4 10 0	January and July	..	..
58,000	5	1/0	United River Plate	1½	2	1½	2	–	" "	..	–
£146,733	Stock	5%	Do. 5 per Cent. Debenture Stock xd	90	100	90	100	5 0 0	" "	..	–
			ELECTRICITY SUPPLY COMPANIES.								
40,000	£10	..	City of London Electric Lighting (fully paid)	12½	13½	12½	13½	..	..	13½	12¾
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	13¾	14¼	13¾	14¼	4 4 3	..	14¼	14
19,900	£5	..	Electricity Supply Co. for Spain	..		..		..	–	..	–
£30,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	4½	5½	4½	5½	–	..	..	..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900 xd	–		127	130	..	..	..	–
8,322	£5	..	House-to-House Electric	..		–		..	..	..	–
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	..		..		–	..	..	–
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..		..		–	January and July	..	–
45,000	£5	2/6	Liverpool Electric Supply (fully paid)	6¼	6¾	6¼	6½	–	..	..	–
111,000	5	..	London Electric Supply	¾	⅞	..		–	..	..	–
49,900	£10	5/0	Metropolitan Electric Supply (fully paid)	8½	9	8½	9	2 15 7	..	8¾	8½
£100,000	Stock	5%	Do. 5% Debs. (Bonds of £10, £20, and £40)	108	111	108	111	4 10 1	June and December	..	..
6,452	£10	..	Notting Hill Electric	4½	5½	4½	5½	.		–	–
19,980	£5	4/6	St. James and Pall Mall	7	7½	7	7½	.	..	..	–
20,000	£5	7%	Do. 7 per Cent. Preference	8½	8¾	8½	9	3 17 9	..	8¾	8¾
59,900	5	2/6	Westminster Electric Supply (fully paid)	6¼	6¾	6¼	6¾	2 19 3	–	6¾	6¾
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
90,000		1/6	Brush Electrical Engineering	2¾	3	2¾	3	6 0 0	..	3	..
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	2½	2⅝	2½	2⅝	5 1 1		2 9/16	2½
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	109	112	109	112	4 0 4	March & September	..	–
20,000	5	2/6	Crompton and Co., 7 per Cent. Cumulative Pref.	2¾	3¼	2¾	3¼	–	January and July	..	..
12,139	5	..	Edison and Swan United					..	..	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	–		–		..	..	–	..
120,000	2	..	Electric Construction	¾	⅞	¾	⅞	..	..	–	–
12,845	2	..	Do. 7 per Cent. Cumulative Pref.	1½	1¾	1½	1¾	..	–	–	–
91,195	2	10/0	Elmore's Patent Copper Depositing	1	1¼	1¼	1¾	..	–	..	1½
20,000	5	..	Fowler-Waring Cables (fully paid)	½	1	½	1	..	–	1 1/16	–
50,000	10	15/0	India Rubber, Gutta Percha, &c., Works	23½	24½	23½	24½	5 2 9	February & August	24½	23½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103	105	105	106	4 5 0	March & September	..	–
15,995	£10	6/4	International Okonite Ordinary	..		..		–		–	–
16,000	£10	..	Do. 8 per Cent. Preference	–		–		..	December and June	–	–
20,000	9	.	Manchester Edison-Swan "A" (£1 5s. paid)	–	½	½	½	..	..	–	..
78,949	5	3/6	Swan United (£3 10s. paid)	2	2½	..		..	May and November	..	..
37,350	12	36/0	Telegraph Construction and Maintenance	40	42	40	42	5 14 8	March and July	..	..
£150,000	100	5%	Do. 5 per Cent. Bonds xd	104	107	102	105	4 13 6	January and July	..	–
37,514	£5	–	Woodhouse and Rawson Ordinary (£3 15s. paid)	–		–		..	..	–	–
41,098	£5	–	Do. Preference (fully paid)	–		..		..	..	–	–
			RAILWAYS AND TRAMWAYS.								
£630,000	Stock	½%	City and South London Railway	36	38	36	38	1 16 2	May and November	36½	–
£67,130	Stock	4%	Do. 4% Perpetual Debenture	119	121	119	121	3 6 2	May and November	..	..
7,000	10	5%	Do. 5% Perpetual Preference	12½	13	12½	13	3 16 11	..	..	..
37,500	£10	1%	Liverpool Overhead Railway	8 3/16	8 5/16	8¼	8½	..	..	8½	8 5/16
6,29	10	5%	Do. 5% Preference	12¾	13½	12¾	13½	3 16 2	..	13	12¾
£125,000	Stock	4%	Do. 4% Debenture	112	114	110	112	3 11 5	January and July	–	..

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THE ELECTRICIAN:

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NOTES.

On Monday *The Times* gave publicity to some rather unnecessary queries addressed to the Postmaster-General by Mr. Henniker Heaton, M.P. If the member for Canterbury had taken the trouble to obtain the copy of the National Telephone Company's licence he would have been able to secure all the information he wanted without wasting the time of the Postmaster-General and looming large in the public eye in the columns of the newspapers. However, it is some satisfaction to know that the Post Office has an opinion in matters telephonic, and that opinion a decidedly definite one. According to the Post Office reading of the National Telephone Company's licence the right of the National Telephone Company to carry on telephone exchange business will absolutely cease and determine on the termination of the licence in December, 1911; and all they will have to sell will be their plant, and even this the Government will be under no obligation to buy. With this view, any other than which is inconceivable, so clearly stated in 1894, the shareholders of the Company cannot in 1911 raise the cry of confiscation, when their property is bought up at a knock-down price by the State. The general policy of allowing private capitalists to flourish exceeding well for a short time, on the condition that they consent to be swallowed up afterwards with or without a murmur, is not indeed one which is calculated to encourage thrift, genuine private enterprise or good service; but if the terms of such contracts are explicitly stated and kept well before the public, there really can be no ground for accusations of unfair treatment.

The London County Council and the promoters of the proposed electric railway to Epping Forest are to be congratulated upon having hit on a timely compromise, the full terms of which will be found in another column, as regards what appeared to be an irreconcilable difference of opinion as to the running of workmen's trains. Ample, cheap, and rapid communication between the business centres of this great city and its suburbs is, it is generally agreed, the most certain way of preventing that overcrowding which all deplore; and the Greathead tube combined with the electric train would appear to be the combination above all others that is likely to secure these *desiderata*. But unless our municipality undertakes to build and run these lines at the expense of the ratepayer, which the gods forbid, it is mere midsummer-madness to impose such onerous conditions upon capital that even company-mongers, who are notoriously over-sanguine, refuse to accept them. Half a loaf is better than none, and workmen, if they are constituted like other men, which we are given to understand is still the case, will probably prefer to be temporarily charged the not extravagant sum of 4d. for an eighteen-mile ride rather than go without a ride at all until the capitalist has been disciplined into taking them nine miles for one penny. Of course it is quite right and proper that someone should look after the public interest and see to it that excessive profit is not made out of the transit necessities of the workers of the metropolis; between the extremes of *laissez-faire*, however, and pedantic obstinacy, there is a mean which is in all senses of the word golden.

Anyone who knows murky Manchester will be a little astonished to find that the reason assigned by the Gas Committee of that city for the serious reduction in the consumption of gas during the past year is the "unusually bright weather during the greater part of the year, and the almost entire absence of fogs during the winter months." We fancy we have heard this several times before. It is, however, comforting to find the confession that "the extended use of the electric light" has contributed something towards this result. In Manchester the gas and electric light interests are hand-in-glove, being controlled by the Corporation; but, in some other places, their rivalry has led gas companies to accept any sort of explanation of the falling-off in gas consumption rather than admit that the rival luminant could have produced one iota of effect.

The Directors of the Morecambe Electric Light and Power Company have, it is stated, announced an advance in their charges for energy as follows:—For 8-candle lamps, from 10s. to 12s. per annum; for 16-candle lamps, from £1 to £1. 0s. 4d.; and for 32-candle lamps, from £2 to £2. 8s. per annum. The reason officially given for this advance is said to be that "the excessive and unjustified use of the light by many consumers, combined with the cost of production, has compelled the Directors to adopt this course to insure an adequate return on the shareholders' capital." Is it possible that the Directors expect, by such a course as this, to reduce the "excessive and unjustified use of the light"? If so, we fear they will be disappointed. They are but experiencing one of the inevitable results of a combination of the "fixed rental" system with human nature as it exists in the present year of grace. Economy at the lamps will only occur when the consumer, unregenerate man that he is, sees it to be to his

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advantage. An increase in the fixed rental will only lead him, prompted by his old Adam, to leave the current on longer than before. Salvation to the supply company lies only in the adoption of a meter tariff.

THE large-scale example of Dr. LODGE's "coherer" experiment, described by Prof. ELIHU THOMSON in our correspondence columns this week, is very interesting. To perform this experiment you take a thunderstorm, some Smee cells, bad contacts, and a plating bath. The bad contacts offer a considerable resistance, necessitating an excess of battery power; all goes well until you turn on the thunderstorm, when the bad contacts break down, the cells boil, and the work in the bath is ruined. Prof. THOMSON says that "the secret came out" on an inspection of the connections; but it is not every one who could recognise that under these circumstances a flash of lightning would cause coherence of badly-conducting surfaces. Prof. THOMSON remarks that we have practically little or no information about the waves which are propagated during thunderstorms. It seems probable, from the great variety of flashes which were visible during the storm on Friday last, that the complete study of such waves would be very difficult.

THE cathode rays about whose interesting peculiarities Dr. P. LENARD has recently told us so much, have not had to wait long before a more or less practical application has been made of their properties. In a communication to the Académie des Sciences last week M. ALBERT HESS proposes to make use of these rays for the purpose of obtaining a sort of inertia-less Ewing curve-tracer. M. HESS's idea is to allow cathode rays to fall upon a rapidly-moving photographic film, and to place the whole "observing space," as Dr. LENARD calls it, within the variable magnetic field to be investigated. The curve obtained would not thus be in any way distorted by the inertia of moving parts, and there need not, therefore, it would seem, be any limit to the frequency of the magnetic field. An absolutely inertia-less index pointer is a desideratum in many other instruments than the one proposed; and it is possible that if a cathode beam turns out to be a successful pointer in this latter instrument, we may soon see a large quantity of other refined research apparatus similarly modified.

EXACTLY what the legal liability of a newspaper may be when it hazards a comment on a lawsuit in the state of suspended animation in which the action Brasyer *v.* Harness and Another now finds itself, we neither know nor propose to put to the test. It is permissible, however, to call attention to Mr. Justice CHARLES's definition of the "note of quackery." According to the learned Judge, a medical quack is one who professes that a single remedy will cure everything. The dictionary definition is a comparatively simple affair, and does not, it would seem, contain such serious implications as the judicial dictum. WEBSTER boldly labels a quack as one who "boastfully pretends to skill or knowledge of any kind not possessed." Should Mr. Justice CHARLES's phrase prevail over this very unmistakable indication, we are afraid the "note of quackery" will be struck by those innocent individuals who so persistently in season and out of season advocate "*tout par l'électricité*," and who will never be satisfied until everything, from express engines to curling tongs, is electrical.

Congress of Learned Societies.—The thirty-third Congrès des Sociétés Savantes is fixed for Tuesday, April 16, 1895.

French Association for the Advancement of Science.—This Association will hold its meeting at Caen from August 9th to 15th.

The Latest Transatlantic Cable.—The "Britannia" has arrived at Hearts Content, Newfoundland, with 190 miles of cable for the new Anglo-American cable.

Cable Interruptions:

	Date of Interruption.
Bissao-Bolama	Nov. 24th, 1893.
Sierra Leone-Accra	July 2nd, 1894.

Relative Resistances.—Prof. Kohlrausch, it seems, has made experiments with the purest water which he could obtain, and finds that a column of one inch has a resistance equal to a copper wire of the same cross-section passing twenty-five thousand times around the earth.

Electric Traction in Algeria.—The question of electric traction is now being considered at Algiers. It is proposed, in the first instance, to convert the horse-tramway between the Plateau Saulieu and the Hôpital du Dey, a distance of about 4½ kilometres, into an electric line on the overhead conductor system.

Magnetic Disturbances.—The report of the Kew Committee for the year 1893 states that as regards magnetic disturbances no very large movements were registered during the year. The principal oscillations that were recorded took place on the following days:—February 4-5, March 14-15, April 26, June 18-19, July 16, August 6-7 and 18, November 1-2.

Electrical Engineering in Switzerland.—Permission was granted by the Swiss Government authorities during last year for the establishment of 34 electric lighting plants (26 on the continuous-current system, and 8 on the alternate-current), 5 electric power transmission plants, 7 combined electric lighting and power transmission plants, and 1 electric tramway.

Municipal Electric Lighting in Berlin.—An important matter is just now under consideration in Berlin, nothing more nor less than the municipalisation of the electric lighting undertakings, a proposal having been brought forward at a recent meeting of the Municipal Council that the latter should acquire and carry on the various electric lighting stations of the Berlin Electricitatswerke.

Silver Jubilee of Eastern Telegraphy.—In connection with the 25th anniversary of the Eastern and Eastern Extension Companies, the employés of these Companies will present Sir John Pender with a massive silver centrepiece of emblematical design, in recognition of the services he has rendered to submarine telegraphy, and through it to the political, commercial and social life of the world, as well as of the warm interest he has always taken in the welfare of the staff.

Oil Insulation and Circulation.—The transformers at the power transmission plant of the Oerlikon Electrical Works are interesting from the fact of their having an oil circulation. Taking the average load on each transformer as 170 kilowatts, and allowing a loss in conversion of 2 per cent., some 3·4 kilowatts is being lost, appearing as heat. In order to dissipate this heat, the oil is circulated through serpentine tubes immersed in a tank through which there is a constant flow of cold water. The circulation is effected by means of a pump.

Postal Telegraph Clerks' Grievances.—Mr. Pickersgill, M.P., presided over a large meeting of the London telegraph staff, held in the Memorial Hall, Farringdon-street, on Wednesday evening, at which resolutions were passed unanimously protesting against the refusal of the Postmaster-General to redress the grievances of the postal telegraph service, and renewing their demand for a Parliamentary inquiry into the administration of the Post Office telegraphs. Telegrams of approval and encouragement were read to the meeting from the clerks in all the large offices throughout the kingdom. The speakers included, besides the chairman, Mr. W. Saunders, M.P.

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Telegraph Messengers' Institute.—At the City Temple Schools last Thursday week the annual meeting and distribution of prizes of the East Central Postal District Telegraph Messengers' Institute was held. The number of members of the Institute was now estimated at about 500, and there is every prospect of a continued increase. The evening classes have been held on 55 evenings, 220 messengers joined, and the session showed a total attendance of 8,215. Mr. Spencer Walpole congratulated them on the Treasury having provided them with new premises, and expressed sympathy with the Institute. The report was adopted, and the prizes were distributed by Mrs. Sanderson.

Short Cuts to Knowledge.—In an interesting leading article on the dangers attending the increasing use of "short cuts" to knowledge by engineers, our esteemed contemporary, the *Engineer*, thus tersely expresses its views: "From a physical point of view, 'short cuts' proverbially lead the unwary and inexperienced traveller astray, land him often at a great distance from his wished-for goal, and prove, paradoxically as it may sound, the longest way to his destination. He has no alternative but to retrace his steps, and toilsome and arduous as this frequently is, it is but light labour in comparison with the strenuous efforts which attend a similar mental retrogression which becomes a task few can accomplish at any time, and after a certain age none."

Obituary.—We learn with regret of the decease in Berlin on 6th inst. of Imperial Privy Postal-Councillor Carl Grawinkel, whose name is well known in all matters relating to the German Telegraph Department. Originally stationed in Frankfort as telegraph engineer in that city, he was called some ten years ago to Berlin to become Dr. von Stephan's right-hand man in technical matters. He took a prominent part in the development of the telephone, and had several times visited London in connection with cable affairs. He was active in the telegraphic section of the Frankfort Exhibition in 1891. He was author of a German work on the Telephone, which ran through several editions, and had translated into German Prof. Silvanus Thompson's works on "Dynamo-electric Machinery" and on "The Electro-magnet." He was 49 years of age.

Electric Power for Gold Mining Purposes.—According to the Johannesburg correspondent of the *Glasgow Herald*, Mr. E. Lippert has formulated a scheme which contemplates the erection of an electric power station at Brakpan to deliver 2,000 effective horse-power at the mines. It is not intended at first to furnish battery power, but to supply motors for electric lighting and for various odds and ends both above and below ground. As the aggregate power used on the Rand is over 20,000 H.P., it will be seen that the scheme, by which it is hoped working costs will be considerably reduced, has not been formulated too soon. The firm of Siemens and Halske, of Berlin, are willing, it is reported, to lay down the plant and hand it over as a going concern upon receipt of 250,000 shares in a company with a nominal capital of £300,000.

Thunderstorms.—Several severe thunderstorms have occurred during the past week, and much damage to life and property has resulted. At Lowestoft the lightning struck the mast of a longshore fishing boat, killing two men and cutting a round hole in the side of the boat. At Glasgow a house was set on fire, it is said, though the ignition of gas by a lightning flash; and at Preston a servant girl was severely burned by the flames from a can of petroleum which had been set on fire in a similar manner. Even the stumpiness of a cricket wicket did not prevent the lightning splintering it to fragments, at the same town. The wicket was set up in the middle of a cricket ground, when the lightning struck it. Cattle, mostly under trees, have been killed and mutilated by lightning at a great number of places. The lightning struck a chimney at East Chiltington and cleaned off all the soot, making the brickwork look quite new.

Non-Magnetisable Watches.—The results of some interesting experiments, made by Capt. Wharton, the Hydrographer of the Admiralty, on the effect of powerful magnetic fields upon the going rate of non-magnetisable watches, have just reached us. The watches were of the well-known patterns, manufactured by Messrs. Smith and Son. They were placed at ½in. distance from the pole of a dynamo, which at the time was generating a current of 400 amperes at 80 volts, and which had a stray field which could easily be detected at 70ft. from the poles. At the end of a ten days' trial under these severe conditions it was found, curiously enough, that the watches kept better time than when they were not in any unusual magnetic field. The daily error during the ten days' trial never exceeded one second, and on four occasions was less than could be determined; while the daily error of the same watch, during a six days' trial under ordinary conditions, was never less than half a second, and attained a maximum of four seconds. In a similar trial of a different pattern of watch the results were practically the same.

Private Electric Lighting.—Electric engineers are often asked by the owners of large establishments to advise them whether it will be more economical to lay down their own lighting plant or to buy energy from a supply company. This, opines *Engineering*, is a difficult question to answer, seeing that the reply must be founded upon assumptions, many of which are more or less hypothetical. For example, the apparent cost of working a private installation depends greatly on the system of book-keeping adopted. A pedantic accountant will charge against the account every possible item he can think of. Not only will he include labour, coal, stores, interest, depreciation, rent and taxes, but also a share of his own salary, and of that of clerks, managers, foremen and watchman, and a proportion of the fire insurance. Another man will not only ignore these latter small matters, but he will also take no account of rent and taxes, on the ground that these have not been increased, nor the facilities of the establishment diminished, by the erection of the plant in an odd corner of the basement. Quite a sensible difference in the apparent cost per unit can be made by variations in the method of book-keeping.

The Pacific Cable.—At the Intercolonial Conference recently held at Ottawa, a resolution was adopted asking the Canadian Government, after the rising of the Conference, to make all necessary inquiries, and generally to take steps expedient, to ascertain the cost of a Pacific cable and promote the establishment of the undertaking in accordance with the views expressed by the Conference.——According to a Dalziel telegram, dated Montreal, July 10th, Mr. Alexander Siemens has submitted an offer to the Government of the Dominion of Canada for laying a cable under the Pacific ocean from Victoria, British Columbia, to Sydney, New South Wales. He undertakes to complete the construction within three years. His offer is now being considered. Reference was also made to this subject by Sir John Pender at the general meeting of the Eastern Telegraph Company, which was held yesterday, and is reported in our columns.——In reply to Sir G. Baden-Powell, Sir U. Kay-Shuttleworth stated in the House of Commons on Tuesday evening that soundings were taken by Her Majesty's ship "Egeria" during a period of about two and a-half years from 1888 to 1890 between the North Cape of New Zealand and the Phœnix Islands, about 200 miles south of the Equator; and the positions of several islands on that line were fixed and some were surveyed with a view to determining their suitability for cable stations. This was done in the ordinary course of hydrographic survey, in accordance with communications from the Admiralty to the Colonial Office. The distance between the extreme points of the area examined was over 2,000 miles.

Fatal Accident to a Voltmeter Boy.—A sad accident resulting in the death of a boy occurred at the British Insulated Wire Company's factory at Prescot last Friday. The youth, who was 19 years of age, was employed in the dynamo room as voltmeter boy and oiler, the station being in charge of a man who was superintending that and other machinery in the factory. The boy was alone in the engine-room at the time the accident occurred, and therefore the exact manner in which he met his death will never be known. He was seen alive at 9:20 a.m. in the engine-room and was found dead at 9:30 by one of the assistant electricians. The pressure at the time was 2,000 volts alternating, and on examination it was found that a voltmeter wire, which was well inside the frame and attached to one of the armature connections, had been forcibly broken at the soldered joint, and the end thus dragged away showed evident signs of burning. From the nature of the burns on

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the boy's hands, and from the fact that he had a mark on the back of his neck, it is believed that he was leaning against a rail which runs parallel with the driving ropes, and stops short close up to the bed of the machine. While leaning against this rail he must either have slipped or fainted, and dropping between the end of the rail and the machine, his neck coming in contact with the ropes. While in this position he clutched at the armature of the machine, dragging out the voltmeter wire in question, and breaking it at the joint, so getting killed. The verdict at the inquest was "Accidental Death," and there was no suggestion of any negligence on the part of anyone concerned.

The Production of Hail.—A very interesting theory of the genesis, structure, and the metamorphosis of hail has recently been advanced by M. O. Marangoni. Heretofore the hailstone has been, to the popular mind, simply moisture that has been congealed in falling through strata of cold air; but its production is now shown to involve many processes. The hail cloud is first drawn out by the wind in a form of an horizontal tongue. It becomes rapidly evaporated, producing an intense cold. There are thus formed flakes of dry snow, which, by friction against the minute drops of water, become charged with negative electricity, and are then attracted by the positive electricity of the drops of water. The snowflakes behind the cloud—*i.e.*, to the windward—are covered with a layer of ice, at first dry and then moistened. Recent research has shown that they are at the same time charged with positive electricity, and are driven in an outward direction by the positive electricity of the rain drops. Being thus cooled below zero, they break through the cloudy stratum, and become charged anew with negative electricity, they are coated with a new snowy layer, and are again attracted by the cloud. Each hailstone, taking a wavy line, becomes enlarged by coating itself with alternate layers of opaque and transparent matter, and is ultimately thrown to the right or the left, occasioning thus the roaring noise which precedes the fall of hail, which then takes place in two parallel bands, separated from each other by a region of rain.

Oil Engine Trials at Cambridge.—The genuine and rapid progress which is being made by gas and oil engines was exemplified in the exhibits of these engines at the Royal Agricultural Society's Show at Cambridge recently. Most engineers have been awaiting with something akin to impatience the carrying-out of the careful scheme of oil engine trials which had been arranged, and are still anxious to hear the official results. It is some time since any independent trial of oil engines was made; and since then the older patterns have undergone considerable improvement, while many competitors have newly entered the field. There were 20 entries for the Cambridge examination, and the great majority put in an appearance. The judges had evidently an idea, remarks *Engineering*, that many of them had but little staying power, and that their labours might be lightened by putting a number of them out of court. Accordingly, they prescribed three days running at full load to commence with, the period being nominally 10 hours per day, but actually barely nine. During the whole of this period the engines were not to be opened up. so that the deposit (if any) might accumulate. If the judges had counted on a serious falling-off of numbers during this stage, they were disappointed, for only two engines failed to answer this test. These were the Root's engine of Clarke's Crank and Forge Company, and the "Capitaine" engine of Messrs. Tolch and Co., which we understand had not been previously tried with the prescribed oil—Russoline. This oil has a higher specific gravity and flashing point than the "tea rose" oil more generally used on account of its cheapness, and naturally an engine needs some adjustment in order to get the best results from it. At the end of the preliminary run of three days, during which, however, the brake load, revolutions, explosions, and oil consumption were regularly noted, came the more critical trials. These were a full-power trial of two hours, a half-power trial of two hours, and a light-running trial of four hours, during which all the data were carefully gathered.

Solar Disturbances and Terrestrial Magnetism.—In a Paper recently read before the Massachusetts Society of Arts, Mr. G. E. Hale remarks that the question as to the manner in which solar disturbances and terrestrial magnetic storms are related has long been under discussion, and its present condition is one of great uncertainty. The apparent existence of a twenty-seven-day period in the recurrence of magnetic perturbations is considered by some to indicate that disturbances in certain regions of the sun's disc—at the eastern limb or the central meridian, for instance—are alone capable of affecting the magnetic needle. To prove this it has been shown that the maxima of curves of magnetic intensity generally coincide with the appearance at the sun's central meridian of a spot or facula. Others have been no less successful in finding a spot or facula at the sun's eastern limb whenever an aurora is seen. The test whether these coincidences might not be due to chance, photographs of faculæ taken on 142 days in 1892 at the Kenwood Observatory were examined. It was found that for 1892 the probability that at any time one or more groups of faculæ would be on a given meridian of the sun was 0·93. Under such conditions it would be almost impossible for an aurora or magnetic storm to occur without the simultaneous existence of faculæ at either the central meridian or the eastern limb, and such coincidences must, therefore, be regarded as of doubtful importance. As for the *eruptions* photographed on the solar disc, that of July 15, 1892, was simultaneous with "slight trembling in the horizontal force magnet, which was the prelude to the violent storm which set in and lasted over the 16th and until midnight of the 17th." A similar though less important eruption shown on a spectroheliogram, taken June 20, 1892, was not accompanied by a disturbance of the magnets; but a series of small oscillations commenced one day later, and lasted until June 26th. Eruptions on January 26 and August 3 and 10, 1893, were without corresponding maxima on the magnetic curves. On August 6, 1893, there was a slight magnetic disturbance simultaneous with a small eruption.

Boiler Corrosion.—An abstract of a Paper from the German on "The Internal Rusting of Boiler Shells," has been published in the *Journal* of the Society of Chemical Industry. This report commences with an account of the physical and chemical phenomena which promote and cause the formation of rust upon iron. The internal rusting of boilers is dealt with under two headings, namely, when the boiler is in use and when it is standing idle. The causes of rusting are first considered, the most important being the introduction of air with the feed-water. By properly placing the feed-pipe—namely, so that the feed-water enters the boiler near the low-water level, and thus meets the hottest layers of water—the air is quickly expelled, and passes out of the boiler with the steam, unless pockets exist in which it can accumulate. Such pockets are sure to rust rapidly; and it is recommended that they should be covered internally with a protecting paint or filled up with cement, provided that they are not subjected to external heating. It is also recommended that the feeding should be completed before the withdrawal of steam ceases for the day, in order that the water left standing in the boiler overnight may be as free from air as possible. An efficient circulation is also a means of preventing rusting, as it hinders the formation of air bubbles on the shell, which, if they remain clinging to it, cause rusting. The author is of the opinion that faulty construction is more often the cause of internal rusting than unfavourable conditions of working, and summarises the means of preventing rusting as follows:—First, whilst the boiler is working—(1) Removing air from the feed-water before it enters the boiler. (2) Removing air from the water whilst in the boiler, and preventing its accumulation in pockets, &c. (3) Addition of chemicals to the feed-water. (4) Protective coatings applied to the inside of the shell. Second, whilst the boiler is standing idle—(1) Removing all moisture from the boiler, (*a*) by blowing it off whilst hot, (*b*) by producing an air current through it, (*c*) by placing hygroscopic bodies inside. (2) Direct protection of the shells, (*a*) by painting with tar, varnish, &c., (*b*) by covering with protective paints and such an alkaline coating as milk of lime. (3) Protecting the shells from varying temperatures by keeping the draught in the flues constant, and so as to prevent moisture alternately depositing and evaporating on the shell. (4) Protecting the shell by completely filling the boiler with water from which all air has been expelled.

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MOTIVE POWER AND GEARING.*

BY E. TREMLETT CARTER.

(*Continued from page 176.*)

Furnaces and Boilers.

Green's Economiser.—Of appliances for utilising the heat of the furnace gases between the temperature at which the gases leave the boiler and the lowest temperature at which it is economical to allow them to enter the chimney, none is so well-known or has so largely been adopted in electric power stations as that manufactured by Messrs. E. Green and Son (Limited). Fig. 17 shows a longitudinal section of Green's economiser, with its setting, for about 400 to 450 H.P.—*i.e.*, for about 10,000lb. of feed water per hour. The economiser consists of a number of vertical cast-iron pipes, connected at the top and bottom by cross horizontal pipes in such a way as to give a multitubular passage for the feed-water. The water enters at the bottom right-hand main, D, and leaves at the top left-hand main, the former feed main having a blow-off connection, and the latter being fitted with a safety valve and thermometer. The group of pipes is suspended in an expansion of the flue between the boiler dampers and the chimney smoke-chamber, and the floor of this expanded flue is hollowed out to form a soot chamber, into which the soot, which is continuously scraped from the pipes, may fall. Scrapers are maintained in continual motion up and down the outsides of the vertical pipes for the purpose of keeping their surfaces efficient. These scrapers are suspended by chains, which pass over a number of toothed wheels above the roof of the economiser flue, and these wheels are rotated by a number of worm gears fitted on a shaft, which is driven from some convenient shafting or by a small engine or motor which can be attached to the end of the gearing frame. The direction of motion of these worm gears is automatically reversed at each time that the scrapers reach the end of the pipes. One of the most effective arrangements of an economiser, relatively to the boilers, which the author has met with is that shown in Fig. 18. The boilers, B B, discharge their furnace gases into a main flue. This flue is so arranged that the gases, before they reach the chimney, may be passed through the entire economiser or through only one-half of it; or they may be shunted through a reserve flue straight to the chimney. The whole arrangement is compact, and carries the gases through but a short length of flue; while in cases where the boiler plant is required to be a long time on light loads the advantage of using only half the economiser is very great.

An economiser of this description should not be supplied with quite cold water, otherwise the pipes and bottom boxes become chilled and condensation of the vaporous gases ensues, thus causing a deposit of mixed soot and water to adhere to their outer surfaces, and this deposit hardens on the pipes and cannot be thoroughly removed by the scrapers. An even more important point, however, is the rapid corrosion which takes place, unless the feed water is slightly warmed before entering the apparatus. Moreover, a hot-feed into the economiser will prevent the pipes being choked with mineral deposits. The usual allowance of heating surface in a Green's economiser is four 10ft. pipes per ton of fuel burned per week; or, where the consumption of fuel is not easily predetermined, one pipe for every three I.H.P. gives about the same result. These data are based upon an assumed feed-temperature of 90°F., the lowest temperature at which it is advisable to feed the water into this type of economiser. The proportion of economiser surface to the useful surface of the boiler flues varies from 0·6 to 1·0. From the data supplied by Table XV., the saving in fuel by the use of an economiser may be estimated, as compared with the performance of the same boiler plant without the economiser.

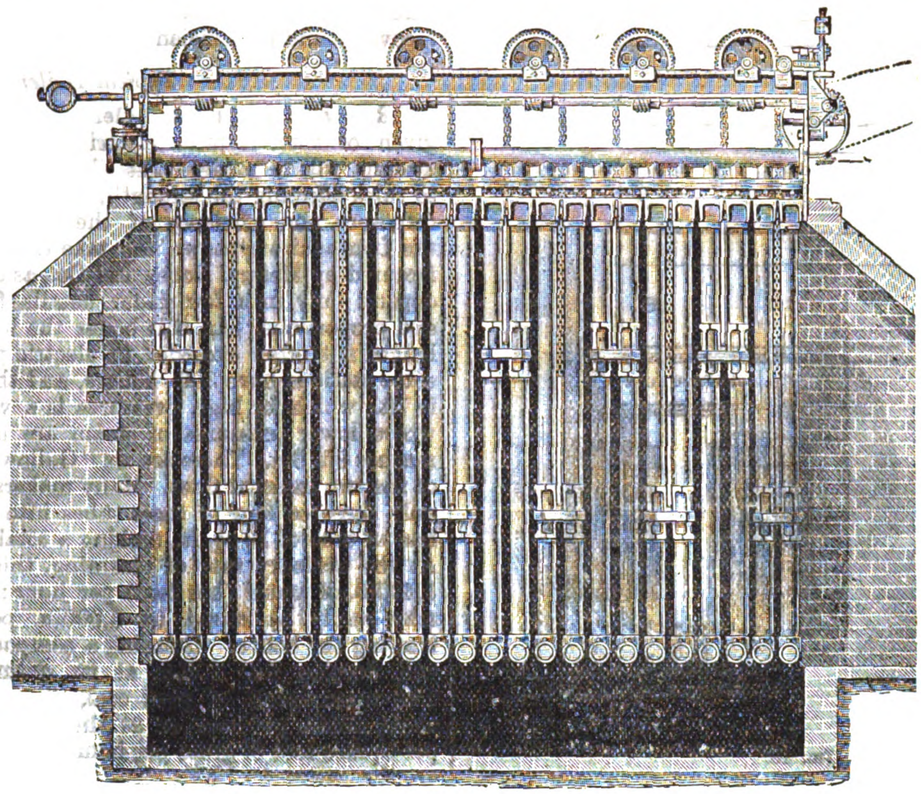

Fig. 17.

Table XV.—*Percentage saving in Fuel by heating Feed-water to Temperature of Evaporation.*

Temperature of water entering feed-heater. (Fah.)	Steam pressure in lb. per sq. in. above atmosphere, at which evaporation takes place in boiler.			
	80	100	150	200
	Percentage economy in fuel.			
32	24·7	25·8	28·0	29·6
50	23·2	24·3	26·4	28·2
100	19·0	20·1	22·2	24·0

* From a forthcoming work to be published by *The Electrician* Printing and Publishing Company. All rights are reserved.

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Feed Pumping.—The work done in pumping water into the boilers is by no means an insignificant item of the load on the engine or boiler plant. This work may be divided into two parts: (1) raising the cold water to the level of the boilers, and (2) forcing the water into the boilers against the back pressure of the steam. The sources of feed water have already been enumerated; and it will be seen that in some of these the water would require considerable work to be done in raising it to the feeding level. In many stations the cost of town water is so great that it is less expensive to pump water, both for boiler feed and for condensing purposes, from well borings, or to raise the dirty water of a neighbouring river up to a filter tank, whence it would descend to the boiler feed pumps. In non-condensing stations the exhaust steam cannot be recovered, and a continual draught has to be made upon the lifting pumps for feed water, in proportion to the total evaporation of the boiler plant; but in condensing stations most of the feed water circulates continuously between the boilers and the cooling pond or tanks, and has only to be supplemented by new water in proportion to the loss by evaporation and leakage.* A "feed make-up evaporator" is a

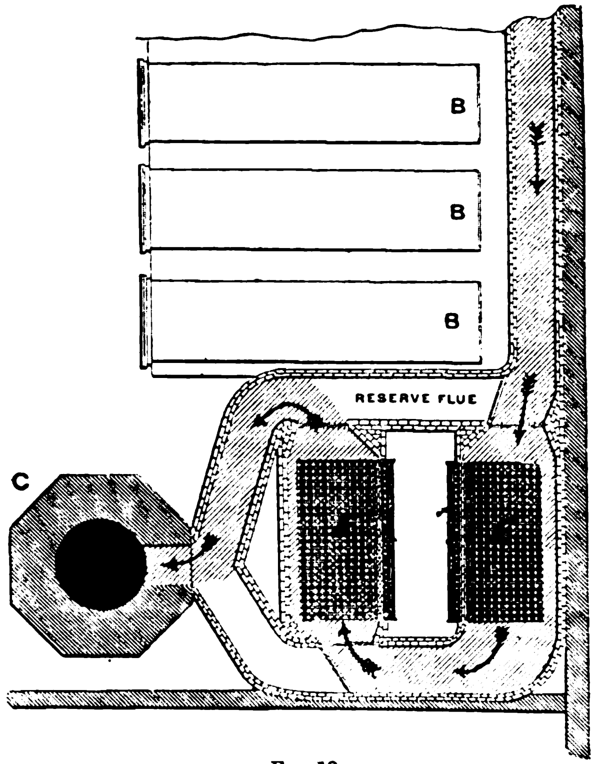

Fig. 18.

supplementary evaporator for supplying this additional water where surface condensers are used, the water from the source being unsuitable for direct feed into the boilers.

Whether the station is non-condensing or condensing will not directly affect the fact that work must be done in pumping the feed water into the boilers; although in the latter case, since less water will be required, less work will have to be done. Theoretically, the work may be estimated from the volume of water fed, in cubic ft., and the effective pressure of the steam; and, if Q is the number of cubic ft. fed per minute, and p the effective back pressure of the steam in lbs. per sq. in., the theoretical H.P. expended will be:—

$$\text{H.P.} = \frac{144\,Q\,p}{33{,}000} = 0.00436\,Q\,p \quad . \quad . \quad . \quad . \quad (83)$$

In practice, the effective H.P. is from ten to fifty per cent. greater than this, exclusive of power absorbed in the pump, owing to frictional losses and shocks. The allowance of effective H.P. must be still greater, because it will sometimes be necessary to feed the boilers much above the normal rate and because there is a certainty of the pumping machinery being sometimes under repair. Where there are two feed pumps, it is usual to provide that each one shall be capable of feeding the boilers at or slightly above the normal rate; where there are more, there should always be at least one as a reserve; or where there are two sets of boilers (as at some stations) each fed from a distinct set of feed pumps, there should be a reserve pump at each set. A portion of the reserve pumping apparatus often takes the shape of a live-steam injector.

* An exception occurs in the few cases where, as at the Portsmouth Corporation electric supply station, jet condensers are used with condensing water which is too foul to be fed into the boilers. In such cases all the heat of the exhaust, as well as all of the boiler water, must pass away with the water from the condensers. It is difficult to understand the circumstances which could lead an engineer to prefer or adopt such a system as this.

"Worthington" Steam Feed-Pump.—Direct-thrust steam feed-pumps, such as those manufactured by the Worthington Pumping Engine Company, are very largely used in electric power stations for feeding boilers. Direct-thrust cannot conveniently be combined with low steam consumption, owing to the difficulties in using the steam expansively; but the simplicity of construction and the consequent small liability to get out of order have led to the almost general adoption of this type of feed pump. Considerable saving in labour is effected by making the feeding plant automatic in its action. The exhaust steam from the feed pumps should be passed through the feed heaters, as thereby some of its heat is recovered and the efficiency of the pumping plant is increased.

Typical Boilers.

"Robey" Lancashire Boiler.—Some account will now be given of some typical electric power station boilers. No attempt will be made to describe the design of these in regard to rules affecting the strength, but only in regard to the performance and efficiency of the boilers. Commencing with the Lancashire type, we may take the "Robey" boiler, manufactured by Messrs. Robey and Co., as being an example which departs only in a few minor details from standard practice and proportions. In this boiler the length of shell is 28ft., a length not often exceeded in electric power stations, though some stations have 30ft. boilers, and the diameter of the shell is 7ft., which for high pressures is a very safe figure, though where lower pressures of steam are used the diameter often reaches 8ft. 6in. There are six "Galloway" cross tubes in each of the two internal flues. Many makers, however, prefer to fit only three or four of these tubes into each flue. Each grate has an area of 19 sq. ft., making a total grate area of 38 sq. ft. At the ordinary rate of steaming, this boiler will evaporate 5,400lb. of water (hot feed) per hour; but the steaming rate may easily be raised to 6,000lb. per hour without distressing the boiler. Running a compound engine, this boiler will develop 240 I.H.P. at its ordinary rate of working. The consumption of good coal, at ordinary load, would be about 650lb. per hour, or at the rate of about 17lb. or 18lb. per square foot of grate per hour. The normal steam pressure on the gauge is 120lb. per square inch. The allowance of heating surface for this boiler is 750 sq. ft., which is somewhat under the usual allowance. The heating surface consists of 360 sq. ft. of internal flue surface, and 390 sq. ft., of external flue surface. The ratio of the heating surface to the grate area is practically 20. The normal evaporation per square foot of heating surface per hour is 7·2lb., which is a very high rate, and one which could only be obtained under normal conditions with well-heated feed water. When forced, this boiler will evaporate 8lb. of hot feed water per square foot per hour. After passing through the two internal flues, the furnace gases descend to the external flue directly below the boiler, passing to the front along this flue. At the front, they divide into two halves, and pass along two side flues. Again reaching the back of the boiler, the gases mingle and pass on to the economiser and chimney. Most makers of Lancashire boilers now adopt this mode of setting, in preference to the older plan of carrying the gases through the side flues before passing them through the bottom flue. The new plan has the advantage that better circulation is promoted, because hotter gases are brought into contact with the very bottom of the shell.

The feed water inlet-pipe is placed directly below the water line, the water entering at the front end of the boiler, through a feed stop-valve fixed to the front plate. The water traverses

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about 15ft. of inlet-pipe before dispersion; and with cold feed, or only moderately hot feed, this provides for the water becoming heated before it is dispersed into the boiler. Otherwise, the water might fall to the bottom of the shell and cause shrinkage through cooling the plates. Dispersion is produced by a perforated length of inlet-pipe. Where the feed-water is at the evaporating temperature on its entering the boiler, so great a length of inlet-pipe is not necessary, and feed may take place directly into the dispersion pipe. In such a case the inlet must be at the back of the boiler. The advantages of feeding just below the water line are: (1) that with cold or slightly warm feed a better circulation is promoted, and (2) that in any case the risk of the boiler becoming emptied and the crown of the furnace being exposed, by any mishap to the feed check valve, is removed. Boilers fed at the bottom of the shell have exploded through becoming emptied while under fire, the water having been forced by the steam pressure out of the shell *viâ* a defective check valve. In this connection, we may refer to the Hopkinson low-water safety valve, which is fitted on the boiler. In its usual form, this fitting gives warning both of too high a pressure of steam and of too low a water level. In some boilers, this fitting is arranged to open a communication between the boiler and the auxiliary feed connections.

Below the mounting for the steam stop valve is fitted a steam collecting pipe, consisting of a horizontal perforated cylinder supported on end brackets. The purpose of this collecting pipe is the separation of primed water from the steam. Where the connections of steam mains to the boilers are duplicated, it is sometimes the practice to have two separate mountings or stand-pipes, both connected to the same collecting pipe. More commonly, there is a single mounting connected to a steam drum or to a U-pipe with two stop valves.

The passage way for the furnace gases in this type of boiler is usually proportioned as follows:—

Position of flue.	Percentage of area of grate.
Air space in grate	33·0
Space over bridge	12·0
Internal flue between cross tubes	36·0
Bottom external flue	22·0
Side flues (each)	20·0
Side flues (total)	40·0

In the Lancashire boiler about 43 per cent. of the heating surface is usually contributed by the internal flues, 8·5 per cent. by the cross-tubes in these flues, and the remaining 54·5 per cent. by the external flues. The total heating surface varies directly as the product of the length into the diameter of the shell; the water capacity and steam space varying directly as the product of the length into the square of the diameter of the shell. Of the heating surface, only about 10 per cent. is exposed to direct radiation from the solid fuel on the grate; and even this proportion is not attained except by the use of long grates. It is of the utmost importance, therefore, that flame radiation shall be provided; in other words, this type of boiler is not adapted to the combustion of dry fuels, such as anthracite, Welsh coal or coke, but its performance and efficiency may be very high—as high as those of any other boiler—when suitably bituminous or flame-producing coal is burned on its grates.

(To be continued.)

ON IMPULSIVE CURRENT-RUSHES IN INDUCTIVE CIRCUITS.

BY ALFRED HAY, B.SC. (EDIN.)

(Continued from page 262.)

§ 11. Before dismissing the subject of current-rushes in circuits of constant permeability, it may be well to point out the effect on the current-rush of varying the periodicity. Referring once more to equation 3 of § 4, we see that if the value of t in the term $e^{\frac{-rt}{L}} \sin\theta$ on the right-hand side is considerable, this term becomes very small. Also, since $\tan\theta = Lp/r$, it follows that a lowering of the periodicity will have the effect of diminishing θ, and therefore also $\sin\theta$.

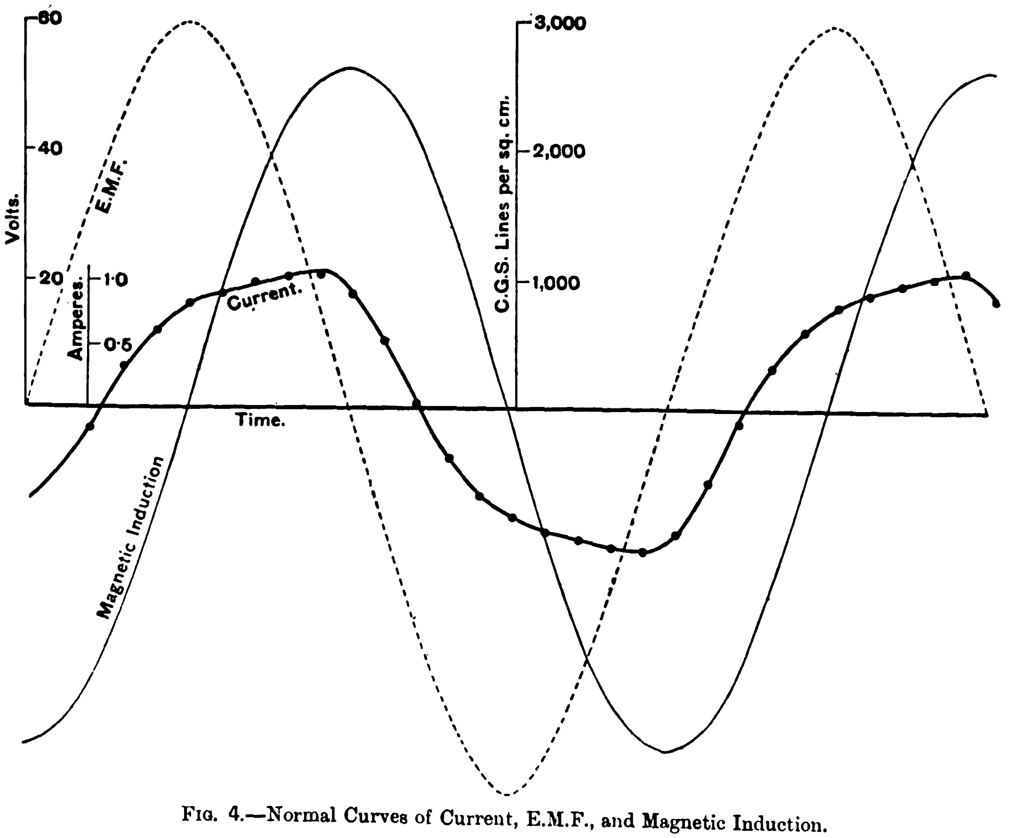

Fig. 4.—Normal Curves of Current, E.M.F., and Magnetic Induction.

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Now it is evident that with a lower periodicity, a wave, whether normal or abnormal, takes a longer time to rise to its crest. Hence, if the periodicity is lowered, the value of t corresponding to the crest of the wave is increased, and the

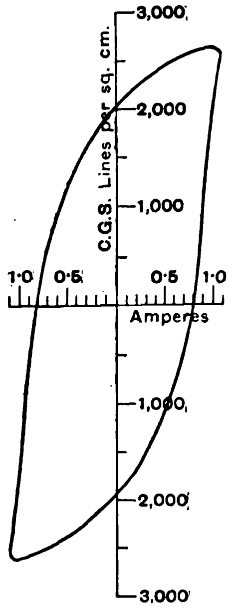

Fig. 5.—Normal Hysteresis Loop.

value of $\sin \theta$ is diminished. Both these causes will reduce the distortion of the waves. We thus have the result that *the current-rush increases with the periodicity.*

Experiments on Current-Rushes in Inductive Circuits containing Iron.

§ **12.** We have now to investigate the much more difficult problem of impulsive current-rushes in circuits whose inductance is not constant, and which are further complicated by

1. The phase of the E.M.F. at the instant of switching on; 2. The initial magnetic state of the iron, determined by the phase of the E.M.F. at the instant of breaking the circuit; 3. The normal maximum of magnetic induction at which the iron is worked.

§ **13.** The transformer used in the experiments described below was specially constructed for experimental purposes. The core was built up of 245 discs of annealed soft iron, each ·0123in. thick, having an external diameter of 8in. and an internal diameter of 5in. The mean length of the magnetic circuit was thus 51·9 cm., and its sectional area 29·2 sq. cm. The discs were insulated from each other by a coating of bitumen varnish. The winding consisted of three sets of coils, each wound with cotton-covered copper wire ·083in. diameter; we shall call these coils A, B and C respectively. Each coil was subdivided into 12 sections; every section of coil A contained 48 turns, so that the total number of turns in coil A amounted to $48 \times 12 = 576$. Coils B and C had eight turns in each section, giving $8 \times 12 = 96$ turns for each coil. The various sections of each coil could be connected up in different ways, and any section of any one coil coupled to any section of any other coil.

§ **14.** In order to compare the normal working condition of the transformer with the changes which take place during a rush, it became necessary to obtain the normal E.M.F. and current curves of the tranformer when working on open secondary circuit. These curves are given in Fig. 4. The periodicity was 122 ∿ per second. Coil B (of 96 turns) was used as the magnetising coil. The resistance of this coil was 0·21 ohm, and the non-inductive resistance connected in series with it was 0·809 ohm, giving a total resistance of about 1·02 ohm. By subtracting from the ordinates of the E.M.F. curve the drop due to resistance of the circuit, we obtain the counter-E.M.F. curve of the transformer. By integrating this latter we find the curve of magnetic induction, after the manner used by Dr. J. Hopkinson in his experiments on magnetic viscosity (see *The Electrician*, Vol. XXIX., p. 510). If b stand for the instan-

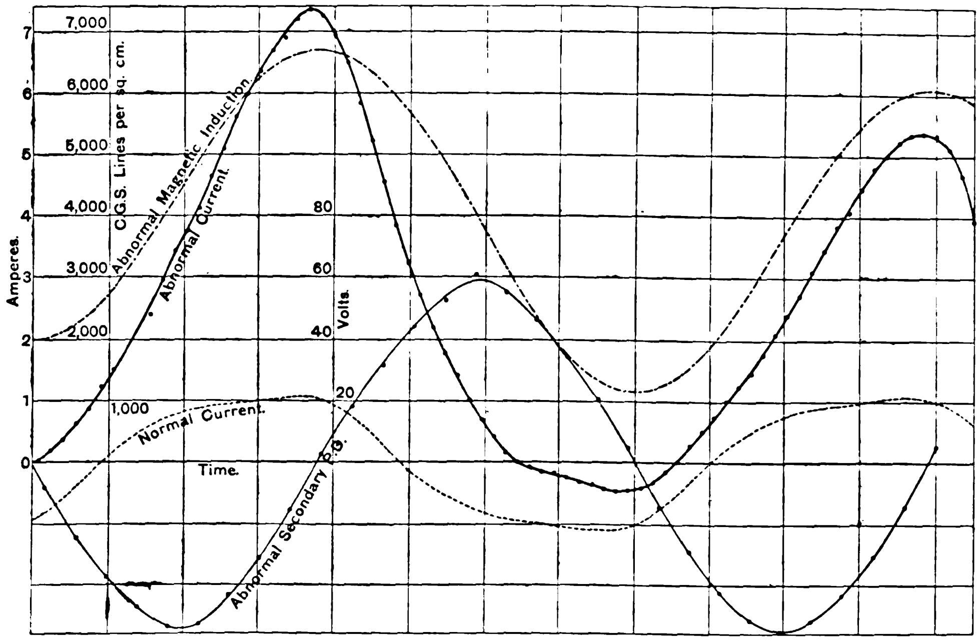

Fig. 6.—Abnormal Curves of Current, E.M.F., and Magnetic Induction.

the phenomenon of hysteresis. Without at present going into theoretical considerations as to what might be expected to take place in such cases, we at once proceed to give the results of experiments showing what actually does happen.

In dealing with circuits immersed in a medium of constant permeability, it was unnecessary to note the phase of the current at the instant of switching off. In the present case, however, we must take into account the initial magnetic state of the iron, and this, as is shown by experiment, plays an important part in determining the current-rush. The main factors to be considered in dealing with this problem are:—

taneous magnetic induction (in C.G.S. lines per square centimetre), a for the sectional area of iron (in square centimetres), and S for the number of turns in the magnetising coil, then, e denoting the instantaneous counter-E.M.F. in volts, we have

$$e = \frac{a\,S}{10^8}\,\frac{d\,b}{d\,t},$$

whence

$$b = \frac{10^8}{a\,S}\int e\,d\,t + \text{constant},$$

the constant being determined by the consideration that the maxima and minima of the integrated curve correspond to equal mag-

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netisations of the core in opposite directions. In our experiment, $a = 29 \cdot 2$ sq. cm., S = 96, so that $b = 35{,}700 \int e\,d\,t +$ constant. The integrated curve is shown in Fig. 4. We can now draw the hysteresis loop for the iron by taking corresponding values of the current and magnetic induction. This loop is shown in Fig. 5. The scale of current may be converted into a scale of magnetic force by multiplying by a certain constant. Since the number of turns in the magnetising coil is 96, the magnetomotive force is $\frac{4\pi}{10} \times 96\,i$ (where i stands for the current in amperes) or $120 \cdot 7\,i$ approximately. Dividing this by the mean length of the magnetic circuit, viz., 51·9 cm., we obtain $2 \cdot 32\,i$ for the magnetic force. Multiplication by the factor 2·32 therefore converts the current scale into a scale of magnetic force. The greatest value of the induction is about 2,630 C.G.S. lines per square centimetre. The corresponding value of the current is 1·09, and of the magnetic force $1 \cdot 09 \times 2 \cdot 32 = 2 \cdot 53$. We thus get for the permeability corresponding to this induction $\frac{2{,}630}{2 \cdot 53} = 1{,}040$ approximately (this agrees very fairly with the result obtained by Ewing for a certain specimen of soft iron. *See* his "Magnetic Induction in Iron and other Metals," p. 55.)

§ 15. We may now compare the normal current curve with the curve during a rush. With precisely the same arrangement of the circuit as that used in obtaining the normal curve, we get an enormous distortion of the initial current waves, as is evident from Fig. 6. During the first half-wave the current runs up to about 7·35 amperes, and since the normal maximum is 1·09 amperes, the current rush (§ 3) is $\frac{7 \cdot 35}{1 \cdot 09} = 6 \cdot 74$. The abnormally large half-wave is succeeded by an abnormally small one (just as in the case of a circuit of constant permeability); this, again, is followed by an abnormally large half-wave, and so on. For the sake of comparison the normal current wave is repeated in Fig. 6 in dotted lines. In order to determine the changes which the magnetic induction undergoes during a rush, a set of readings was taken for the secondary potential difference curve (coil C, which had the same number of turns as the magnetising coil B, being used as the secondary). This secondary potential difference curve is also given in Fig. 6. It will be noticed that, as might have been expected, it is considerably distorted. By integrating this curve we obtain the magnetic induction curve, which is the chain-dotted curve of Fig. 6. The rush shown in Fig. 6 is the greatest rush which it was possible to obtain when working at the given magnetic induction.

(To be continued.)

PHOTO-ELECTRIC RESEARCHES OF M. AUGUSTE RIGHI.*

BY DR. OLIVER LODGE.

M. Righi has observed the following facts: (1) That ultra-violet rays reduce to sensibly the same potential two metals placed near each other (plate and gauze parallel and close); (2) That several photo-electric couples of this kind can form a battery; (3) That a simple metallic plate charges itself positively under the influence of radiation; (4) That a voltaic arc formed with a zinc rod gives the strongest effect, while the sun gives none.

Besides these facts he finds:—(*a*) That certain gases and vapours, such as coal-gas and CS_2, absorb the active rays strongly.

(*b*) That if the discharging body is easily movable it recedes like an electric windmill.

(*c*) A film of gypsum interposed between gauze and plate charges itself negatively on the side facing the negatively-charged plate.

(*d*) Radiation produces its discharging effect even on non-conductors (ebonite and sulphur). With glass, resin and varnishes the action is feeble, or nearly nothing.

* *Comptes Rendus*, vol. 107, p. 559.

(*e*) If the experiment is made with a copper gauze and a zinc plate, the phenomenon nearly disappears on varnishing the gauze. His hypothesis is that radiation produces convection of negative electricity, the carriers being molecules of air.

(*f*) The carrying molecules move along the lines of force, and throw electric shadows. To show this he varnishes a zinc cylinder, all except a generating line, charges it negatively to 1,000 volts with a dry pile, and places it parallel to a large earth-connected plane, which has a narrow rectangular portion insulated from the rest and communicating with an electrometer. Light only acts on the uncovered line of the cylinder, and on turning the cylinder round the electrometer is only deflected when it is exposed to some of the (circular) lines of force emanating from the active line of the cylinder.

(*g*) Radiation charges positively an insulated metal, even when it is an enclosure with walls of the same metal: the metal being certainly uncharged at the beginning of the experiment. The same occurs with sulphur and ebonite. If there is a feeble initial *plus* charge, radiation increases it.

(*h*) While the discharging power of radiation for negative electricity is strongest with zinc and aluminium, and slower with copper and gold, following the Volta series; the E.M.F. set up by radiation, when it charges things positively, is greatest with gold and carbon, and less with zinc and aluminium; again following the Volta series, but inversely.

(*i*) If radiation falls on an insulated metal plate connected with an electrometer, in an enclosure of the same metal, the positive electrification shown by the deflection of the electrometer is greater as the plate is further from the walls of the enclosure. The action stops when the metal has attained a certain electric density, constant for a given metal; so the potential of a plate is naturally higher as its capacity is less. It is thus established that radiation acts on the particles of gas in contact with a conductor; they go away with a negative charge, leaving *plus* on the conductor, until an electric density sufficient to balance this action is attained.

(*j*) It is probable that if the solar rays do not produce an effect it is because of the absorbing action of the atmosphere. In fact, if one places a tube whose ends are glazed with selenite between the source of light and the metals being experimented on, the effects become sensibly stronger when the tube is exhausted.

THE ROTATION OF THE ELECTRIC ARC.*

BY A. P. TROTTER.

In the course of experiments made with the view of realising as a practical standard of light, the method of using one square millimetre or other definite area of the crater of the positive carbon of an electric arc†, the author has found that the effective luminosity is not as theory would predict,‡ either constant or uniform. By the use of a double Rumford photometer, giving alternating fields, as in a Vernon Harcourt photometer, his attention was called to a bright spot at or near the middle of the crater. The use of rotating sectors accidentally revealed that a periodic phenomenon accompanied the appearance of this bright spot, and although it is more marked with a short humming arc, the author believes that it is always present.

An image of the crater was thrown on a screen by a photographic lens; and a disc having 60 arms and 60 openings of 3°, and rotating at from 100 to 400 revolutions per minute, was placed near the screen. Curious stroboscopic images were observed, indicating a continually varying periodicity seldom higher than 450 per second, most frequently about 100, difficult to distinguish below 50 per second, and becoming with a long arc a mere flicker. The period seemed to correspond with the musical hum of the arc, which generally breaks into a hiss at a note a little beyond 450 per second. The hum is audible in a telephone in the circuit, or in shunt to it. The current was taken from the mains of the Kensington and Knightsbridge Electric Light Company, often late at night, after all the dynamos had been shut down. The carbons were, of course, not cored; six kinds were used.

A rotating disc was arranged near the lens, to allow the beam to pass for about 1/100th of a second, and to be cut off for about

* Paper read before the Royal Society.

† J. Swinburne and S. P. Thompson, discussion on Paper by the Author, "Inst. Electrical Eng.," Vol. XXI., pp. 384 and 403.

‡ Abney and Festing, *Phil. Trans.*, 1881, p. 890; S. P. Thompson, *Soc. Arts Jour.*, Vol. XXXVII., p. 332.

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1/100th of a second. It was then found that a bright patch, occupying about one quarter of the crater, appeared to be rapidly revolving. Examination of the shape of this patch showed that it consisted of the bright spot already mentioned, and of a curved appendage which swept round, sometimes changing the direction of its rotation. This appendage seemed to be approximately equivalent to a quadrant sheared concentrically through 90°. Distinct variations in the luminosity of the crater are probably due to the fact that this is only an approximation.

The *a priori* theory of the constant temperature of the crater is so attractive, that the author is inclined to attribute this phenomenon, not to any actual change of the luminosity of the crater, or to any wandering of the luminous area, as is seen with a long, unsteady arc, but to the refraction of the light by heated vapour. All experiments, such as enclosing the arc in a small chamber of transparent mica, or the use of magnets, or an air blast, have failed to produce any effect. A distortion of the image of the crater while the patch revolves, has been looked for, but nothing distinguishable from changes of luminosity has been seen.

An unexpected difficulty is thus introduced in the use of the arc as a standard of light, and one which may interfere with its use under some circumstances as a steady and continuous source of light. The author is further examining this phenomenon with the view of ascertaining its nature, and of finding practical conditions under which it is absent or negligible.

NOTE ON THE POSSIBILITY OF OBTAINING A UNIDIRECTIONAL CURRENT TO EARTH FROM THE MAINS OF AN ALTERNATING CURRENT SYSTEM.*

BY MAJOR P. CARDEW.

In carrying out some tests on the high-pressure alternating current system of the Metropolitan Electric Supply Company (Limited), of a combination intended to act as an indicator of leakage to earth, the existence under certain conditions of an excess of current in one direction to earth by leakage through the dielectric of the cables, or through small faults therein, has been demonstrated. The combinations and connections used are shown in Fig. 1, where A is the alternating current generator, M_1 and M_2 the distributing mains, T T the transformers, B a battery of a few

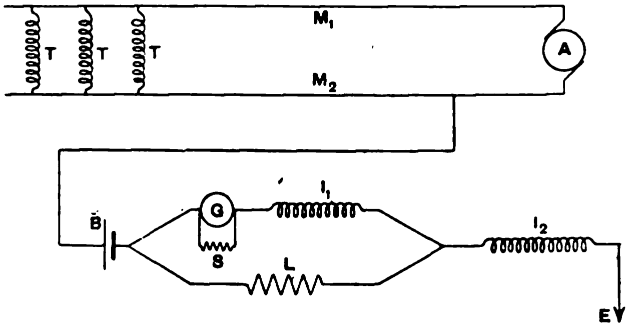

Fig. 1.

Leclanché cells, G a sensitive D'Arsonval reflecting galvanometer, S its $\frac{1}{9}$ shunt, I_1 and I_2 impedance coils, calculated to pass a current of less than 0·005 ampere with the whole alternating pressure in use on the system between the terminals; L a non-inductive resistance formed of four 50-c.p. 50-volt incandescent lamps in parallel, E a connection to the iron water-pipes supplying the station.

The object sought to be attained by the use of this arrangement was to obtain an indication of any leakage on the alternating system by a method which would be unaffected by the capacity effect of a large system. It is intended to substitute for the D'Arsonval galvanometer used in these tests a form of siphon recorder, so as to obtain a continuous record of leakage.

In the first test, made on April 25, 1894, the mains in connection consisted of eleven circuits all connected to one machine. The pressure in the alternating circuit was rather greater than 1,000 volts, and about half this pressure was indicated by an electrostatic voltmeter between M_2 and earth throughout the experiments. The battery used was six cells, and the following deflections were obtained :—

With +ve pole of battery to the mains...... 20 to left.
With −ve ,, ,, ,, ... 140 to right.
With battery out of circuit .... 48 ,,

Various modifications were tried ; but in all cases the results showed an apparent electromotive force of from 5 to 6 volts, tending to cause a flow of positive electricity to the water-pipe earth.

* Paper read before the Royal Society.

In order to settle this question, a small copper voltameter, consisting of two No. 40 S.W.G. copper wires in $CuSO_4$ solution, was inserted in place of the galvanometer and the shunts were removed. In two hours and ten minutes after connection the wire connected to the mains was so far eaten through that it dropped off, while that connected to the water-pipe earth was visibly thickened by a deposit of copper. The gauge of the wires before and after this experiment was approximately as follows : Original gauge of each, 0·005in. ; gauge of anode after experiment, 0·002in. ; ditto of cathode, 0·0069in.

The connections are shown in Fig. 2, where V is the voltameter cell, *a* the wire which acted as anode, *k* that which acted as cathode.

On May 2, 1894, some further tests were taken. In the first place a connection to the opposite main was substituted for the connection to the water-pipe, as shown in Fig. 3. This connection gave a deflection of about 235 to either side, according to the direction of the battery E.M.F., and absolutely no deflection without the battery. On reverting to the connections of Fig. 1, a deflection of 130, gradually falling to 98 in 10 minutes, was ob-

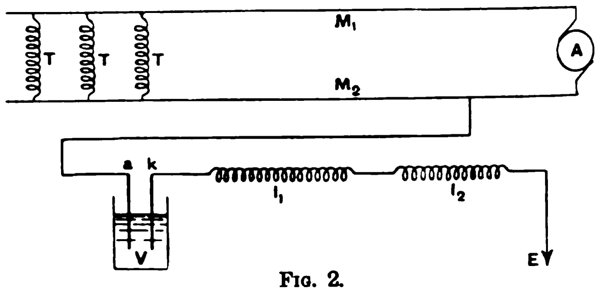

Fig. 2.

tained without any battery ; and five Leclanché cells connected +ve to mains exactly reduced the deflection to zero. The deflections obtainable with the connections of Fig. 1 without battery for varying lengths of street mains in connection with the machine were then found to be as follows.

With the trunk main to Manchester Square Station alone, disconnected at the far end, no deflection was obtained :—

Adding No. 10 circuit, deflection of 15
,, No. 11 ,, ,, 25
(with a sudden rise to 70 and then a fall to 20).
Adding No. 12, no increase of deflection
(this is a small circuit for station lighting only).
Adding No. 7 circuit, deflection of 35
,, No. 6 ,, ,, 40
,, No. 5 ,, ,, 48
,, No. 4 ,, ,, 63
,, No. 3 ,, ,, 70
,, No. 2 ,, ,, 90
,, No. 1 ,, ,, 115

In all cases the first deflection was a few scale divisions greater than that after a few minutes.

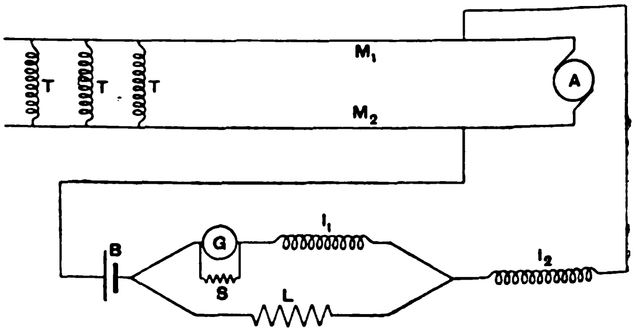

Fig. 3.

The effect of an artificial leak of about 103,360 ohms resistance, consisting of a pencil of graphite mixed with clay or cement, and connected to the water pipes and to the main M_1, was then tried. This produced no effect on the deflections without a battery, but slightly increased the deflection with a battery and with all mains connected. When tried on the trunk main alone with the lamps removed, galvanometer unshunted, and six Leclanché cells, the deflection was increased from about 23 to 360. With seven Leclanché cells (say 10 volts) and the impedance coils and shunts as shown in Fig. 1, a deflection of four scale divisions was produced when the circuit was completed through the resistance of 103,360 ohms in place of the mains and earth ; this gives an indication of the sensibility of the arrangement.

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The explanation of the results obtained appears to be that when the cables are charged with positive electricity the polarisation produced is sufficient during the time of one alternation to considerably increase the resistance of the slight leakage to earth by the formation, probably, of a film of oxides; this obstruction is cleared off by the succeeding wave of negative charge, which, as is well understood, opens the leak. The time of an alternation is, however, quite insufficient to produce any such effect on the water-pipe earth, and, in consequence, the net result is a passage of negative electricity to earth through the cables, and of the corresponding positive quantity to earth by the water-pipes.

The maximum effect that has been observed so far amounts to an apparent E.M.F. slightly exceeding 10 volts, with the eleven circuits connected to one machine; but it appears that a greater effect would be produced by still further increasing the length of mains in connection.

HEINRICH HERTZ.*

(Continued from page 274.)

In 1881 we already find him investigating electrical equations which do not belong to the older theories. An interesting Paper written at this time is "On the Distribution of Electricity on the Surface of Bodies in Motion." The theory of action-at-a-distance shows that in every electrically-charged body at rest the charge resides wholly on the surface, so that the interior of a hollow sphere is quite free from any trace of the hypothetical fluid, and throughout the whole conductor the electric potential has everywhere the same value, even in the interior of the mass of the conductor. Hertz asks himself, "What happens if bodies so charged are moved towards each other?" The distribution of electricity on the surface must at any instant be quite different from that on the surface of bodies at rest, even if these could be brought to exactly the same position in space as the moving conductor momentarily occupies; further, the potential is now no longer constant, either on the surface or in the interior of the body, and whereas a hollow metallic conductor at rest completely screens its interior from external electrical forces, this is no longer the case when the conductor is in motion. Currents are set up in its interior, and along with them heat is developed, resulting in an apparent loss of energy. Continuous motion of charged bodies can therefore only be kept up by supplying external work.

Hertz developed very skilfully the formulæ for these cases, and the general formulæ of electrostatics are greatly extended by them. He applied the general solutions to the specially important cases of a solid of revolution rotating in an electric field with constant velocity about an axis, and particularly considered solid and hollow spheres and cylinders. In the latter, even in a uniform field, electric currents are set up which are deflected in a singular fashion by the rotatory motion; inductive effects act through the metallic body upon its interior, so that it no longer behaves as a perfect screen, and so on. In connection with this Hertz arranged an experiment. Over a horizontal and only moderately good-conducting glass plate a needle, provided at its ends with horizontal metallic plates, is suspended by a metal wire. As soon as these plates are charged so that they become electric poles their oscillation becomes greatly damped. The phenomenon is analogous to the damping of a swinging magnetic needle which excites opposing induction currrents in a copper conductor surrounding it. In this work we find the following significant passage:—"If an electric pole be moved at a constant distance above a flat plate the electrification, when once excited, follows it, and the simplest and, indeed, the usual explanation is that the electricity, supposed material, is the thing which moves, but we reject this hypothesis." We here see Hertz already freeing himself from the "usual explanations."

In the year 1883 he devoted his attention to a group of phenomena which always interested him, namely, electrical discharges in gases. In his first work on this subject, "On a Phenomenon accompanying Electric Discharge," he describes some singular luminous rays and cloud-like or arborescent appearances observed when the electrical discharge from an induction coil is allowed to pass out of a tube into a mass of gas which is not too highly rarefied; the positive electrode was inside the tube and the negative one near its mouth. The experiments were greatly varied, and the description of them, although only eight pages long, is full of detail.

To the same year belong the "Researches on the Glow-Discharge," which were carried out in Berlin, although the Paper is dated from Kiel. At that time there existed but three methods for the production and study of the phenomena of electric discharges as they occur in rarefied gases; namely, the influence machine, the induction coil and large voltaic cells of high electromotive force. Of these Hertz chose the third, and constructed a secondary battery with 1,000 pairs of lead plates, enabling him to obtain an electromotive force equal to that of 1,800 Daniell cells in series. The current yielded by it was led by electrodes into discharge-vessels of various shapes. Hertz observed more especially the luminous appearances near the cathode with high vacua.

Here it is the rays of the glow-discharge and the cathode rays, which are certainly related to them, concerning which Hertz's work discloses many important facts, although he was not able to entirely lift the veil from them. Apparently this was not possible except from his higher point of view attained through the later researches, namely, that of the doctrine of electric oscillations and waves. Even here we find occasional mention of electrical waves and of electrical movements which are propagated through a medium like waves; but the ideas are not yet so clear as they came to be eventually by reason of the later striking experiments.

The first part of the Paper is devoted to an old and much-debated question, "Are the discharges through a rarefied gas continuous or discontinuous? Are they still discontinuous in the particular case considered here, when we apply to the gas an apparently continuous battery current?"

Hertz endeavours by ingenious arrangements to prove that his discharges are continuous. On looking over the lines of the argument, however, it is seen that they are only able to establish a lower limit to the number of separate discharges in a second. Whether discontinuities of very high frequency occur or not cannot be definitely decided by the method used, a fact of which Hertz himself was quite aware. If we consider the phenomena after assuming the existence of oscillations, evidence for which is furnished by the striation of the luminous column, thus rendering it analogous to the interference phenomena of a periodically varying source, a distance of 1·5cm. between the striae, which is easily obtained, would correspond to a wave-length of 3 cm. From Hertz's later investigations we know that this represents an electric disturbance, with a frequency of 10,000 million per second. Fluctuations with such high frequencies were no longer observable by the method used, since they do not obey the ordinary laws of electric currents, as was shown by Hertz's later work. I cannot here enter into details concerning the experiments. It would appear that his proof had not satisfied him on this point, for at the end of the Paper referred to he suggests the intermediate assumption, according to which the flow of electricity through a gas is, on the whole, continuous; but that in the tube itself electrical motions of an oscillatory character may be superposed on the constant current, a view which is rendered even more tenable by more recent investigation.

He likewise considered the very important question of the course of the stream lines in a gas traversed by electric discharges. A necessary introduction to this was the proof that cathode rays do not deflect a magnet, although they are deflected by it. It appeared, further, that the cathode rays do not indicate the path of the discharge, but are set up in the course of the discharge, and then obey definite laws of propagation. Experiments upon the absorption of cathode rays were indicated, which have since led to a series of beautiful experiments by Philipp Lenard.

In the last part of this Paper he shows, among other things, that the cathode rays do not exert any electrostatic action, and so they certainly cannot be regarded as electrified particles shot out from the cathode, although many physicists often adhere to, and express, this view.

I should like to refer to the experiments here described concerning the peculiar property of cathode rays, that of bringing about the equalisation of electric potential in a direction transverse to them, and so promoting "transverse discharges," experiments which have been extended by other observers. This behaviour of cathode rays reminds us of a quite analogous property of light-waves, discovered by Hertz; namely, that the ultra-violet waves possess the same equalising power in a high degree.

The general results of the work can be better understood when it is stated that they support a view expressed in similar form by other observers, for example, E. Wiedemann and Goldstein, namely, that the cathode rays consist of a certain form of ether-motion more nearly allied to light than to any other natural agent, and that they are set up by electrical actions; but afterwards constitute an independent phenomenon, just like the light sent out from an electric lamp.

(To be continued.)

* Memorial Address by Prof. Hermann Ebert, delivered at the meeting of the Physical Society of Erlangen, March 7, 1894. Translated by James L. Howard.

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EVOLUTION IN MACHINERY.

It is a great pity that certain branches of science should be encumbered by an uncouth phraseology; it repels the ordinary reader and leads him to suppose that the ideas are difficult to grasp, that the subject is dry, and that the reasoning is complicated. There are many sciences in which dabbling is useless, and of which an elementary knowledge is almost always a superficial knowledge, and therefore inaccurate. So long as evolution was confined to biology, the general public was content to discuss the examples without understanding the general principles; but now that other branches of thought are becoming affected by it, and its application to the conditions of social progress are recognised as of profound importance, an exchange of a few six- and seven-syllable words for more homely ones would be very welcome. That process of change in detail and modification of type; by which machinery constantly adapts itself to the ever-changing character of the work it has to do, follows in many respects the same laws of development as those which express the orderly evolution in the organic world. One of the highest authorities in the sciences of biological and social evolution has defined this process as one of progress "from a state of undifferentiated homogeneity to a state of highly differentiated heterogeneity." The prime "determinants" of the change are, the nature of the environment and the specific properties of the evolving item. In machinery, the nature of the environment has a two-fold influence on the development of the machine type: firstly, in that it determines the character, amount and regularity of the supply of that essential—the energy; secondly, in that it embodies the character of the work which it is the object of the machine's existence to perform. The evolution of electric supply machinery requires to be considered from two distinct points of view, before we can realise that it is one which has its parallels in the evolution of living organisms. It must first of all be considered in relation to machinery in general, and secondly in relation to itself internally.

In the early stages of electric supply, when the requirements of an efficient supply were little understood and less met, it was thought that any type of engine would serve the purpose of motive power, and that any arrangement of plant which

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could be most conveniently and most cheaply purchased would answer the purposes of generation and distribution. Types of plant by no means adapted to the work were violently forced to perform an unnatural function. Hence, partly at least, the high death-rate among electric supply stations just about that time. But the hardier organisms lived on through the struggle—indeed, have even succeeded in rearing a small progeny—though their ultimate extinction is but a matter of time. The conditions of the new field of activity, however, were on the one hand too important and on the other hand too violently in conflict with the conditions which had moulded the species of machines up to that time, for either the survival of the hybrid species or its complete extinction to occur. Gradually there was evolved a distinct and pure species of plant, and one which was practically adapted to the new requirements. Rudimentary organs there may be here and there, such as eye-bolts, once frequently used for removal of dynamos for repairs. Possibly, even now, there may be traces of imperfect development; but, in the main, the creation of the new field of electric light and power supply has added one more distinct type to machinery, and has advanced by one step more its evolution from undifferentiated simplicity to highly differentiated complexity.

Viewed internally, in relation to itself, the new type or species of plant, which we have called electric supply machinery, exhibits some interesting parallels with the development of species of living plants and animals. Both kinds of species may conveniently be sub-divided into varieties, and again into individuals. In view of the perpetual struggle for existence which is going on among machine varieties, electrical engineers not uncommonly express the opinion that the reduction of the entire species to one dead level must ultimately result; some even believe that such a levelling would be beneficial. Probably nothing of the kind will ever happen; certainly, if it does happen, it will create a precedent, and be distinctly opposed to the ordinary laws of development. Certainly, too, any such reduction of the varieties of electric plant to one type would be far from beneficial. No cant phrase has ever been more misrepresented nor more misunderstood than the one—"the survival of the fittest"—which is usually quoted in this connection. In the first place, as Prof. HUXLEY has pointed out, the "fittest" does not by any means imply the *best*, and, in the next place, the "fittest" in one locality, or under one set of conditions, will be far from being the fittest in another locality, or where other conditions obtain. Fitness consists in the degree of perfection with which the individual or species adapts itself to the conditions under which it finds itself. Not until there is perfect uniformity of conditions in all places can there be any approach to a perfectly dead level of type, and extinction of variety. There are engineering climates, as well as hygienic and social ones. An engine which would thrive exceeding well amidst the belts, pulleys, and shafting of an "old-time" American central station, would find the restricted space and quiet of Knightsbridge or Eccleston-place oppressive and not to be endured.

In quite another respect, if we examine the tendencies of living organisms, we shall be able to illustrate the incorrectness of popular views in regard to machinery. The opinion is not uncommonly advanced, even by engineers, that the tendency in machine design is towards simplicity; and the advocate of this view, having no actual example to support his assertion, generally falls back on the platitude that to expect such a tendency is "only natural." Nature, however, acts quite in the reverse manner. Nor, in face of the history of engineering can it be said that machinery is any exception to the natural rule. The boy who tied a length of string to the valves of his steam-engine, in order that, thereby, they might be made self-acting, took a forward not a backward step in the evolution of machinery; but he made his machine more complicated, by just that one extra detail. Again, a merely superficial comparison of the machinery of a modern steamship with that of the earlier vessels is enough to show how vigorous has been the evolution of detail in structures of this class. It is the function, not the structure, which has a tendency towards simplification. In early types of machines, where the number of parts was small, each part had a multitude of offices to perform, and each set of parts required the close and constant attention of the attendant. Nowadays, we give to each detail fewer duties; we multiply the number of parts accordingly; and we throw in a large number of additional details, to act as links between the others, for the purpose of rendering the entire machine more automatic in its action. Successful machine design can never be consistent with imposing a large number of duties on a single detail which can better be performed by a number of details; and the only scope for simplification lies in the removal of obsolete parts which have no special function to perform, and in the elimination of unnecessary functions. As the physical conditions of human existence become more complex and more refined, it seems probable that there will be a corresponding increase in complexity and refinement in the machinery with which the great forces of nature are directed for "the use and convenience of man."

REVIEWS.

Continuous-Current Dynamos and Motors. By FRANK P. COX. (New York, 1893: The W. J. Johnston Company.)

It should be added to the title of this little book—"Their theory, design, and testing; with sections on indicator diagrams, properties of saturated steam, belting calculations, &c., &c.," for such things indeed are found on the title page. The custom of including disconnected subjects under one general treatise is a relic of an old fashion, when every country gentleman who had "thoughts" would make a book of them, and when such entitles as "Thoughts on Astronomy, with Some Suggestions on How to Behave at Table," were not uncommon. The reader need not stay to inquire into the logic of the combination. It is enough for him that a knowledge of both dynamos and saturated steam is useful to him, and he will do well not to inquire too closely as to why they are both treated between the same covers. The critic, if he too wishes to know the object of offering an elementary student such various fare, may comfort himself with the reflection that this is hardly the sort of book which a serious student would be likely to take to—it is more suited to the intelligent dabbler who, although desirous of learning with accuracy a few elementary facts, by no means intends to follow up his studies along the more advanced and conventional lines. Besides, the critic has recently been warned that any driveller can blame, but it takes a real artist to praise. Still, though this is by the way, there are some books which no kind of real artist could succeed in praising. Many of these, most of these, perhaps, are on electricity. They are, doubtless, written with the intention of developing real art—in the critic. Not that the idea of blaming an author has any direct suggestion from the writings of Mr. Cox in the book before us. Mr. Cox had a difficult task before him, almost an impossible task in fact—namely, to give an exact and intelligible account of the dynamo without the use of more than the simplest mathematical language. His imperfect success is only rendered imperfect by the hopelessness of the task before him. Other writers have set themselves a similar task, but they have all ended in one or the other of two results. They have either been compelled to admit a higher grade of mathematics than

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was the original intention, or they have cut a sorry figure with inadequate carving implements. It is impossible that anyone can properly understand the details of the subject, as discussed by Mr. Cox, if they have no higher mathematical knowledge than the simple algebra to which he confines himself. This fact is quite independent of the achievement of any particular author, and the recognition of it should ever deter future authors from attempting so much with such little means.

Mr. Cox commences with an elementary exposition of fundamental principles, units, &c.; and we notice that he is particularly lucid in his exposition of why the ohm is a velocity, though he offers no explanation of why the ohm is *not* a velocity. We hope, however, that the reader is not expected to carry the earth-quadrant-per-second idea through the chapters on dynamo design and testing. The sine curves given by all of Mr. Cox's dynamos consist of two straight slanting lines capped with a bit of a circle, notwithstanding which approximation many of the curves are provided with figured scales. The majority of the other curves, however, of which there is a great number throughout book, appear to have been carefully drawn.

In the chapter on the "Design of Armatures" there is a very funny attempt to arrive at the correct proportions of an armature which has purposely been badly designed to start with. The poor armature generates more heat in its iron alone than it can possibly get rid of from its limited cooling surface without overheating, besides which it has a huge copper loss; and the problem the writer proposes is to put things right without upsetting the balance of a lot of other things. The supposition that "if by some miracle the iron loss could be reduced to zero" is reluctantly abandoned; so is the idea of increasing or decreasing the iron section; another tack is followed, and the armature comes out "out of proportion." Sadly, it almost seems, the author drives at still another idea, "has a shot" at it from two or three standpoints, and at last triumphantly exclaims: "We have now designed a Siemens armature which will develop the required potential at the given speed, and will not overheat when operating continuously with the full number of lamps." Then our pulse goes down to the normal, and we breathe once more. But, at the last minute, it is decided to have a Gramme armature, and it happens all over again, this glorification of "trial and error" which they call the design of armatures.

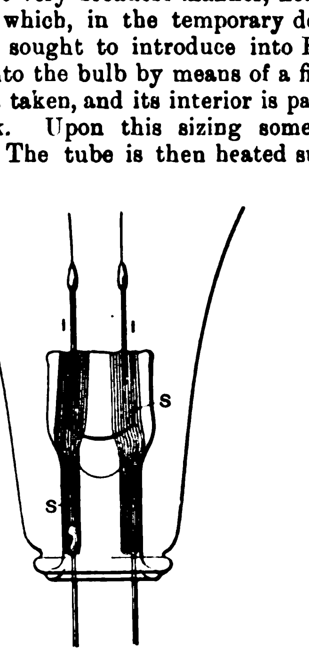
But it does not do to take this type of book too seriously. No one intending to design a dynamo, or to test a dynamo, in anything but an amateur fashion, would think of looking to it for instruction. To the amateur it may prove very pleasant and entertaining literature.

THE POLLARD GLOW LAMP.

The only rational theory of the origin and meaning of "difficulties" is the one which tells us that they are strewn in the path of inventors, manufacturers, and the world generally in order that they may act as anti-soporifics, and be overcome by the very energies they arouse. At any rate, whether this be so or not, would-be American glow lamp makers have evidently regarded the Edison patent, with its apparently indefeasible claim for "the combination of a carbon filament within a receiver made entirely of glass, through which leading wires pass, and from which receiver the air is exhausted," as merely an obstacle to be circumvented. Hence the United States market has been flooded with Maggie Murphy, Westinghouse very-removable-stopper, Beacon, and inert-gas lamps, not one of which, we venture to say, would have lightened our darkness but for the necessity of either evading the Edison patent or "going out of the business altogether."

The latest rival and the latest victim of the Edison monopoly in the States is the lamp invented by Martha W. Pollard, of 113, Otis-street, East Cambridge, Massachusetts, the characteristic feature of which is likely to prove of some value apart from the fact that it would appear to the lay mind to make the lamp a non-infringer, although the United States Courts, taking cognisance of what in this country would be deemed the extraneous consideration that Edison having created an industry is entitled to have his fundamental patent construed in the very broadest manner, hold otherwise.

In the Pollard lamp which, in the temporary default of an American market, it is sought to introduce into England, the current is conducted into the bulb by means of a film of silver. A piece of glass tube is taken, and its interior is painted with a sizing of printers' ink. Upon this sizing some fine silver powder is sprinkled. The tube is then heated sufficiently to



cause the silver to adhere firmly to the glass, and whilst hot the walls of the glass tube are pinched into contact, and the plug thus formed is sealed into the lamp bulb in the ordinary way.

As will be seen by our sketch, the iron wires I I, which conduct the current from the silver films S S to the filament, do not pass right through the glass plug, but are only embedded a little way in it, there being a long length of solid glass beyond. External connection is made with the exposed ends of the silver films by ordinary soldered joints. In all other respects the Pollard lamp is as other glow lamps.

SILK AS A DIELECTRIC FOR CONDENSERS.

In the latest numbers of *L'Elettricista*, Sgr. Luigi Lombardi gives an account of his attempts to construct condensers with silk as a dielectric, instead of mica, paraffin, or other material usually employed. The attempts have, he says, been completely successful, where certain precautions were observed. The chief source of error was found to be the state of humidity of the silk. The desiccation of the sheets of pure white silk and tinfoil was carried out on sheets of brass heated to 200°C., on which the sheets were first placed singly. The dried sheets were kept on a plate at a slightly lower temperature, and were heated to the higher temperature immediately before being mounted in their places. One condenser constructed in this manner contained a hundred rectangular sheets of tinfoil 28cm. by 18cm., separated by double sheets of silk; single sheets having been found subject to short-circuiting. The total thickness was 1·2cm., and the capacity 0·351 microfarads at 21°. The insulation resistance was 10,000 megohms. The greatest variation of capacity was 1·7 per cent., and the sum of the residual discharges after one minute's charge was a little over 3 per cent.

The measurements were repeated after seven months, and gave figures higher by a fraction of 1 per cent. This may be due to an elastic yielding of the sheets under the compressing screws, or to the absorption of a slight amount of moisture, whether contained in the case after sealing up, or admitted subsequently. But there is no reason why this should not be avoided in systematic constructions. As regards the temperature coefficient of the specific inductive capacity, this was found to be of the order of one-thousandth per degree centigrade, positive for rising temperatures.

Silk condensers may be safely used for all differences of potential commonly in use. Measurements with the same ballistic galvanometer, and with potentials increasing by 20 volts up to 200, showed no variation of capacity exceeding 0·4 per cent., and with a large battery of accumulators the first spark passed across the silk at 500 volts. Finally, the material for the dielectric can be obtained at a low cost and of uniform quality in sheets of any size, and could be specially manufactured for purposes of the highest accuracy.

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MEASUREMENTS OF THE ABSOLUTE SPECIFIC RESISTANCE OF PURE ELECTROLYTIC COPPER.*

BY J. W. SWAN AND J. RHODIN.

This Paper is a record of measurements of the absolute specific resistance and temperature coefficient of pure electrolytic copper. The authors had the opportunity of comparing a large number of different specimens of electrolytic copper, the origin of which was fully known to them; more material for this kind of research was at hand than has usually been the case. Several specimens of the copper were at first roughly compared, and the best ones chosen for further investigation. The best specimen was then electrolytically refined. It was deposited in the form of a plate, from which narrow strips, square in cross section, were cut, these were filed round, and drawn through sapphire dies to the requisite diameter, the resulting wire being subjected to measurements. The first sample, "A," was measured both when hard and also after annealing at a red heat in an atmosphere of carbon dioxide gas; the second sample, "B," was only examined after annealing.

Aware that the differences in the results obtained by different authorities on this subject are only to a very small extent due to error in the electrical measurements, but are chiefly caused by difficulties in the exact estimation of the sectional area of the wires subjected to measurement, the authors took extreme care in finding the dimensions of the wires and the temperatures at which they were measured. The lengths of the wires taken for examination were measured by comparison with a standard metre rule, and the diameters accurately determined by the specific gravity method, care being taken not to alter the hardness by handling. An apparatus similar to a calorimeter was employed for maintaining the various temperatures required.

The determination of the conduction resistance was made by the fall of potential method, applied so as to eliminate error from variation of the resistance of the leads. From the resistances of the wires at different temperatures, the temperature coefficients were found, and the absolute specific resistance at 0°C calculated.

The values of the two specimens in C.G.S. units were as follows, the density being 8·9587 at 15°C.

——	Absolute specific resistance. C.G.S. units.	Temp. coefficient. Δt.
Sample A. Hard, as drawn	1603	0·00408
" A. Soft, as annealed	1566	0·00418
" B. Soft, as annealed	1559	0·00415

The mean of the values for the two specimens of soft copper is probably the correct value. As a general conclusion it is stated that probably the following express the true values for the two varieties:—

	C.G.S. units.	Δt.
Hard variety	1603	0·00408
Soft, or annealed	1563	0·00416

PROPOSED ELECTRIC TRANSMISSION OF POWER FROM THE TROLLHÄTTAN WATERFALL, SWEDEN.

Last autumn a Royal Commission was appointed for the purpose of investigating the important question of electrically utilising the Trollhättan Waterfall, and their report is now completed. In the first place, says our Scandinavian correspondent, they claim for the Crown full proprietary rights of several islands in the river, where the Crown, consequently, is at full liberty to erect generating stations. In addition to these islands, the Crown is the owner of some land on the border of the river, which would be admirably adapted for the building of industrial establishments, for which electricity could be conveniently provided. The Commission has been at great trouble to ascertain the water-power available, and the outcome is an apparently reliable calculation, according to which the Swedish Crown has here at its disposal no less than 49,000 H.P. The Commission proposes that the Government shall utilise 20,000 H.P., and erect two separate stations of 10,000 H.P. each, the second of which, however, is only to be taken in hand when the whole power of the first station is employed.

At the Gullön island there is to be a 10,000 H.P. station, for which 74 cubic metres of water per second (16,280 gallons) is to be taken from the Gullö-Toppö course of the river. Having passed the Upper Gullö cataract, the water would be conveyed to a reservoir, blasted out of the rock, from which it would again proceed to the turbines through a tunnel, also blasted out of the rock, 770ft. long, which will have its exit at the lower border of Stora Toppö Island. The fall from the reservoir to the bottom of the tunnel will be about 51ft., and the effective fall from the turbines 48ft.

With an aggregate water consumption of 74 cubic metres per second, evenly divided between 10 turbines, and with a percentage efficiency of 72·5 per cent., there will be an available effective power of over 10,000 H.P. Each turbine is to operate entirely independently. Alternate-current generators and transformers will produce a current at a pressure of 15,000 volts.

When this power has been fully utilised, it is proposed to build another station of similar capacity at the Spikön Island, for which the water would be taken from the course of the river on the west side of the Gullön Island, the Nolström fall. From here a tunnel of about 1,030ft. would be carried under the river to Gullö, and fall into that tunnel, which from there goes to Stora Toppö. This latter tunnel would, therefore, from the outset, be made so as to have sufficient capacity for taking the water for both installations. The Spikö installation will thus have greater effective fall than the Gullö installation—viz., 53ft.—so that nine turbines, with a consumption of 66 cubic metres of water per second (14,520 gallons) will be sufficient to produce 10,000 H.P.

The next question is how this power of respectively 10,000 or 20,000 H.P. can be used in the best manner? The whole or part of the power might be led to some Crown property—Stallbacka, for instance—where a receiving station might be erected, and from where the power could be distributed to the various industrial establishments which it is expected would spring up; or the power, the whole of it or otherwise, might be conveyed to Gothenburg, where, according to calculations, the electric power could easily compete against the steam power at present used, which amounts to some 6,500 H.P. It might, therefore, be advisable to bring 5,000 H.P. to Gothenburg, where it would be received by two receiving stations. Customers who can do with some hundreds of horse-power, and who can provide their own lines, may rely upon very cheap power, although it is not considered necessary to fix a lower charge than 80kr., or £4. 9s, per horse-power per annum. The cost has been estimated in various ways.

A. For providing and conveying to Stallbacka electric current to the extent of, say, 3,000 H.P., with receiving station there.

B. For producing and conveying to Gothenburg electric current to the extent of, say, 5,000 H.P., with two receiving stations there.

C. For producing and conveying to Gothenburg 10,000 H.P., with three receiving stations there.

In all three cases the installation at Trollhättan is built ready for the production of 10,000 H.P., but the greater the power the smaller, naturally, is the cost per horse-power, and the greater the profit, exclusive of 4 per cent. interest on the capital. Scheme A is estimated to result in a net profit of 4·82 per cent., scheme B 7·8 per cent., and scheme C 10·55 per cent. The estimated costs are—for A £47,000, for B £86,000, and for C £147,000. The annual outgoings are estimated at respectively £4,600, £8,800, and £15,500.

PARLIAMENTARY INTELLIGENCE.

LONDON, WALTHAMSTOW AND EPPING FOREST RAILWAY.

This Bill, which had given rise to a controversy between the promoters and the London County Council on the question of workmen's trains, and which had been recommitted to the same Committee, was dealt with on Monday. It will be remembered that originally the Committee, at the instigation of the London County Council, decided that the charge should be 1d. for nine miles up to 8 a.m.; whereupon the promoters, declaring that they would not be able to raise their capital upon those terms, declined to proceed with the Bill. Since then further negotiations have taken place, with the result that the following clause was agreed upon:—

(1) The Company shall at all times after the opening of the railway, or any part thereof, for conveyance of passengers run or provide a sufficient number of trains for the conveyance of workmen, which shall stop either at all stations or at such stations as may be required, and shall be timed to arrive in London up to but not later than eight o'clock on every morning of the week except Sundays, Christmas Day, Good Friday, and Bank Holidays.

(2) The fares by such trains shall not exceed at any time—

For a distance not more than nine miles, and the return journey, fourpence.

(3) From and after the expiration of five years from the opening of the Railway, or any part thereof, the fares by such trains shall not exceed

* Abstract of a Paper read before the Royal Society.

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at any time for a distance not more than nine miles and the return journey—

By trains required to be run, or provided under this section timed to arrive in London up to, but not later, than 7:15 in the morning, twopence;

By trains required to be run as provided under this section timed to arrive in London after 7:15, and up to, but not later, than eight in the morning, fourpence.

(4) "London" shall for the purposes of this section be deemed to include the stations at or near South-place, Finsbury, and Kingsland-road, and any station that may be erected between those places.

(5) A return ticket issued in pursuance of this section shall entitle the holder to return in a third-class carriage by any train during the day, and to leave the train at the station from which the holder started, or at any intermediate station at which the train shall stop.

(6) The Company shall publish and keep published in some conspicuous and convenient part of every station on the railway notice boards or placards setting forth the conditions on which workmen's tickets are issued, the fares charged in respect thereof, and the trains by which such tickets are available, and shall also publish the like information in their book of time-tables.

(7) The liability of the Company under any claim to compensation for injury or otherwise in respect of any passenger travelling by any trains run or provided under this section, or any passenger returning at a fare fixed under and for the purposes of this section shall be limited to a sum not exceeding one hundred pounds.

(8) On complaint being made to the Board of Trade with respect to the sufficiency convenience, number or times of workmen's trains arriving in London in the morning, or the sufficiency of the accommodation provided thereby, the Board of Trade may after inquiry order the Company to provide such further trains or accommodation as, having regard to the circumstances, may appear to the Board to be sufficient for the purposes of this section.

Sir John Kennaway, on behalf of the Committee, endorsed the Bill with this clause in it, and it was then formally ordered to be reported for third reading.

THE LONDON COUNTY COUNCIL AND THE EPPING FOREST ELECTRIC RAILWAY.

At the meeting of the London County Council on Tuesday the Parliamentary Committee reported that they had been in further communication with the promoters of the London, Walthamstow, and Epping Forest Railway with reference to the insertion of clauses providing for cheap workmen's trains. The committee had consented on behalf of the Council to terms with the promoters by which the opposition to the Bill would be withdrawn.

Alderman Fleming Williams said that the proposals contained in the report had been very carefully considered by the Public Health and Housing Committee, and by an almost unanimous vote the Committee had instructed him to move to refer the report back for further consideration. He did not in the slightest degree desire to cast any blame on the Parliamentary Committee for the special character of the recommendations which were contained in the report. He had no doubt the Committee had done the best that was possible under the circumstances, but the best they had done fell far short of what they in the Public Health and Housing Committee regarded as desirable.

Mr. Westacott: Is it not a fact that the Committee of the House of Commons have passed the Bill with the conditions contained in the report?

Mr. Charles Harrison (the Vice-Chairman) said the Bill passed its third reading that afternoon.

Alderman Fleming Williams said he was sorry to hear it, for it placed the Council in an exceedingly undesirable position. All he could do now was to enter his protest against what seemed to be a very unfortunate course, and one which fell little short of a disaster. They had missed a splendid opportunity of insisting upon an adequate and suitable service of workmen's trains. He knew that Mr. Harrison thought he had made moderately fair terms with the promoters, but if he had had the backing of the whole of the Council he would have made a much better bargain. The new line under present conditions would not relieve in the least the over-crowded cheap service on the Great Eastern, because the fares would be much more.

Mr. Torrance was exceedingly sorry that the Committee had not been able to do more for the thousands of working men and women who so much required their help. He had lived in the City for thirty years, and he knew that there were thousands to whom cheap trains running up to 8 a.m. would have been an inestimable boon. They came up by the early workmen's trains, and had to wait about in the streets in all weathers for an hour or more until it was time to go to work, because they could not afford to pay the ordinary rates charged for later trains. If the people of London were not to look to the Council for help in this matter, to whom were they to look? If our legislators had witnessed the waiting about that he had himself, the law would have been altered before this.

Mr. Charles Harrison said the Parliamentary Committee had made the best terms possible. He supported the Council's demands before the Select Committee, and the Committee accepted them, with the result that the promoters withdrew the Bill on the ground that it would be impossible to raise the capital required.

Mr. Lloyd moved an amendment: "That the Council do oppose the Bill in its further stages through the House of Lords, in order to secure the insertion of provisions making the 2d. return tickets available up to 8 a.m., and the 4d. tickets available up to 8:30 a.m."

Alderman Ben Tillett supported the amendment, because, having travelled much by the workmen's trains on the Great Eastern Railway, he knew what a great boon it would be to vast masses of working people. Morning after morning he had seen men and women crowded into the Great Eastern trains like herds of cattle. A considerable proportion of those who travelled by the trains had to wait about for an hour or so, and as many of them were women earning only 7s. or 8s. a week, the Council would realise what an extra shilling a week to come by a later train meant to them.

The Council divided, with the result that the amendment was lost by 52 to 28, and the action of the Committee was approved.

Alderman Beachcroft suggested that the Vice-Chairman should confer with the promoters of the Bill with a view to have a clause inserted so that it should be made clear that the Company would not, by reason of the terms now arrived at, be relieved from any obligation that might otherwise be placed upon it by virtue of the Cheap Trains Act, 1883, or any other statute hereafter dealing with the subject of cheap trains.

CORRESPONDENCE.

HERTZIAN WAVES IN LABORATORIES AND ELECTRO PLATING WORKS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In the issue of your valuable paper of June 8, 1894, under the heading "Hertzian Waves at the Royal Institution," you take occasion to remark: "It is wholly probable, as Dr. Lodge suggests, that Hertzian waves may often have manifested themselves in physical laboratories to the annoyance of the workers," &c.

I may mention in this connection that in 1877, if I remember the year correctly, while working a Ruhmkorff induction coil, one terminal of which was grounded, and the other terminal of which was attached to an insulated metallic body, Prof. Houston and I noticed that when the sparks were passing between the terminals of the coil, it was possible not only to obtain minute sparks from all metallic bodies in the immediate neighbourhood—that is, in the same room—but that delicate sparks could be taken by holding in the hand a small piece of metal near metallic objects in many other rooms and on different floors in the building, although the pieces were not connected to ground. These could only have been Hertzian effects, but there was no recognition of their true character at the time, though the effects were seen to be connected with the very quick charging and discharging of the insulated body. An account of these experiments was, I think, published in the *Journal* of the Franklin Institute at the time.

I desire also to mention, as coming under my notice within the past year, a curious and rather amusing illustration of the principle upon which the beautiful instrument for detecting the presence of electric oscillations devised by Dr. Lodge, and called by him the "coherer" is based. It was reported to me when in Philadelphia that a certain electro-plater had found that he could not pursue his silver-plating operations during thunder-storms, and that if he left his plating over night and a thunder-storm came up the work was invariably ruined. I was disposed to be thoroughly sceptical, and expressed my disbelief in any such effect. Being urged, however, I went to the silver-plater's shop, which was a small one, and questioned the silver-plater himself concerning the circumstance which had been reported. While it was evident that he was not a man who had informed himself electrically, I could not doubt that, after conversation with him, he had indeed been stating what was perfectly true; namely, that when his operations of plating

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were going on and a thunderstorm arose, his batteries, which were Smee cells, acted as though they were short-circuited, and the deposit of metal was made at too rapid a rate. The secret came out on an inspection of his connections. The connections of his batteries to his baths were made through a number of bad contacts, which could not fail to be of high resistance under ordinary conditions. I could readily see that virtually he was working through a considerable resistance, and that he had an excess of battery power for the work. Under these circumstances a flash of lightning would cause coherence of his badly-contacting surfaces, and would improve the conductivity so as to cause an excessive flow of current, give a too rapid deposit, and, as he put it, "make the batteries boil." The incident suggests the use of Dr. Lodge's ingenious instrument in the study of the waves which are propagated during thunderstorms, of which waves we have practically little or no information.—Yours, &c., ELIHU THOMSON.

Lynn, Mass., June 25, 1894.

"CATALOGUING SCIENCE."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It has occurred to me that the expense of preparing abstracts for the proposed international catalogue of scientific Papers referred to in the leading article of last week's *Electrician* might be almost entirely avoided in the case of *future* Papers, if it became customary for the author of a Paper to conclude it with an abstract drawn up according to such rules as to length and form as might be prescribed by the future international bureau.

In order to introduce the custom the leading scientific societies and periodicals might make it a rule that every Paper should be accompanied by such an abstract. It would then, probably, soon become quite general.

Abstracts prepared in this way would be better and more reliable, which would be a still further advantage.—Yours, &c.,

WILLIAM LUCAS.

CURRENT-RUSHES INTO TRANSFORMERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It was with no small surprise that I read Dr. Fleming's letter in your last week's issue. The only inferences which I can draw from this letter are: (1) That he has not *read* my Paper; (2) That he credits me with a surprising amount of ignorance on the very matter of which I treat. He is good enough to refer me to his Paper read before the Institution of Electrical Engineers in 1892. Will he kindly take the trouble himself to refer to § 1 of my Paper (p. 229), the opening sentence of which runs thus:—"Since the publication of Dr. Fleming's Paper on 'Experimental Researches on Alternate Current Transformers,' read before the Institution of Electrical Engineers in November, 1892, it has become generally known that under certain conditions there is an abnormal rush of current into the primary coil of a transformer at the instant of connecting it to the supply mains." Clearly, Dr. Fleming's recommendation to me to study his Paper and the discussion thereon is somewhat superfluous. Dr. Fleming will also see that I have been careful to give him all due honour for having been the first to investigate the interesting phenomenon of impulsive current rushes.

If Dr. Fleming had taken the trouble to read the introductory portion of my Paper carefully, he could not have failed to notice that the theoretical conclusions which I arrive at in §§ 4—6 apply to a circuit *which does not contain iron*; these conclusions were thus never meant to account *fully* for the current-rushes in transformers. The whole of his criticism on this point, therefore, falls to the ground. The sentence which seems to have caused particular offence, viz., that I was not "aware of any experimental evidence for these current-rushes" (in circuits of constant permeability, as is amply evident from the context) I must still uphold—unless, indeed, Dr. Fleming is prepared to refer me to experiments on this point, or to curves *obtained experimentally*, such as those which appeared in last week's *Electrician*, p. 262. Not a word regarding current-rushes in coreless coils is mentioned in the Paper alluded to above.

Dr. Fleming claims to have investigated "experimentally in the fullest possible manner" the phenomena of current-rushes. Whatever this assertion may mean, if it refers merely to the experiments described by Dr. Fleming and Mr. Mordey in the Paper already referred to, I must absolutely deny that the experimental investigation is either full or satisfactory. Among other things, Dr. Fleming refers in his letter to an experiment made by him to determine whether the rush is unidirectional or alternating. This experiment is described on page 682 of the *Journal* of the Institution of Electrical Engineers, Vol. XXI., and the conclusion arrived at there is that "probably the rush of current is an alternating rush." This view, however, is corrected later on, page 97 of the *Journal*, Vol. XXII., where it is stated that "the whole effect is over in less time than one period." No statement could be more utterly misleading and erroneous. For experimental proof of this I have merely to ask Dr. Fleming to refer to Fig. 6 of my Paper, appearing in this week's issue. The hysteresis loop given by Dr. Fleming on page 98 of the *Journal* is also far from being correct. I hope to publish the correct form in the next instalment of my Paper.

It is not, however, my object to pick holes in Dr. Fleming's statements, and what I have said is merely on account of the half-dictatorial, half-patronising tone about his letter which provokes criticism. I hope my statements will have the effect of shaking Dr. Fleming's confidence in some, at any rate, of his conclusions, and possibly even of leading him to think that the publication of my series of articles is not *altogether* superfluous, and that it is indeed premature to criticise a Paper, only a small portion of which has as yet appeared.—Yours, &c.,

University College, Nottingham. ALFRED HAY.

ENGINE REPAIRS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We have read with much interest the continuation of the article on "Electric Motive Power," by Mr. Albion T. Snell, in your number of the 16th inst.; but upon one paragraph we should like to say a few words.

We are aware that in stating that the repairs to a closed type of engine take a long time to execute, because the casing must first be removed and the rods, &c., cooled, Mr. Snell is only giving expression to an opinion which is commonly held among engineers; the idea is, however, mistaken.

In the Willans engine the only parts which have to be removed are the doors in the casing, each of which can be removed in a few seconds by slackening a single nut. (As now made they are considerably larger than the doors shown in your illustration.) The crank-shaft, main bearings, connecting rods, and brasses are then accessible for inspection or repair, the doors being sufficiently large to allow repairs to be effected. The casing itself, which really forms the standard carrying the cylinders and cross-head guides, does not require to be removed. Even in the event of the cross-head guides requiring examination, the removal of the casing is not necessary. By lifting off the cylinders every part of the engine can be completely exposed. That this is not a lengthy operation is evident from the photograph of our works engine, shown at the Institution of Civil Engineers on the occasion of the reading of the Paper by the late Mr. Willans on "Economy Trials of a Condensing Steam Engine," which we enclose, together with a copy of the note attached.

[This engine was driving Messrs. Willans and Robinson's works as usual at one o'clock this afternoon (April 18, 1893). The parts shown (including everything but the base) were removed during the dinner-hour, and replaced by similar parts taken from store, and the works were restarted as usual at two o'clock. This engine was fixed in July, 1889, and has had unusually severe running, probably equal to nearly five years of ordinary running. No part has been replaced except one piston-ring, and there are very small signs of wear in any part.—April 18, 1893.]

We might even ask if there has ever been another case in which a 60-H.P. factory engine has been completely dismantled, with the exception of the bed-plate, and replaced by a new one ready to begin work, *within one hour* after stopping the works. Remember that the crank chamber upper part (casing), drawn out of store, fitted on the old lower part, *made four years previously*; that the new crank shaft, with its brasses (also drawn

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from store), went into the old bearings; and that the new fly-wheel, also a standard one, had to be coupled up to the old first-motion shaft.

The parts of these engines are light, and can be removed by simple lifting; all packing is metallic, consisting of springs and rings, and the steam joints require no making, being plain metal to metal. Re-erection is therefore easy.

As regards the cooling of the rods, the case of the 60 I.H.P. engine is in point, but in the later engines the temperature of the lubricant in the crank chamber rarely reaches 150°F. in condensing engines, or in non-condensing engines, when, as is desirable, a portion of the feed water is taken through the lubricant in cooling pipes. All parts can be got at without touching the lubricant—its level being sufficiently low to allow of this being done—and, consequently, by the use of a little waste there is no difficulty in removing any part in the crank chamber almost immediately after stopping the engine. We should like to see a competition in quick repairs.—Yours, &c.,

(For Willans and Robinson, Limited) A. LAZENBY.

Picton House, Thames Ditton, Surrey, July 10, 1894.

LEGAL INTELLIGENCE.

Re Woodhouse and Rawson United (Limited).

FRIDAY, JULY 6TH.

Mr. SAMUEL POPE, Q.C., was the first witness called. Examined by the Official Receiver, he said he was not one of the original Directors of the Company, but was appointed on August 5, 1889, at the same time as Sir Rawson Rawson and Sir Leopold M'Clintock. He certainly should not have objected to his name appearing on a prospectus as a Director after he had consented to join the Board, although he had not actually been elected. The prospectus dated July 15th, purporting to be a copy of the original prospectus, and containing his name as one of the Directors, was issued without his knowledge; but he did not know that he should have objected to it.

Mr. JENKINS said that prospectus was never sent out.

The OFFICIAL RECEIVER: 500 copies were printed.

WITNESS: I have no doubt there were several draft prospectuses got out, and if I had given my consent I should not have objected to my name appearing on it.

The OFFICIAL RECEIVER: This is a copy of the original prospectus sent out, and which offered 200,000 Ordinary shares, 150,000 Preference and 100,000 Debentures, stating that the list will open on Monday, July 22nd, and close on or before Wednesday, the 24th.

WITNESS: It is obvious I could know nothing about that, because I was not appointed a Director until August 6th.

The OFFICIAL RECEIVER: That is the point I want to get at. That is the original prospectus containing the names of Sir Albert Cappell, Sir John Coode, and Col. Howard Vincent. Those three gentlemen resigned. This prospectus, it appears, was printed by order of somebody connected with Woodhouse and Rawson. It is an almost identical copy, except that your name, Sir Leopold M'Clintock's, and Sir Rawson Rawson's are given as the original Directors, so that anybody subscribing under that prospectus might naturally suppose that you personally had looked into all these matters stated in this prospectus.

Mr. JENKINS: I think, if the question is to be asked, it should be shown that somebody got a copy of that prospectus.

WITNESS: I do not quite understand to what the question is pointed. Of course, I did not see the prospectus, or was not a party to issuing it until I was appointed a Director, but I should expect that the prospectus would go through several drafts before being issued, and for all I know you have got hold of one of those drafts.

The OFFICIAL RECEIVER said he was not trying to fix any responsibility upon the witness, but merely to bring out the point that Mr. Pope's name was included in the prospectus as if he had joined the board prior to July 15th.

Mr. JENKINS: Then the document speaks for itself.

WITNESS: The inference I draw from that is this. Before July 15th I must have been asked to become a Director and given consent, and whoever did that presumed that what I had given my consent to I should not wish to withdraw from.

The OFFICIAL RECEIVER: That cannot be quite the case. The explanation given in Court yesterday by Mr. Rawson was that a number of fresh copies were printed in case anybody should apply for a prospectus or a copy of the prospectus.

Mr. F. L. RAWSON: It was not a prospectus issued to individuals outside for the purpose of getting capital.

WITNESS: At the first meeting I attended I inquired whether proper investigation had been made with regard to the businesses about to be taken over, and I was assured by Lord Aberdare, then in the chair, that a most careful investigation had been made, and that it was unnecessary for me to incur the time or expense of a second investigation over and above that, because I might be perfectly assured that the Directors had taken every pains to ascertain the correctness of those statements. I accepted that without going further.

The OFFICIAL RECEIVER: Then you did not personally inquire into the facts as to whether the profits of the Limited Company for 1888 were £21,440?—No. I accepted Lord Aberdare's assurance that that had been previously done, and, further, I had an interview with Sir John Coode, whom I knew as a most cautious man, to ascertain whether there was any dissatisfaction upon this head, and he assured me there was not. He told me that he found the subscriptions from the public were not what he had been led to anticipate, and he did not desire to be associated with a company whose working capital he regarded as inadequate. He expressed not the slightest dissatisfaction with anything else.

Did you understand that the business was to be mainly industrial or financial?—I understood that the backbone would be the industrial business, but that the opportunity would be afforded to form companies to work any electrical inventions which our business might enable us to investigate. I should like to say this emphatically, that I cannot comprehend how anyone who attended any meeting of the new Company could doubt as to what its purpose was. It is clearly defined in the Articles, and it is not only so, but I myself and Lord Aberdare, at the first meeting held, expounded to that meeting that it was impossible for the profits shown to have been accomplished by a purely industrial business. I do not comprehend how anybody could have misunderstood the matter. Even on that prospectus I cannot understand any difficulty in the matter.

Is there any reason why it should not have been stated clearly?—I know of none, for we had the anticipation that the financial part of it would be an immensely profitable part of the business. We believed that the boom in companies, and especially in electrical companies, would be perpetual. If it had been perpetual we should not have been here now.

As regards what was taken over, the agreements entered into, did you also adopt those without personal inquiry?—I felt a little bit sat upon when I, coming new on to the Board, proposed to go over again that which the Directors told me had given them so much trouble. I accepted their assurance that it had been gone carefully into. I felt a little bit snubbed when I suggested a further investigation might be interesting to me.

In 1890 the patents appear in the balance-sheet as £74,000. I want to know whether the Directors or yourself took any steps to ascertain whether that amount really represented the value of the patents at that date.—I did not personally take any steps, but no doubt the Directors made any inquiries they thought necessary, and took the opinion of the men best qualified, having more technical knowledge. On every occasion I was at the Board and the balance-sheet was discussed the greatest care was taken by the Directors in informing themselves from such sources as were available as to the correctness of the assets. I do not know that any special investigation was made into the patents; but the whole of the assets were inquired into.

One large source of value in the patents was the lamp patent?—I always understood, in a general sort of way, that one of the most valuable patents was the lamp patent.

That was being worked by the Company under an agreement with the British Company?—That was not sufficiently direct to please me, but I confess I felt bound by higher authorities than myself in such matters when they said that was the proper way of dealing with it.

The Edison-Swan Company had, I think, in the commencement of 1890 commenced an action to restrain this manufacture?—So I understand.

So, at the end of the financial year 1890 there must have been considerable doubt as to that portion of the value?—Not necessarily so, because a patent might be applicable, notwithstanding that in England it was an infringement upon the patent of Edison and Swan, and I understood that Lord Justice Davey had himself intimated that if the manufacture were conducted even in England upon the basis that the shareholders contended for that that would prevent the patent from being an infringement. I, of course, except for the difficulty that Edison and Swan would not allow it if they could help it, would very much rather that we made the incandescent lamps ourselves. I think, further, that if we had been able to develop a trade in incandescent lamps at that time that would have formed a very valuable portion of the business.

You did not allow anything for diminution of value on that special patent?—As the balance-sheet was first prepared there was no question as to that; but ultimately, upon the report of the auditor, there was a reduction made in the value of the patent. I remember we had a discussion as to what the depreciation should be, and we came to the conclusion that the period of the expiry of the patent should be the basis. There was no special sum reserved to meet the possible effects of this action.

Continuing to reply to questions, WITNESS said he was not aware that nearly all of the industrial businesses showed a loss until some time afterwards. It was represented to him that they were doing as fairly well as under the circumstances of a new industrial business could be expected. He always understood, and told the shareholders at every opportunity, that the industrial business could not be expected to yield the profit to provide the dividend they were receiving. He became a Director of the Okonite Company, but he knew nothing of a cheque of that Company for £30,000 being held over, at the Company's request, for a week, nor that in the meantime the United Company, through Mr. Rawson and certain nominees, applied for shares in the Okonite Company, their application money going to supply the money for that cheque. He had some idea that the United Company did apply for shares in the Okonite Company, but he did not know whether those applications were formally authorised by the Board. He was not even now satisfied that the industrial business was conducted at a loss; he should doubt that it was so. He considered the proposal under which the guarantee fund was returned was so eminently satisfactory and in the interests of the shareholders that he did not vote against it, but, on the contrary, approved of it. If he had known the business was being conducted at a loss he would not have been a party to the representations made to the shareholders that it was not. He thought, if it were the fact, the shareholders should have been made aware

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of it. But it had not yet been proved that it had been carried on at a loss. In 1892 he became aware by some process that it was desirable that some special measures should be taken to stop what he then became aware was a leak in the industrial business, and at that period they devoted great attention—constant, wearisome attention—to endeavour to accomplish that purpose. With regard to the return of the guarantee fund, even now he thought that transaction was reasonable, and in the interests of Woodhouse and Rawson United. They were at that time being pressed by the liquidators of the Limited Company; he, personally, had an interview with Mr. Hoster, in which he told him that the profits, as disclosed by the balance-sheet of 1890, showed such figures as to entitle them (the Limited Company) to demand either a rapid payment or some setting aside of the funds that were so shown in the balance-sheet to exist, in order to liquidate that £75,000. Mr. Hoster acted most strenuously in the interests of the old concern, threatening litigation, and a very early impression which he (witness) gained was that the antagonism between Mr. Hoster and Mr. F. L. Rawson arose from the circumstance that the former looked to no interest but that of the old concern, whilst Mr. Rawson sought also to serve the new concern. Relations became very strained between them in consequence of the vigour with which Mr. Hoster put forward the claims of the Limited Company. He (witness) was perfectly certain they would be prevented from issuing new capital by Mr. Hoster unless they did something to set aside that guarantee. That stood in the way of the completion of the liquidation, and when he saw they could by arrangement dispose of that difficulty, and carry out a transaction which in itself seemed to be somewhat advantageous for the Company, he thought they were bound to do it if the shareholders would permit them. The expression "realised profits" was one which he did not understand in connection with a balance-sheet. It might be a very prudent thing for a partnership to say they would not divide their profits until they had actually ascertained them, but it seemed to him that in a company that could not be done, and that the only question was whether at the time of the balance-sheet the assets presented were fairly and reasonably and *bonâ fide* valued. The shareholders who existed at that time were entitled to the profits of that year, and the Directors were not entitled, under the statement that the profits were not realised, to refuse to credit the shareholders of that year with the profits which they had earned at a fair valuation. He did not say that if they had proposed to their shareholders to postpone a dividend until all the assets had been realised it might not have been a prudent thing to do, judging by the circumstances which had arisen since, but he could not conceive that a body of shareholders would have assented to it. He was aware that the basis upon which the Okonite Company's business was purchased was an old valuation, and a difficulty arising through the gentleman who was to become Managing Director declining to admit that valuation, Mr. Vaughan Stephens was sent to America in order to obtain a restitution of some of the assets which had been sold, and the result was the return of £20,000 of the purchase money in shares. He should like to say that the Okonite Company was at this moment a prosperous concern in America. The American shareholders intervened, and turned all the English directors out. That Company had weathered very satisfactorily the terrible financial storm which had passed over all industrial businesses. No dividend, however, had yet been paid on the Ordinary shares. When he learnt that the Managing Director of the United Company (Mr. F. L. Rawson) was connected with the Phœnix Trust Company, and that there was also associated with that Company a man whose name was well known in the City, and who, whatever his ability might be, did not seem to him calculated to add to the prestige of their Company, he was earnest in urging the separation of the Company from a company so managed. He had not known that the Epstein Company was floated on the last day of the financial year until he read of it in connection with these proceedings. His impression about that Company was that if Woodhouse and Rawson had been able to do their duty by that Company and supply it with means it would have been, and would now be, a prosperous concern. He would not have been connected with this Company if he had not caught the electric fever, like so many other people. That brought him into contact with some of the most eminent electricians in the world—Lord Kelvin and others—and before accepting the valuation of the Epstein shares he made every inquiry as to what was the value of the electric accumulator, and he satisfied himself that it ought to be a highly valuable enterprise, for it solved many of the most difficult questions which had been perplexing electricians, especially with regard to traction, for a very long time. It was the fact that the Directors of the United were continually borrowing money during 1891, the reason being that they were very anxious not to call up the shares; he had no share himself in such scruples.

By Mr. PILLING: In February, 1888, he became a shareholder in Woodhouse and Rawson (Limited) to the extent of £500, and in December of the same year he bought 571 Ordinary shares on which 35s. had been paid. When he became a Director of the United, being a little doubtful as to the exact nature of the qualification required of a Director with regard to his holding, he applied for and obtained a sufficient number of shares in the new Company to qualify him apart from his transferred interest in the old Company. Ultimately his interest in the old Company was converted into 115 Preference fully-paid shares and 172 Ordinary fully paid. He had never sold a share. No such dream ever entered his imagination as that he would get his money back four times over from the Limited Company. With regard to the advantage to be gained by the repayment of the £75,000 guarantee, in the first place it was not a cash balance; it was simply a retention of purchase money which would become payable in cash about twelve months later. They must have been then prepared to find £75,000 in sovereigns. In the next place they were able by the arrangement made to reduce that amount by £12,000. Then Mr. Hoster insisted, although witness could not see how the liability arose, that the earnings amounting to £42,000, shown on the balance-sheet ought to be passed to the credit of the £75,000. The only mistake he made, as it seemed to him, in the calculation of the advantage was that he did not at the moment realise that they were converting a debt not bearing interest into a debt which did bear interest.

Mr. PILLING: Had you it on your mind that there was a great overvaluation of the properties acquired?

WITNESS: Do you not see that you are asking me whether I was consciously a fraud?

WITNESS further said he assented to the settlement of Mr. Rawson's account, but resented the suggestion that it was "squared off." In reply to Mr. M'Kay, who put numerous questions as to whether he approved of the issue of the prospectuses, WITNESS said: If I am responsible for the prospectus, I am responsible for it. If I am responsible you must establish my liability. Whatever liability attaches to a Director I cannot set myself free from. I have never repudiated it, and if it is necessary that I should, in order to relieve myself of liability, I have never taken that step.

By Mr. H G. RAWSON: With regard to the account with the Managing Director, his recollection was that long before the completion of the matter there was an arrangement whereby the Managing Director would receive his payment in debentures, and it was considered only fair that he should be entitled to pay his debt in the same way. Sir Rawson Rawson impressed him from beginning to end with the value of his independent services to the Company; he had had a very considerable experience of Chairmen in other companies, and he had rarely seen a more industrious and painstaking Chairman. He had from various causes been very much interested in the Epstein accumulator, especially after the inquiry last year regarding the interference of existing forms of electric traction with telephone and telegraph wires, and his opinion of the value of that accumulator had not altered in the least.

In conclusion, WITNESS said there was just one grain of comfort to him, notwithstanding the unfortunate result of his share in the management had been considerable loss to so many, and that was the absolute knowledge that not one of the Directors had put a single halfpenny in his pocket at the expense of the shareholders.

Mr. STUTCHBURY was recalled, and, in reply to the OFFICIAL RECEIVER, said he had prepared a balance-sheet which showed a loss of £15,000 on the industrial business. He took the Phœnix Trust shares at £25,000, and the Epstein shares at the amount paid for them, £4,000, the amount spent on the Epstein Company was treated as a book debt. The extension of the financial accounts in 1891 to the end of July was done at the direction of the Board, but he did not know their reason for adopting that course. The effect of the extension was undoubtedly to include the Epstein profit, and if that had not been included there would have been a slight loss on the year, or the accounts would have just about balanced. Had the accounts of the industrial business been extended to the same period it would have increased the loss by about £4,000. He had stated that the values placed on the shares and debentures held by the Company in other companies, the stock-in-trade, the goodwill and patents, and the debts due to the Company, were all over-estimated. The Managing Director was in daily communication with Baron Grant; he did not think the Directors were aware of the Managing Director's connection with the Phœnix Trust when that connection was first formed. Letters and circulars were sent out with his name attached to them, which he did not see until after they were sent. He remonstrated with the Managing Director upon one occasion, and the latter was more careful afterwards. There was a constant scarcity of funds in 1891, and witness suggested to the Chairman of the Board that it would be a good thing if the Managing Director would discharge his debt to the Company instead of their borrowing money, but no action was taken upon that suggestion. He believed many attempts were made to realise some of the securities held by the Company, but unsuccessfully. The Maskelyne typewriter was brought to the notice of the Company by Mr. Baker, and a proposal was made that Mr. Baker should join the Board of the Maskelyne Company. Eventually an order was given for the manufacture of certain machines at a certain price, to be delivered within a certain time. Owing to a combination of circumstances the machines were not finished in the time; the Company was hard up for money, and the Maskelyne Company threatened an action. The witness thought the best course would be to resist the action, but the Directors thought that would not be wise, and agreed to sell to the Typewriter Company the whole of the plant and tools, the finished and unfinished machines, for £5,000 or £6,000—paid in debentures.

By Mr. JENKINS: He made up the balance-sheet showing a loss on the industrial business from the balance-book and the profit and loss account, including several sums, such as salaries, wages, &c., really belonging to the industrial account, but not credited to that account in the books.

The further hearing of the case was adjourned until Tuesday.

TUESDAY, JULY 10TH.

Mr. STUTCHBURY again went into the box, and his examination by Mr. Jenkins was continued. He became secretary of the Company in the middle of January, 1891. He was asked by the Official Receiver to get out certain figures, as he wished to check some figures of Mr. F. L. Rawson's. The sheet showing the accounts for 1890 was compiled by Mr. Fox, the Official Receiver's clerk, with the apportionments given by witness of expenses to different departments. He made those apportionments in the light of his three years' experience in Woodhouse and Rawson United, and they were quite fair, being, in fact, in favour of the industrial business. He brought out as the total debit side of the account for that year £44,556. He had included the head office expenses in proportions according to the space occupied by the different branches. His analysis of this balance-sheet and profit and loss account showed a loss on the industrial business of £24,603. His draft balance-sheet, which was submitted to the Directors, showed a loss of £15,000 on the whole of the business. He was not an expert in the valuation of stock, but he knew it was not right to take stock at the old value year after year. There was depreciation of stock in some cases,

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but he contended that there should be depreciation all round. The stock and plant at Kidsgrove were very antiquated and greatly over valued. Money was spent in improving the plant, but he could not say to what extent. Witness upon various occasions suggested that the whole of the stock should be valued by an expert, and also that the auditors who audited the Manchester accounts, and went into the valuation of the stock there should also audit the accounts of the Cadby Hall works. His suggestions, however, were as a rule taken no notice of. He thought there was a good business if it had been properly managed. He attributed the loss to many causes. First, there were too many departments, all more or less cutting each other's throats and trading entirely on their own account. Then there was no guiding hand over the whole lot; and the works were scattered about all over the country, necessitating a large amount of money being spent in carrying them on. There was an increase in the turnover of the Company as time went on; but the profits did not increase. He had several discussions with the Managing Director as to the value put upon the shares of the different companies which they held, and he suggested that as they had not realised any large amount of Okonite stock or shares in the previous year, they ought to take those in at a lower value. He did not pretend to be a financier, nor did he base his opinion upon the merits of the inventions concerned in this and the Epstein case, regarding which he expressed the same opinion. The supply department had been selling a few Epstein accumulators; but there was no large public demand for them, and it was this fact which led him to suggest writing down the value. The way in which he would have treated that matter under the circumstances, the Company being brought out on the last day of their financial year, would have been to have simply taken the amount spent on the invention, and regarding it as a book debt. He would not have included anything as profit for that year upon that head, but would have held it in suspense.

By Mr. MUIR MACKENZIE: At the time, shortly after he joined the Company, that he found it was being conducted at a loss so far as the industrial business was concerned, he thought there should be a good future for the Company, but that it depended absolutely upon the management. He certainly believed there was a goodwill, but was astonished to find it put at so high a figure. That was, however, a subject upon which people might reasonably differ; so much depended upon personality. His opinion was that the goodwill would have been much more valuable but for the financial operations of the Company, for it rested mainly in the industrial part of the business, and people would not put so much faith in them in consequence of their conducting a financial business, as they would have done had they confined themselves to the industrial side.

By Mr. F. L. RAWSON: He could not say that the Directors were desirous of extending the industrial business in the sense of acquiring new works, but certainly they wanted to develop the resources of the works they had, and carry them on at a profit. It would take from two to three years before any large outlay on a business of that kind would become remunerative. Expenditure upon advertising, exhibitions, and catalogues, should show some return at a considerable period. He would be astonished to learn that the value of the time expended by him (Mr. Rawson) upon the preparation of the catalogue and price list for 1889, taken at a reasonable rate, would amount to £1,500. In November, 1891, they were anticipating a large increase of business, and there was a certain amount of new business of a nature requiring outlay before it could be carried out. Most electrical companies made big losses at the outset, or in entering upon new developments. He agreed that, owing to great competition, the profits on contracts were so small that they were swallowed up by the standing charges, and yet it might be necessary to keep up those standing charges in the hope of getting larger work in the following year. He was not, however, in favour of keeping up those standing charges to the full extent. The competition was more severe in their case than in that of others on account of their carrying on a dual business. If they tendered at the same price as other leading companies the others would always get the preference. Had the Champs Elysées work, for which they were negotiating, been carried out there would probably have been £200,000 worth of work done there. The Jensen bell works were closed when it was discovered that they were being carried on at a loss. The stoppage of the lamp business was undoubtedly a severe blow to the Cadby Hall Works. Attempts were made to bring about an amalgamation between the Epstein Company and another Company; but he did not know of any other steps taken to realise the shares in that Company. Mr. North, the manager of that Company, expressed himself very sanguine as to the prospects of success of the industrial business about the end of 1891. Witness could not say what it was that induced him (North) to express such an opinion; but it was a fact that about that time he approached Witness with regard to obtaining money for him without the knowledge of the Managing Director. This witness positively refused to do, and, as his suspicions were aroused, he began to look into matters with which North was connected, and found that there were certain irregularities, which he reported to Mr. Rawson. It was possible that North feared if he reported the true state of affairs in regard to the industrial concerns matters would be looked into and a discovery made of his irregularities. Mr. North had the absolute confidence of the Directors, and witness was never more astonished in his life than when he discovered what had been going on. Witness had always thought there was a possibility of turning the industrial business to good account, and when he was made manager said he would undertake that it should show a profit if all the debts were paid off, and he was given £15,000 clear, not to be interfered with for other purposes of the Company.

By Mr. H. G. RAWSON: His relations with Sir Rawson Rawson had always been most friendly. He had spoken frankly to Sir Rawson, who in return spoke frankly to him, with regard to the affairs of the Company. He believed Sir Rawson gave careful consideration to his suggestions, and discussed them at the Board meetings, but he could not distinctly remember any particular occasion when he took witness's view and advocated it in opposition to that of the Managing Director. Sir Rawson was indefatigable in the attention he gave to the business. When he suggested to the Board that it would be well if the Managing Director would repay the loan made to him, he was not aware of the circumstances attending that loan, nor of the arrangement made with regard to its repayment. He adhered to his statement that the fact of their carrying on a dual business acted prejudicially with regard to the industrial side of the business. Witness himself once had an interview with Mr. Preece, electrician to the General Post Office, and that gentleman told him plainly that he could never recommend the Company whilst it carried on such a business. Witness tried to remove what he regarded as Mr. Preece's misapprehension with regard to the nature of the financial business, and stated that the contract department was really anxious to develop industrial business, but to no purpose.

JOHN MUMFORD, a transfer clerk in the employ of the United Company, was examined as to the withdrawals prior to the allotment, but could throw very little light upon the matter. In reply to Mr. Pilling, he stated that 270 £5 vendors' shares were registered in his name, as the nominee of Woodhouse and Rawson (Limited), for the purpose of registration at Somerset House, and they were immediately afterwards transferred to the Limited Company. In response to a query by Mr. F. L. Rawson, witness said he (Mr. Rawson) was frequently at the offices of the Company into the small hours of the morning.

Sir RAWSON RAWSON was next called, and, replying to the Official Receiver, said he was elected a Director of the United Company on August 5, 1889. He was away in the country at the time the prospectus was issued, and had no part in the preparation or issue of it. He was not in any way interested in any of his son's companies prior to that, but he had been connected with another electric lighting company. He was appointed a member of the Works and Finance Committees, and he took an active part in the work of those committees.

The OFFICIAL RECEIVER: What was your view as regards the business? You have heard what Mr. Stutchbury gave as your opinion?

WITNESS: That is Mr. Stutchbury's recollection. I dissent from it in this respect: he made use of the term financial schemes, and I repudiate that word "schemes" entirely. From the beginning we took over the business of Woodhouse and Rawson (Limited). The principal business, which has been charged against them here is introducing new electrical inventions and working out the patents which they acquired. Now, that could only be done in three ways: first by working the patents or carrying out the inventions by the Company with its own capital, or by selling the patents, or by bringing out the patents through the instrumentality of other Companies formed to work them. It was clear that with our limited capital—too limited from the beginning—we were not in a position to work any number of new patents, or bring out the inventions ourselves. The question then was, was it most profitable to the shareholders of Woodhouse and Rawson United to sell the patents and divest ourselves of any further interest in these inventions, or to put them into the hands of companies from whom we might not only gain an immediate sum, but also a future interest in the working of the patents.

Did you or did you not say that you would in the future probably bring out 10 companies where in the past you had brought out one?—I have no recollection of having said anything of the kind beyond this, that, as from the beginning, as we stated in our first report—

Do you deny that you stated to Mr. Stutchbury that the Company would bring out 10 companies where they had brought out one in the past?—As so expressed, I do. My memory of it is this, as from the beginning it was stated by myself and the Directors, and by Lord Aberdare, that we could not make a profit of 15 per cent.

Will you point to one patent acquired by the United Company that you sold? You mentioned that it was a matter for your consideration as to whether you should part with those patents you had to different companies, or whether you would endeavour to work them yourselves. Have you throughout parted with one single patent which you had acquired?—I do not remember.

Is it not the fact that these companies you brought out were all companies the patents for which you acquired nothing after the Company was in existence? For instance, the Okonite, the Epstein, and so on?—The Okonite and Epstein we were working at from the beginning.

Those were not the patents I understood you to refer to as the patents you had acquired at the formation of the Company.

Mr. H. G. RAWSON: It is not suggested that they took over patents from the Limited Company for the purpose of developing them.

The OFFICIAL RECEIVER: Those patents you referred to were acquired from Woodhouse and Rawson (Limited)?—Some, and some were acquired afterwards. They came into our possession by purchase not only from Woodhouse and Rawson (Limited), but from others, Mr. Baker and others, and we took out patents after we were formed.

Can you point to a single patent that you sold?—Yes, the Elmore.

Did you ever possess the Elmore patent?—I cannot say now whether we possessed the patent. We possessed the right of disposing of Elmore's process.

In what way?—In whatever way we thought profitable.

What was the process?—The process of depositing copper by electricity.

What do you say the United Company acquired?—That privilege of disposing of the right of using Elmore's process.

I put it to you that this was merely an option to acquire shares?—It may be.

Do you call that an option to use this process? Is not that a great mixing up of financial and industrial?—You may call it so. We were interested in bringing out a most important process.

I put it to you that all you possessed was an option to sell certain shares in the Elmore Company?—That may be.

Did you go into the nature of the business of any of these Woodhouse and Rawson Companies after you joined the Board—take, for instance, the

Manufacturing Company ?—The Manufacturing Company was engaged in the manufacture of incandescent lamps, and I looked upon it that we had a patent——

Did you go into the accounts ?—Generally, not specially.

Were you aware that there was a very large loss ?—No, I was not. I was perfectly aware that immediately before the formation of the United Company a large sum had been spent by the Limited Company in the investigation of the value of several inventions which they then had in hand. Continuing, in reply to questions, WITNESS said he supposed he saw the document prepared by Mr. Baker showing the turn-over and the payments in connection with the Manufacturing Company for each month of the six months immediately preceding the taking over of the business by the United Company. At that time the Limited Company was devoting itself to the development of certain inventions which had been brought to its notice, and no profit could be expected from that expenditure at that time. That was one reason for the loss shown. Another reason was that the works at Cadby Hall had become disorganised. The attention of the Managing Director of the Limited Company—he did not know how far he was interested in the Manufacturing Company—had been devoted to trying to bring about the formation of a large electrical company, and this ultimately resulted in the formation of the United Company. To these causes he attributed the losses shown. He knew that since the Edison-Swan Company obtained judgment against them the losses began.

The OFFICIAL RECEIVER: Were you aware in 1890 that there was a considerable loss on the industrial business generally ?—No. The statement put before me by the accountant did not show a loss. I hear here for the first time that it is established that there was a loss in 1890.

Were you aware that the Manchester business showed a loss of £1,905 ?—I was not. Some of the branches showed a loss, and others did not. The statement to which I refer was the analysis of the accounts for 1890, which I sent to Lord Aberdare.

At all events, for the year to June 30, 1890, the gross receipts appear to have been £109,597. There was premium on shares, £4,050; Okonite profit, £37,235; Kensington Stores profit, £17,384; and the Elmore shares profit, £29,437. Those, I think you will agree with me, must be all treated as exceptional items ?—I do not know what you mean by exceptional items.

You could not expect to make another profit of £29,000 on Elmore shares the next year ?—Yes, we could. Not from the same articles, but from business of a similar nature. All this occurred in 1889 and 1890. You must remember the great depression which followed that, in judging of the action of men, and the valuations put upon patents at that time.

Mr. Registrar HOOD: You say you do not regard those profits as exceptional because you laid yourselves out for that kind of business ?—Decidedly. We told our shareholders we were going to do it. We took over the business of Woodhouse and Rawson (Limited), and that was the business of Woodhouse and Rawson (Limited) to acquire inventions and buy patents and bring out those patents.

The OFFICIAL RECEIVER: With regard to the Elmore Companies, you got that profit by acquiring an option from the Limited Company, and that, I put to you, was pretty nearly exhausted by this £29,437. So from that source you could not expect to make a profit on the next year ?—Yes, we could, because we had the American Elmore Company.

Did you hope to make £29,437 out of the American Elmore ?—No, but we expected to make £20,000.

You did not expect to repeat the Kensington Stores profit ?—Certainly not.

Or the Okonite profit ?—That might be repeated annually.

Not from Okonite shares ?—No, but from similar transactions.

This only leaves you, as the receipts on your industrial business, the amount of £21,491, as against an expenditure, exclusive of Mr. Rawson's commission, of £34,737. Those figures would not be very satisfactory ?—I do not see what right you have to exclude all our principal sources of profit and then say the expenses were in excess of the receipts.

It would not be very satisfactory to the shareholders to know that their industrial business was not paying ?—They were informed of it. They knew it.

The OFFICIAL RECEIVER read an extract from a speech made by the witness at a meeting of the shareholders, in which he said there was every prospect that "the success which had hitherto attended the Company would be maintained," and asked: Do you think that was possible, seeing the state of this industrial business ?—What I said then I meant. At that time we had a prospect of negotiating business which would have entailed as large a profit as that made in the first year.

Was there anything in the prospectus to lead people to believe that out of a gross income of £109,000, £88,000 would be earned in this exceptional manner ?—The prospect held out in the prospectus was of a dividend of 15 per cent. on the Ordinary shares, and of 8 per cent. on the Preference.

But how was that to be earned ?—That did not matter so that it was earned honestly. Our Articles of Association gave us unlimited scope, but we confined ourselves almost exclusively to matters connected with electrical inventions.

At this stage the Court rose, the further hearing being adjourned until Friday, the 20th inst.

Woodhouse and Rawson United (Limited) v. Jolin and Co.

In the City of London Court on Monday the plaintiffs sought to recover the sum of £8. 11s. 9d. for goods supplied to the defendants. It appeared that the claim was not in dispute, but the defendants raised a counter-claimfor goods supplied by them to the plaintiffs, for a larger sum. The goods which formed the subject of the counter-claim were supplied before March 10, 1893, on which day Mr. F. D. Leslie was appointed by the Court as Receiver of the plaintiff Company in an action by the debenture-holders, and in that capacity he was still carrying on the business of the Company, and he had sold the goods which were now sued for by the plaintiffs to the defendants. The question was whether the defendants were entitled to set up against the Receiver a claim which he could only prove against the Company, it being in liquidation. This was one of several cases which must of necessity come before the Court, and the people who were being sued were in each case setting up counter-claims.

The defence was that no notice of the appointment of the Receiver had been given until after the contract had been entered into. If the Receiver was not practically the same as the plaintiff's, what right had he to enter into the contract.

Mr. Registrar WILD, before whom the case was heard, pointed out that a Receiver for debenture-holders was different from a Liquidator in a winding-up. There might be a Receiver appointed by debenture-holders without the outside world knowing anything about it. Of course, if the Receiver were acting in the winding-up, the defendants would be supposed to know of the matter. As it was, how were the defendants to know whether they were dealing with the Receiver or with the Company.

Mr. HICKS, for the plaintiffs, admitted it was very difficult, but in this case the Receiver was appointed in open Court.

The REGISTRAR said that made no difference. He did not think there was any difference between a Receiver acting on behalf of debenture-holders and an ordinary Receiver in a partnership action. If there was a dispute between partners a Receiver was put in, and he went on managing the business, as was the case here.

Mr. HICKS pointed out that in a case of a Receiver for partners, he acted for two interested parties. The Receiver in this case was the secured creditor of the assets of the Company, and the defendants were trying to get at his (the Receiver's) assets. The defendants wanted to spring upon the Receiver the debts of the old Company, and the Receiver could not carry on the business if that were to be done.

The REGISTRAR said if the Receiver had dealt with the defendants in his capacity as a Receiver with notice to the defendants, then it would be a different matter. But as it was he must determine to entertain the counter-claim. He would adjourn the case so that the authorities on the subject might be looked up, and then the point could be argued before the judge, with a view to its going to appeal.

The case was therefore adjourned.

National Telephone Company v. Morris Brothers.

At the Sheffield County Court judgment has been given in this action, particulars of which have appeared in *The Electrician*.

The defendants are chemical manufacturers at Doncaster, with works at West Stockwith on the Trent, and the plaintiffs sought to recover £50 rent due for a private wire. There was a counter claim for £50 damages for alleged ineffective service of the telephone wire.

The JUDGE said the claim for rent was admitted, and therefore judgment would be entered for the amount. The counter claim, with which he had only now to deal, was for the damage alleged to have been suffered owing to the defective working and construction of the telephone. The damages were caused by delay in communicating between the works and the office of Messrs. Morris, which had caused delay in executing orders for goods, had put the defendants to additional expense for delivery, and had caused their customers to refuse payment; loss of time was also alleged in unsuccessful attempts to obtain telephonic communication. The contract entered into was that Messrs. Morris should pay £100 per annum in advance for a term of years for the use of a private telephone wire and three sets of instruments between the office at Doncaster and the works at West Stockwith. The conditions of the contract were that subject to the performance by Messrs. Morris of the conditions laid down, the Company would maintain the telephone in good working order. One of the conditions was the payment of rent in advance, and, in point of fact, it had always been in arrear. Another clause was, "In the event of the said wire or apparatus not being in good working order, the Company shall repair and restore the same at its own expense, and with all possible despatch, but the Company shall not be held responsible or liable to the lessee in damages or otherwise howsoever for any delay provided it uses every reasonable endeavour to restore the communication as speedily as possible." From the letters and evidence, it appeared that on numerous occasions the wire was out of order, caused by all kinds of accidents, such as the falling of branches of trees, shooting, rain, and the fumes from Messrs. Morris's works. In every case where a complaint was made to the Telephone Company it was at once acknowledged and attended to. He thought the Telephone Company had a right to complain of the way in which Messrs. Morris had brought the counter-claim. The particulars of the claim covered a space of nearly three years, and the claim was brought by the Company. It was very well observed the other day that in nearly all cases a counter-claim was the result of an after-thought, and until this action was brought Messrs. Morris never thought of claiming. When the claim did come, it was in the most unfair way a claim could come against a company. How could a company explain everything that happened to one particular wire during three years? The counsel for the defence relied somewhat on a letter written by Mr. F. W. Carr, who stated, "We guarantee that the communication between your office and works will be absolutely satisfactory to you, and that any repairs will be attended to at once." There was nothing to show that this gentleman had authority to bind the shareholders, and there was no consideration for this, as was the case in the contract itself. On the whole he thought the Telephone Company had performed their contract as well as such a contract could be performed, because the wire must be subject to sudden accidents of all kinds. They seemed to have remedied the causes of complaints as soon as they were mentioned, and, in his opinion, had taken a great deal of trouble in doing so. In more than one instance a clerk walked the whole length of the

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wire—22 miles—to find out where the fault was. That was extreme carefulness on the part of the Company. He found a verdict for the Company.

Mr. ELLISON, for the plaintiff, asked for costs on the higher scale, and his HONOUR said Messrs. Morris had done very wrong in bringing the counter-claim as they had done, and he should grant Mr. Ellison's request.

Brasyer v. Harness and Another.

The further hearing of this case was resumed on Friday.

Dr. M'CULLY, recalled, was cross-examined by Mr. Witt. Asked as to the prosecution against him for libel, he said he had got two years' imprisonment on account of it, and he served the whole term. That was in September, 1887. It was about two years later that he went into Harness and Co.'s business. Asked about Harness's trusses, he said he knew nothing at all about Harness's truss or belts.

Letters was then read in which witness offered the solicitors to the prosecution to give them his assistance as a witness against the Harness Company.

Mr. FRANK DODD then read the cross-examination of Dr. Lewis Jones, M.R.C.S., given at the police-court proceedings against the defendants, with the object of showing that it was possible to have an electric current even in the unconnected belt.

This closed the evidence for the defence, and Mr. Witt proceeded to call evidence in rebuttal of the defendants' counter-claim.

The case was adjourned until Monday.

MONDAY, JULY 9TH.

On the hearing of this case being resumed,

Mr. COLYER, the plaintiff's solicitor, was further examined by Mr. Witt. When Col. Brasyer first instructed him the colonel was doubtful whether he should take civil or criminal proceedings, and after the *Pall Mall* articles he decided to take criminal proceedings as well as the civil.

Mr. ABINGER: Why was Dr. M'Cully selected for prosecution out of the 130 employés at Harness's?—Because he was the only one Col. Brasyer knew.

Mr. ABINGER: That is your only answer?—WITNESS: Yes; that was the reason. He thought that had all the witnesses for the prosecution —some 400—been called at the police court the result would have been different. He did not say that he thought there would have been a conviction, but he did think there would have been a committal.

Mr. GATEHOUSE, the editor of the *Electrical Review*, called, said he had been for 20 years an electrical engineer. He had never in any way been connected with *Science Siftings*, and had had nothing to do with the articles about Harness and Co. that had appeared in the *Pall Mall Gazette*. The connected belt did generate a very minute current of electricity depending upon the degree of moisture of the skin of the wearer. There was no such current in an unconnected belt. The highest current he had ever found in a connected belt was a $\frac{1}{100}$th of a milli-ampere. If the webbing of the belt became wet the current generated would flow round and round the belt, and not into the body. Where the zinc discs touched the skin the action upon it by the natural perspiration would create oxychloride of zinc, a poisonous salt, which would cause sores upon the skin at the points of contact. He had experimented with the Harness belts from 1892 up to now, and those experiments had confirmed his opinion that no current from the belt passed through the human body.

Mr. JELF cross-examined witness at some length, eliciting that the witness had for a long time taken a strong view against Harness's alleged curative system. His electrical experience did include the effect of electricity medically, in as far as testing Harness's belt, but it was true that that was not the form in which he was most conversant with electricity. He had heard Lord Kelvin say in his evidence in the Alabaster case that, in his opinion, the electric current from a connected Harness belt entered the body. The witness added that Lord Kelvin was then only expressing an opinion, as he said he had never experimented on the subject. Witness admitted that he had in his cross-examination in former proceedings said that where you obtained the chemical action he had described to-day, there would in all probability be an electric current present. He had never gone to Harness's to see the electrical appliances there, though he had had an invitation to do so. Mr. Lynd had written letters to the *Electrical Review*. Shown a letter of Lynd's in December, 1886, to Mr. Harness, he said it had been produced and put in during the police-court proceedings. In it Lynd did suggest to Harness the idea of the unconnected belts; but witness did not look upon Lynd as any authority on that point.

Prof. HORSLEY, called, said that in diseases of the nervous system the use by patients of something in which they believed went a long way in curing them. As regarded Harness's belt, a belief in its efficacy would assist a cure. That was called "suggestion." The origin of charms and amulets no doubt arose from this cause.

Mr. JELF objected to this evidence.

Mr. Justice CHARLES held it admissible.

Examination continued: These belts gave support and warmth to the body, and that alone in hysterical cases would be of benefit to the sufferer. He had seen Harness's belts produced by patients, but had never scientifically examined them. He had studied questions of electricity, and in his opinion the Harness belts had no effect at all on the human body. The resistance of the skin was so great and the current so feeble that the latter could not enter into the body, but would only irritate the skin, and might produce sores.

Mr. Avory cross-examined WITNESS: To have any therapeutic effect it was his opinion that the electric current must pass through the skin, and this was not the case. He did not believe that there were present at all times in the human body electric currents. Scientific men were not all agreed upon that subject.

Mr. WITT, after briefly re-examining this witness, said that closed the plaintiff's case.

Mr. JELF, addressing the learned Judge, asked if it would be convenient for his Lordship to state what would be the questions which he would ask the jury.

Mr. Justice CHARLES, in reply, said that he would ask the jury, first, as regards the issue in the action—(1) whether Harness or M'Cully had been guilty of the alleged misrepresentations, and whether Colonel Brasyer had been induced to part with his money to the defendant by reason of such misrepresentation; (2) whether Harness or M'Cully had been guilty of negligence in treating Colonel Brasyer.

Mr. JELF reminded his Lordship of his submission at the close of the plaintiff's case on the issue in the action, viz., that Harness, being merely the servant of the Company, could not be made responsible for another servant's negligence.

Mr. Justice CHARLES said he bore that in mind; but he thought, as he had said before, that there was some evidence to go to the jury that Mr. Harness—notwithstanding the fact that this business was carried on by a company—was the real head, and his the controlling hand, and not the Company at all. Referring to the issue raised by the counter-claim of the defendants, the learned judge said he should ask—(1) Did Brasyer honestly believe in the case which he laid before the police magistrate? (2) Did Col. Brasyer or his agents (the solicitors) take reasonable care and precaution to investigate the facts upon which the information was laid? (3) Was Col. Brasyer actuated by malice towards Harness or M'Cully? And should these gentlemen, or either of them, be entitled to succeed on their counter-claim, then what damages were they respectively entitled to?

Mr. JELF then proceeded to address the jury for Mr. Harness.

Mr. AVORY followed on behalf of Dr. M'Cully.

TUESDAY, JULY 10TH.

On the hearing of this case being resumed before Mr. Justice CHARLES, the learned Judge summed up. He said that there were two actions to be decided—(1) by Brasyer against Harness and M'Cully for false pretences and negligence; (2) by Harness and M'Cully against Brasyer for malicious prosecution. The plaintiff said that both defendants were parties to the issue of false and misleading advertisements, by which the plaintiff was led to present himself at 52, Oxford-street. M'Cully was not by name a party to the issue of these advertisements, and he was a servant in the service of the Company. Whether he was so implicated in the fraud, if fraud there was, as to be liable, was a question for the jury. Did the defendants represent that they were highly skilled in the treatment of the complaint from which the plaintiff was suffering? His Lordship read various extracts from pamphlets of the Company which had been put in, and said it was clear that Harness had described himself as a "consulting medical electrician." It was no exaggeration to say that he had no medical knowledge; he had studied in no medical school and under no doctor; he was in no sense a scientist. What was what he might call the "note of quackery?" Was it a profession that a single remedy would cure everything? His Lordship read a list of the ailments (including premature old age) said to be cured by the electrical treatment. Could any human being in his senses suppose that all those evils could yield to one thing? The learned Judge then dealt with the evidence at some lengths. With reference to the counterclaim, he pointed out that before the prosecution was begun Brasyer's solicitor, Colyer, had made himself acquainted with all the facts proved in this action, with the extraordinary conduct of the Medical Battery Company in the three actions ending in the spring of 1893. After explaining the law as to malicious prosecution, the learned judge left the following questions to the jury:—As to the claim—(1) Were Harness and M'Cully, or was either, and which of them, guilty of misrepresentations, and was Brasyer in consequence induced to part with his money? (2) Were both or either guilty of negligence in the treatment? As to the counter-claim—(1) Did Brasyer in the prosecution honestly believe in the case laid before the magistrates—(i.) as regards Harness; (ii.) as regards M'Cully? (2) Did Brasyer or his agents act with reasonable care in prosecuting inquiries before they instituted the case—(i.) against Harness; (ii.) against M'Cully? (3) Was Brasyer actuated by malice—(i.) against Harness; (ii.) against M'Cully? (4) What damages, if any, have Harness or M'Cully suffered? Clearly if any damages were due they would be substantial in either case.

The jury returned at 5.30. In answer to question (1), as to the claim, they found that M'Cully had made no misrepresentations; as to Harness they could not agree. In answer to (2) they found that neither Harness nor M'Cully had been negligent. With regard to the counter-claim, they could not agree with regard to any of the questions, or either of the defendants.

Judgment was given for Dr. M'Cully, on the claim, accordingly.

The learned JUDGE said he was prepared to hear further arguments if desired.

Mr. WITT undertook to decide before to-day as to whether he would ask for further argument.

Anglo-American Telegraph Company (Limited) v. Compagnie Française du Télégraphe de Paris à New York.

In our issue of the 29th ult. we gave a *résumé* of the long-protracted proceedings in the action brought by the English Company against the French Company, claiming damages for loss sustained in consequence of the rupture in 1887 of the "common purse" agreement made six years previously.

The final judgment of the Court of Appeal given on Tuesday, was, as was anticipated, in favour of the Anglo Company. The Court held that the P.-Q. Company should have sought the approval of the French Govern-

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ment before breaking the agreement, failing which it acted on its own responsibility and at its own risk. But as it was evident by the Ministerial dispatch of May 21, 1891, that the French Government would not have given its consent to the fusion of the two Companies, the Anglo Company were only entitled to damages for any injury it might have sustained through the rupture for the period between December 31, 1886, and May 21, 1891. The Court was not able itself to assess these damages, and therefore referred the matter to MM. Flory and Verbeecque and a third person yet to be chosen, to determine the amount to be paid as compensation to the Anglo Company. The P.-Q. Company are to pay all costs up to and including this judgment, the question of further costs being reserved.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

SPECIAL NOTICE.

With the next issue of "THE ELECTRICIAN" will be published as a Supplement (Gratis to Subscribers) a large sheet "Practical Wiring Chart."

TENDERS INVITED.—The Waterworks Committee of the Hull Corporation invite tenders for the purchase of land, buildings, wells, bores, pumps, engines, boilers, plant and works recently used at the pumping station of the Newington Water Company near Hull. The land is suitable for a variety of purposes, and especially so for manufacturing premises where a large quantity of water is required. The plant is in good working order. Tenders have to be in by July 20th.

——— The London County Council require tenders for the supply of engines, dynamos, motors, switchboards, &c., for the electric lighting station for the Victoria Embankment and Waterloo and Westminster bridges. Further particulars are given in our advertisement columns, and tenders must be sent in to the Clerk to the London County Council, Spring-gardens, S.W., before 2 p.m. on Tuesday, July 31st. Drawings may be inspected and specifications, &c., obtained at the Engineers' Department, County Hall, Spring-gardens, S.W.

——— The London County Council also invite tenders for the supply of boilers and fittings, steam and exhaust piping, surface condensers, and circular air-pumps and piping required for the electric lighting installation on the Victoria Embankment and Westminster and Waterloo Bridges. Tenders have to be in by 2 p.m. of the 31st inst.

——— The Corporation of Cheltenham invite tenders for the supply and delivery at their central depot of six 12-kilowatt and ten 6-kilowatt transformers. Specifications and other information can be obtained of the Borough Engineer, Municipal Offices, Cheltenham; and tenders have to be sent in to Mr. E. T. Brydges, Town Clerk, not later than 12 noon on the 24th inst.

——— The Carshalton Local Board require tenders for lighting the district with gas, oil, or other illuminant for twelve months from July 31st. Tenders have to be in by noon of the 18th inst. The lighting inspectors of Watlington (Oxon.) also require tenders for lighting by oil, gas, or other illuminant; and the Woking Local Board require tenders for lighting the Woking station and Maybury ward. Tenders must be in by the 18th.

——— The Tunbridge Wells Corporation invite tenders for the erection and completion of an electric light station and chimney shaft in accordance with the drawings prepared by Mr. Arthur Ardron, F.R.I.B.A. Tenders must be in by noon of the 27th inst.

TENDERS ACCEPTED.—The Queen's Hotel Company (Limited), Hastings, has received the following tenders for wiring required at the Queen's Hotel:—

Hastings Electric Light Supply Company (accepted)	£358	13	4
Spiers and Pond, London	510	0	0
Belshaw and Co., London	448	0	0
Strode and Co., London	343	0	0
Roger Dawson and Co., London	300	0	0
Raynes, Smith and Co., London	269	10	0
Fowler, Lancaster and Co., Birmingham	265	0	0

And for the electric light fittings and fixing the following tenders were received:—

B. Verity and Sons, London, W.C. (accepted)	£306	19	0
A. Hands, London	310	9	9
Hastings Electric Light Supply Company	345	18	4
Strode and Co., London	346	11	0
J. Barker and Co., London	411	0	0

——— In reply to the request for tenders issued by the Tunbridge Wells Town Council for machinery, &c., for the electric lighting scheme, 32 tenders were received. These were submitted to Mr. Preece, and the Electric Lighting Committee have recommended the following tenders for acceptance. This recommendation has been adopted by the Council:—

Babcock Wilcox (boilers)	£1,726	0	0
Johnson and Phillips (steam pipes)	277	10	0
ditto. (engines and dynamos)	2,778	13	0
ditto. (arc lamps and posts)	989	1	6
Crompton and Co. (switchboard)	428	10	0
ditto. (transformers)	832	14	0
ditto. (wiring of station)	46	0	0
Callender and Co. (mains)	2,306	12	0
Total	9,385	0	6

TENDERS ACCEPTED.—The St. Pancras Vestry have received the following tenders for boiler and engine-house, &c., at the central station buildings, King's-road, N.W.:—

J. O. Richardson, London, S.E. (accepted)	£7,117	11	1
Steed	7,187	0	0
Godson and Son	7,347	8	0
Pattinson	7,500	0	0
Munday and Son	7,536	17	7
Wilkinson Bros.	7,579	0	0
Mowlem and Co.	8,948	0	0

——— The tender of Messrs. B. Verity and Sons for wiring the Chelsea Town Hall has been accepted by the Vestry for the sum of £277.

——— The tender of Messrs. Jonah, Francis and Son, of Newport, has been accepted for laying down pipes in connection with the Newport electric lighting scheme.

——— The Wolverhampton Corporation have accepted the tender of Messrs. H. Willcox and Co. for the construction of the necessary works and buildings in connection with their electric lighting sub-stations for the sum of £372. 10s., and the tender of Messrs. James Oake and Co., of Alfreton, for the supply of condenser pipes for the sum of £115. 2s. 2d.

——— The Paddington Vestry have accepted the tender of Messrs. Dawson, Hammond and Co. for the supply and fixing of private telephone wires, and sets of instruments to connect the Vestry Hall, the Bridge House, and other wharves belonging to the Vestry.

TENDERS RECEIVED.—The London County Council have received the following tenders for the erection of a generating station in connection with the electric lighting of the Victoria Embankment and the Waterloo and Westminster bridges:—

Messrs. Kirk and Randall	£5,916
Messrs. Foster and Dicksee	£5,562

——— On Monday last the Ayr Town Council met to consider the tenders received for the electric lighting plant recently advertised for. After some discussion the following tenders were remitted to the Electric Lighting Committee. It will be seen from the list that by the acceptance of separate tenders about £900 will be saved over any tender sent in for the whole of the plant and work required. The lowest tender for the whole of the work represents £10,138, and the highest £16,991, but some of the lower tenders are not complete. The actual lowest tender by any one firm is £12,760. Mr. Hammond's original estimate for the contract was within £12,000, and by accepting the lowest tenders in each case the Corporation will expend £11,834:—

Boiler Plant.

Tinkers, Limited	£2,700	Yates and Thom	1,898
George Sinclair	2,431	John Cochrane	1,820
Woodhouse & Rawson United	2,404	James Neilson and Son	1,762
Babcock Wilcox	2,089	*William Arnott	1,563
Anderson and Lyall	2,075	*Daniel Adamson	1,505
Siemens Bros. and Company	2,058	*Penman and Company	980
S. Z. de Ferranti	2,010		

Engine Plant.

John Cochrane	£7,885	John Fowler and Co. (Leeds)	£6,602
S. Z. de Ferranti	7,786	Johnson and Phillips	6,365
ditto. (alternative)	7,730	Siemens Bros. and Co.	5,940
Yates and Thom	7,626	Woodhouse & Rawson United	4,865
S. Z. de Ferranti	7,412	*G. and J. Weir	290

Switchboard and Instruments.

Johnson and Phillips	£902	John Fowler and Co. (Leeds)	£706
S. Z. de Ferranti	795	Woodhouse & Rawson United.	629
Siemens Bros. and Co.	758		

Underground Mains.

William Pollock	£4,038	Henley's Telegraph Works Company	£2,540
Reid Bros.	3,043	John Fowler and Co. (Leeds)	2,509
International Electric Subway Company	2,897	S. Z. de Ferranti	2,231
Walter T. Glover and Co.	2,886	British Insulated Wire Co.	2,146
G. E. Simpson	2,799	Fowler-Waring Cables Co.	2,111
Telegraph Manufacturing Co.	2,774	Silvertown Co.	2,104
Hooper's Telegraph Works	2,651	Ditto. (alternative)	1,952
Siemens Bros. and Co.	2,571	Callender's Bitumen Co.	1,842

* For part only.

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Transformers and Junction Boxes.

C. A. Parsons and Co.	£700	Manchester Edison Swan Co.	£575
Pritchetts and Gold	686	S. Z. de Ferranti	525
Johnson and Phillips	665	John Fowler and Co. (Leeds)	459
Siemens Bros. and Co.	581	Swinburne and Co.............	420

Arc Lamps and Lamp Posts.

Claud Hamilton (Limited)..	£712	Siemens Bros. and Co.	£487
Woodhouse & Rawson United	656	John Fowler and Co. (Leeds)	476
S. Z. de Ferranti	603	International Electric Company............................	318
Johnson and Phillips	541		

Meters.

R. Millar	£640	John Fowler and Co. (Leeds)	£497
S. Z. De Ferranti	590	Siemens Bros. and Co.	492
Chamberlain and Hookham..	535	Westinghouse Electric Co....	423

Overhead Travelling Crane.

Thornton and Crebin.........	£313	Thomas Smith	£241
Woodhouse & Rawson United.	304	Thos. Broadbent and Sons ...	235
John Fowler and Co., Leeds...	302	Marshall, Fleming and Jack..	234
Cowans, Sheldon and Co	297	Alex. Chaplin and Co.	228
S. Z. de Ferranti	291	Fullerton, Hodgart & Barclay..	223
Stothert and Pitt	270	Appleby Bros........................	216
Yates and Thom	264	Siemens Bros. and Co.	203
Bedford Engineering Company	254	Carrick and Ritchie	192
Southgate Engineering Co. ...	246	R. Millar	184

APPOINTMENT.—Mr. J. Bruce Crawford, London, has been appointed Clerk of the Works for the new electric light buildings for the Coventry Corporation. 106 applications were received.

APPOINTMENTS VACANT.—The Governors of the People's Palace, London, E., will shortly appoint for their evening classes a head of the electrical department, at a salary of £150. There are several other minor appointments shortly becoming vacant.

———— The Battersea Polytechnic announce a vacancy for an electrical engineer. Particulars can be obtained of the secretary of the Polytechnic up to the 18th inst.

———— An assistant master for physics and elementary mathematics, at a salary of £120 per annum, and an assistant master for physics and electrical engineering, at a salary of £120 per annum, are required for the Hull Municipal Technical Schools. Particulars can be obtained of Mr. J. T. Riley, D.Sc., Director of Studies, Town Hall, Hull, and applications have to be sent in by the 24th inst.

———— The South-West London Polytechnic require a Principal to undertake the direction of the whole educational work, the higher teaching in at least one department of science, and headmastership of day schools. The salary will commence from April 1, 1895, at £600 per annum. Other particulars will be found in our advertisement columns, and applications must be sent in by the 28th inst. to Mr. F. P. Murray, secretary to the Governing Body, 47, Duke-street, St. James's, from whom forms of application and other details can be obtained.

———— The Corporation of Derby require applications for the post of assistant engineer at a salary commencing at £2. 2s. per week. Further particulars are given in our advertisement columns, and applications must be sent in to Mr. J. E. Stewart, Engineer and Manager, Electric Light Station, Full-street, Derby, by noon of July 21st.

BANKRUPTCY.—A receiving order has been issued against the estate of Edward Percival Oliver, trading as Newington, Priddle and Co., electrical engineers, at 50, Great Sutton-street, Goswell-road, London, E.C. The first meeting of creditors will be held at the Bankruptcy Court, on July 23rd, at 12, and the bankrupt's examination will take place at the same place on August 10th, at 11:30 a.m.

LIQUIDATIONS.—A meeting of the shareholders of the Scottish Electric Supply Company (Limited) is to be held at 5, North St. David-street, Edinburgh, on August 14th, at 12, to receive the account of the winding-up.

SALE BY AUCTION.—Messrs. Wheatley Kirk, Price and Goulty have just issued a catalogue giving particulars of the fixed plant and machinery, loose plant and utensils, stock and stores, patterns and drawings, &c., to be disposed of by public auction, at the Vulcan Iron Works, Market-square, St. Neots, Hunts, on Tuesday, Wednesday, and Thursday next, at 10 for 11 o'clock. The machinery is in first-class working order and by well-known makers, and the stock includes new horizontal steam engines, exhausters, gas holders, wet and dry meters, &c., &c. Nearly 1,000 lots are included in the sale. The catalogue contains full particulars of the train service.

WARNING.—Just now the electrical trades seem to be especially marked out for attention by the swindling fraternity. Last week we received a note from Messrs. Edmundsons; and Mr. Menzies, General Manager of the Consolidated Telephone Construction and Maintenance Company, now sends the following:—"I would caution electrical firms and companies—especially electric lighting, as they appear to be his next happy hunting ground—to be careful of a young man who professes to be in a position to place large orders for distant parts of the globe. His ingenuity is above the average, but unfortunately has, in his travels, got somewhat warped, and after dealing with the familiarity of a Rothschild with figures reaching to thousands of pounds, and after giving Messrs. Glyn, Mills, Currie and Co. as a reference, he wishes to know where he can get some lunch, as he is a stranger in London; and, finally, he winds up, or did in my case, with the information that he has lost his pocket-book! To me, he had come from New Zealand; his name was Harold Stannard; his address, the South-Western Hotel, Southampton; and the railway company he and his father represented was 'The Napier and Wellington.' Neither at the address given nor at Messrs. Glyn's is he known, and I am informed by a legitimate New Zealander that there is no railroad company called by that name."

SHIP LIGHTING.—The Acme and Immisch Electric Works have just completed a combination engine and dynamo plant for a ship in course of construction for the Manchester Ship Canal traffic. The firm have also in hand a 150-H.P. mining plant for South Africa.

IGNITION TUBES.—The Indestructible Ignition Tube Syndicate (Limited) notify that a reduction of 30 per cent. has been made in the price of these tubes.

NON-MAGNETISABLE WATCHES.—Messrs. S. Smith and Son, the well-known London manufacturers of accurate non-magnetisable timepieces largely used by electrical engineers, have just issued a "Guide to the Purchase of a Watch." This is a well-illustrated and admirably got-up treatise on all varieties of timepieces, and contains information which is of considerable interest to the electrical profession. The firm make specialties of their non-magnetisable watches and chronographs.

ELECTRIC CONSTRUCTION COMPANY.—In view of the difficulty experienced by many of the employés of this Company in obtaining suitable residential accommodation, the Directors have decided to erect on a portion of their Bushbury property houses for their workmen. It is stated that 20 houses are to be at first erected, and that subsequently the number to be built will be limited only by the demand.

MESSRS. WALTER T. GLOVER AND CO.—This firm have recently opened new offices, warehouse, staff dining-rooms, &c., in connection with their cable works at Springfield-lane, Salford. Mr. Edmunds, the principal, gave a supper and entertainment to his staff of employés on the occasion of the opening ceremony, to which nearly 400 sat down. In the course of his remarks to the staff, Mr. Edmunds pointed out how satisfactory the growth of the business had been, and the necessity of individual care on the part of all employed by the firm in giving particular attention to every detail, however small, in the preparation of the apparatus and material for which the firm had attained credit in the past, and looked forward to even greater credit in the future. In addition to the added offices, &c., the staff have now been provided with new dining-rooms, new lavatories, and cooking and heating arrangements which will materially add to their comfort. The structural arrangements have been carried out under the direction of Mr. Nodal, architect.

MESSRS. SIEMENS AND HALSKE AND THE ALLGEMEINE ELEKTRICITÄTS-GESELLSCHAFT.—It may not be generally known that the Allgemeine Elektricitäts-Gesellschaft and Messrs. Siemens and Halske, both of Berlin, have since 1883 worked in conjunction with one another. The agreement under which this arrangement has been carried out has still three years to run; but by mutual consent has been annulled. At a recent meeting of the Board of the Allgemeine Elektricitats Gesellschaft the communication was made that the Company had terminated its contract with the firm of Siemens and Halske. In consideration of the present termination of the contract, the A.E.G. pays to Siemens and Halske an indemnity which somewhat exceeds £30,000. Still, according to the agreement now come to, the A.E.G. has the prospect of receiving back from Siemens and Halske at any rate a portion of the above indemnity in the course of time. Under the contract now rescinded the construction and running of central stations, both in Germany and abroad, were to be carried on jointly by the two firms, while in the case of isolated plants the limits restricting the expansion of the manufacturing activity of the Company itself were removed; moreover, an agreement was come to about the prices for glow lamps. Messrs. Siemens and Halske have been relieved from the obligation of giving the A.E.G. the refusal of all concessions which they acquired. A new agreement has been made controlling the supply of cables, which will, it is considered, be advantageous to the A.E.G. The termination of the contract between the two parties has been amicably carried out, and is considered to be advantageous to both.

MESSRS. RUSSELL AND CO.—We have received from this firm of manufacturing electrical engineers and contractors, a newly-issued complete illustrated catalogue of electrical machinery. The catalogue is well printed, consists of over 200 pages of descriptive matter, and can be readily consulted for every variety of plant and apparatus required in electric light and power installations.

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Pollard Glow-Lamp.—Mr. H. L. Merritt, of the Boston Incandescent Lamp Company of Boston (Mass.), is now in London and is seeking to introduce the Pollard glow-lamp in this country. The Pollard lamp, by avoiding the use of platinum leading-in wires, may be expected to have some attraction for manufacturers.

"The Journal."—Part 113 of the *Journal* of the Institution of Electrical Engineers is now ready, and contains a full report of the discussion on Mr. Crompton's Paper on "The Cost of Electrical Energy," and also a Paper by Mr. H. D. Wilkinson, "Notes on the Electrical Tramway System of the United States and Canada."

Catalogues and Price Lists.—We have received from Messrs. W. T. Glover and Co. a complete set of their various catalogues and price lists, which the trade can obtain on application either at Salford or to the London office, 39, Victoria-street, Westminster, S.W. The list includes wires and cables, dynamo and transformer specialities, Glover's patent armature bars, Trotter's wire gauge, Glover's jointing apparatus and materials, patent cable suspenders, &c., &c.

———— Messrs. Drake and Gorham send us an advanced copy of their revised catalogue. Every effort has been made to include in the new catalogue only such information as is likely to be of service and to be easily understood by those contemplating country house lighting and the putting in of electric lighting plant. The catalogue includes information that it is frequently difficult to obtain in such publications, such as the brake horse-powers which can be economically and safely obtained from the different sizes of engines. Messrs. Drake and Gorham claim that the figures given are reliable. The various price lists have been carefully revised, including that of the D.P. batteries ; the illustrations are confined to apparatus actually in general use ; and shippers will find the catalogue of value, as care is taken to set out in detail the necessary plant and apparatus for installations of various sizes.

Agency.—Messrs. Crosier, Mills and Co., have been appointed agents on the North-East coast for Messrs. Holden and Brooke (Limited), of Salford, and are making a display of injector and other steam specialities at Collingwood-street, Newcastle-on-Tyne, where also they invite inspection of a number of labour-saving devices.

Annual Outing.—The *employés* of Messrs. Rashleigh Phipps and Co. held their annual excursion on Saturday last, a gathering considerably in excess of previous years journeying to Brighton, and passing a pleasant day.

Barnet.—Messrs. Joel and Co., who have already had some experience in the lighting of this district, have notified the Local Board that they intend applying for a Provisional Order for the Barnet District Electric Supply Company. The matter has been referred to the Electric Lighting Committee.

Bath.—Notice has been received by the Corporation that the City of Bath Electric Lighting Company intend applying for a Provisional Order to supply electric current within the area of the city. This power the Company now hold under a Board of Trade licence, which restricts them to a certain area, and which gives the Corporation power to purchase the works at the end of seven years from the date of the licence. The matter has been referred to the Electric Lighting Committee for consideration and report. The date of the Company's licence is 1890.

Bedford.—A Local Government Board inquiry has been held by Major-Gen. Crozier in respect to an application of the Bedford Corporation for sanction to borrow £12,000 for its electric lighting scheme. Opposition was made to the proposal by Mr. W. B. Jessop on behalf of the Bedford Electric Lighting Company on the ground that the ratepayers should be acquainted with the total cost of the complete scheme before money was borrowed.

Bristol.—The Local Government Board have sanctioned the application of the Corporation for powers for borrowing £24,650 additional capital for electric lighting purposes. This will enable the Electrical Committee to clear off existing liabilities, and to make several extensions.

Burnley.—Notwithstanding that only about half of the promised subscribers to the Corporation electric lighting scheme have carried out their promises, nearly 5,000 incandescents are now in use in the district. This is considered by the authorities to be an excellent start, and additional applications are being received, which will shortly exceed the capacity of the plant at present installed. The plant is giving every satisfaction in its working.

Church and Chapel Lighting.—The Congregational Church at Castlegate, Nottingham, is now lighted electrically. The church has been connected-up with Messrs. Perry's factory in Stanford-street, where electrical plant is provided. The installation work is being carried out by Messrs. Danks and Co. It is intended ultimately to take the current from the Corporation mains.——The choir at Bristol Cathedral is to be lighted by electricity.

Commissioners of Sewers.—The Streets Committee have considered applications received for the appointment of electricity works inspector, and have resolved to submit for ultimate selection the following names :—T. A. B. Carver, B.Sc., C.E., G. Gerhardi, jun., and A. A. Voisey. The final selection will be made on Tuesday next.

Cork.—Mr. T. G. Fraser has given notice to the Corporation of his intention to apply for a Provisional Order for lighting the city by electricity.

Country House Lighting.—Under the superintendence of Mr. A. A. C. Swinton, Messrs. Edmundsons (Limited) are lighting Elveden Hall, Suffolk, recently purchased by Lord Iveagh. About 500 incandescents will be used. The plant consists of steam engines and dynamos with battery of accumulators.

Darlington.—The Town Council have referred an application from a number of the inhabitants of the Borough for the supply of electric light to a sub-committee for consideration.

Dover.—The charge for electric current has, we understand, been fixed by the Dover Electric Light Company at 8d. per unit, with a minimum charge of 13s. 4d. per quarter,

Fareham.—The proposal of the Local Board to purchase the Fareham Electric Light Company's undertaking does not apparently meet with the unanimous support of the ratepayers, and at the last meeting of the Board considerable opposition was manifested. After an exciting debate the Chairman announced that the contract for the purchase of the undertaking was not yet completed, and must be deferred for consideration at another meeting.

Folkestone.—Mr. Councillor Baker's scheme for the electric lighting of Folkestone is to be presented to the Town Council on the first Wednesday in August. Printed copies are to be sent to each of the members of the Council.

Geelong (Victoria).—The Crompton Electric Supply Company of Australia have submitted estimates to a sub-committee appointed by the town of Geelong and adjoining boroughs, for the electric lighting of the several districts. The Company's proposals have been accepted, subject to a report to be presented by Mr. Ellson, the electrical engineer, to the Mayors of the districts concerned.

Grasmere.—The Local Board have had official intimation from the Windermere and District Company of the Company's intention to apply for statutory powers for supplying current within the Grasmere district. The subject is to be discussed at a future meeting of the Board, the opinion being expressed that the Grasmere authorities are in a favourable position for themselves supplying electric current to the district.

Halifax.—About twelve months back the various rooms and decorations of the Masonic Hall were overhauled at considerable expense. It has now been decided to light the Hall throughout by electricity, which will save the heavy expense of redecorating after a short period. The work has been entrusted to Messrs. Walter Emmott and Co., of Halifax.

Hammersmith —The Electric Lighting Committee of the Vestry have received a report from a sub-committee stating that they have not yet been able to go fully into the report of the Vestry's engineers concerning the electric lighting question. The Committee recommend that applications should be made to the Board of Trade asking for an extension of time for a further two years for the compulsory carrying-out of the electric lighting Order.

Hartlepool.—At the last meeting of the Town Council it was decided to apply for a Provisional Order for electric lighting purposes, which was estimated to cost about £300.

Harrow.—A ratepayers' meeting has been held at the offices of the Local Board to discuss the electric lighting question. The Town Clerk gave a *résumé* of the steps that had been taken by the Local Board in the matter, commencing with the year 1888, when Messrs. Crompton and Co. sent in an estimate for lighting the town by electricity. This scheme was not carried through. In 1893 Messrs. Joel and Co. gave notice of their intention to apply for a Provisional Order for lighting the district, and the Local Board themselves decided to apply for a Provisional Order. The Board had considered the matter, and had come to the conclusion that if it were worth the while of a private company to apply for powers, then it was only right for the Local Board to consider the subject and keep the lighting of the district in their own hands. It is probable that another meeting will be held to discuss the subject shortly.

Helensburgh (Scotland).—The Scottish House-to-House Company has given notice to the authorities of its intention to apply to Parliament for an electric lighting Provisional Order for supplying electric current to this district. The Police Commission have decided to oppose the application.

Ilfracombe.—The Great Western Electric Lighting Company have given notice of their intention to apply for a Provisional Order to supply electric current to Ilfracombe.

Islington.—The Vestry have approved the recommendation of the Special Electric Lighting Committee with regard to the accept-

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ance of the designs for the electric lighting station sent in by Mr. Tiltman, as mentioned in our last issue, subject to the approval of the London County Council. The Vestry have engaged Mr. Tiltman as the architect to superintend the erection of the works, and have decided to advertise for builders and to proceed as soon as the County Council's approval has been obtained.

KEIGHLEY.—It has been decided by the Town Council to call a special meeting to authorise an application to the Board of Trade for powers to supply electric current within the Corporation's district.

KENSINGTON.—The Vestry, having discussed the question of an increase in the salary of Mr. Philip Monson, the Vestry's lighting engineer, have decided that an increase shall be given from £300 to £330 per annum. Additional duties have recently been undertaken by Mr. Monson in the supervision of overhead wires, electric lighting mains, &c. Permission has been given to the House-to-House Company and to the Kensington and Knightsbridge Company to extend their mains to Redcliffe-gardens and a part of the Fulham-road, and to Stamford-road, Kensington, respectively.——The Commercial Electricity Supply Company (Limited), recently formed, has given notice of its intention to apply for a provisional order to supply electricity in portions of Kensington parish.

LANCASTER.—The Board of Guardians are to be asked at their next meeting to give their consent to the application of the Morecambe Electric Lighting Company for permission to carry out their contract with the Lighting Inspectors at Sandilands.——The Windermere and District Company are about to apply for statutory powers to supply electric energy within the Lancaster district.

LAMBETH.—Notice has been given to the Vestry by the St. James and Pall Mall Electric Light Company, of its intention to apply for a Provisional Order to supply electric current for public and private purposes within the borough of Lambeth.

LARNE.—A heated discussion took place at the last meeting of the Town Commissioners on the electric lighting question. The principal business before the Commissioners was the signing of an agreement with the liquidator of Messrs. J. E. H. Gordon and Co. for the lighting of the town for three years from August 15th next. Under the contract 11 1,700-c.p. arcs, 6 32-c.p., and 66 16-c.p. incandescents are to be used. The dispute which arose was as to a penal clause, and after much discussion this was added to the agreement, which was then approved.

LONDON COUNTY COUNCIL.—At the adjourned meeting of the Highways Committee on Tuesday last, a motion was carried that designs should be obtained for the electric lamp standards to be erected on the Victoria Embankment, the Highways Committee to take the necessary measures for the purpose, and to advise the Council what premium should be offered for the best design. It was suggested that the President of the Royal Academy be asked to adjudicate on the designs when they are sent in.

MONTROSE.—The Town Council have been notified by the Northern Electric Supply Company, of Aberdeen, of their intention to apply for a Provisional Order to enable them to supply electric current to the Montrose district.

MULLINGAR.—The Irish Electrical Supply Company will shortly apply for a Provisional Order for lighting this district by electricity.

NEWCASTLE.—The Town Council have agreed to the expenditure of £470 for installing the electric light at the Newcastle Town Hall.

OBAN.—A number of prominent tradesmen in this district are introducing the electric light into their premises.

PADDINGTON.—The Vestry have decided to obtain the information asked for in a requisition from a number of prominent ratepayers referred to in our last issue.

PRIVATE BILLS.—The Bill conferring further powers to acquire lands, &c., on the Charing Cross, Euston and Hampstead Railway Company has passed through the Committee stage in the House of Lords. In the House of Commons the Crystal Palace and District Electric Supply Company's Bill, for extending their system, has been passed, and schemes under which Messrs. Crompton and Co., and the Holloway Electricity Supply Company, are entrusted with similar powers in Chelmsford and Guildford respectively have reached their third reading.

PROVISIONAL ORDERS.—The Clonmel Provisional Order, which has already passed the Upper House, has now passed through the Commons, and is reported for third reading.——The Plymouth Provisional Order has been read a third time and passed.——The Monmouth Provisional Order, which has passed through the Lords and Commons, has been referred back, in order that the compulsory and other areas shall be certified.——The Chesterfield Provisional Order has received the Royal Assent.——The Yeadon Local Board's Provisional Order has passed the Committee stage of the House of Commons.——The Provisional Order applied for by the Wakefield Corporation has passed the Committee stage of the House of Commons.——The Aberdare Electric Lighting Provisional Order, which has passed the Upper House, has been reported for third reading in the House of Commons.——The Order applied for by the Birmingham Electric Supply Company has passed through Committee of the Commons.

RAMSGATE.—The Town Council have decided to give notice of opposition to the Brush Provincial Company's application for a Provisional Order to light the district by electricity.

RUGBY.—The Rugby School Electric Lighting Company are making considerable extensions, and have now connected up the new science department, lecture-rooms, &c.

SALISBURY.—The Town Council have instructed the General Purposes Committee to expend a sum not exceeding £50 in obtaining the services of an electrical expert, to advise the Council in electric lighting matters.

SCARBOROUGH.—The Electric Supply Company, which has now been in operation nine months, reports an equivalent of over 9,000 8-c.p. lamps connected to its mains. Messrs. C. A. Parsons and Co. have on order from the Company a turbo-alternator to give 75 kilowatts complete with condenser.

SHEFFIELD.—It is proposed to extend the electric lighting mains to the Broomhill and Ranmoor districts, and the plans have been approved by the Highway Committee of the Corporation.

SHOREDITCH.—The Vestry are memorialising the Board of Trade for an extension of time in connection with their electric lighting scheme. The question of the appointment of an electrical engineer was deferred.

STEALING.—James Brindley, a wireman, in the employ of the Telegraph Construction Corps, was summoned at Birmingham for stealing 50lb. of wire belonging to the Postmaster-General, and was sentenced to two months' hard labour.

SUNDERLAND.—The brewery of Messrs. C. Vaux and Sons, in Castle-street, has just been fitted throughout for the electric light by Mr. R. Vaux, engineer, of Bedford Works, Sunderland, to the specification and under the superintendence of Mr. G. W. Lummis-Paterson, of Newcastle-on-Tyne. The plant includes an Otto gas engine, a Taunton dynamo, D.P. accumulators, a 3,000-c.p. Crompton-Pochin arc lamp, and about 200 16-c.p. incandescents.

TAUNTON.—The Corporation Electric Lighting Station was inspected last week by Dr. Fleming, who, at the request of the Electric Lighting Committee, came down to examine the results of the improvements and alterations which had been made at his suggestion. When the Corporation took over the station of the Taunton Electric Lighting Company last September Dr. Fleming was invited to advise the Corporation. He reported that it would be necessary to begin laying the mains underground, and that certain additions and extensions to the station plant were absolutely necessary. He at once drew out a scheme for the formation of transformer sub-centres, and the first of these centres is now complete. In the central portion of the town a secondary circuit has been laid down, consisting of a ring main of triple concentric Fowler-Waring cable. This is fed by three feeders proceeding from a transformer station under the municipal offices. This station is provided with two 30-kilowatt Thomson-Houston transformers. All the house transformers in the centre of the town have been removed, and the customers jointed on to the secondary distributing main. Arrangements are being considered for the formation of other sub-centres. In the station a small Thomson-Houston 30-kilowatt alternator, supplied by the Laing, Wharton and Down Construction Syndicate, has been put down, which is driven by a 50-H.P. Bumsted and Chandler engine. This alternator does the light-load lighting. The boiler plant has been increased by the addition of a 105-H.P. Davey-Paxman Economic boiler. The steam piping, formerly in a very unsatisfactory condition, has been remodelled. Steel drums have been erected over the Babcock and Paxman boilers, and cross-connections made, so that any of the boilers can be put into connection with the engines. The Paxman boiler is primarily intended to work the arc lighting plant, but it supplies steam also for the Bumsted engine when that is doing the light load. The whole of the erection of the steam piping and the other alterations as suggested by Dr. Fleming in his reports, have been carried out by the Borough Surveyor (Mr. James Smith), and the Borough Electrical Engineer (Mr. Harold Couzens). The Electrical Committee have expressed themselves as very much pleased with the results of these changes in the plant. After making his inspection, Dr. Fleming was entertained at dinner by the Electrical Committee, the Chairman (Mr. W. Potter) being supported by the Mayor (Mr. Alderman Van Trump), Mr. Alderman Chapman, the Town Clerk (Mr. T. Meyler), the Borough Surveyor, Mr. Massingham, Mr. Newton, and others interested in the electric lighting of Taunton. Dr. Fleming reported fully to the Taunton Town Council on the following day as to the effects of the recent improvements and the probable direction of future extensions. Since the Corporation took over the station there has been a considerable increase in the number of customers, and there are now the equivalent of 3,348 8-c.p. lamps connected to the circuits. The Fowler-Waring cables and the electrical and engineering plant and apparatus generally have given the fullest satisfaction.

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TORQUAY.—The Electric Lighting Committee has recommended the Town Council to retain the electric lighting powers conferred by their Provisional Order in their own hands, but for the present it is desirable to await the development of the scheme relating to the refuse destructor.

TUAM.—The Irish Electrical Supply Company have notified the Town Commissioners of their intention to apply to Parliament for powers to supply Tuam with electric current for lighting and power purposes.

TUNBRIDGE WELLS.—The tenders accepted by the Town Council for machinery, &c., for the electric lighting scheme will be found in a previous column. It will be seen that these are well within Mr. Preece's estimate, and that the outlay on the first portion of the work will not exceed the amount specified by the Electric Lighting Committee. It is expected that the tender for the erection of the buildings will be accepted at the Council's next meeting.

WALSALL.—A Local Government Board inquiry has been held in reference to the application of the Corporation for powers to borrow £22,000 for electric lighting purposes. It was stated that the estimated rateable value of the town was £151,210. The area of supply is the whole of the borough, which is of a scattered character. The Town Clerk said that there had been no application by any person or company within the area to provide electric current in the district. It was probable that ultimately the town would be called upon to supply the large district of Bloxwich, lying north of the borough. The Corporation's scheme had been submitted to the Board of Trade, and had received its approval.

WALTHAMSTOW.—It is stated that a movement is on foot to establish a local company to undertake the introduction of the electric light.

WEST BROMWICH.—A deputation from the Town Council has inspected the system of overhead electric traction in operation on a portion of the South Staffordshire Tramway Company's lines, with a view to sanctioning an extension of the branch from Darlaston to Handsworth.

WEYBRIDGE.—At the last meeting of the Lighting Inspectors a copy of a letter, sent by the Weybridge Electric Supply Company to the Board of Trade in reply to an inquiry regarding the placing of the electric lighting wires underground, was deferred for further consideration at a later date.

WHITEHAVEN.—The Town and Harbour Trustees have discussed a recommendation of the Electric Lighting Committee that application should be made to the Local Government Board for further borrowing powers on electric lighting account. Mr. Dees stated that the original powers allowed for £14,000 to be borrowed, and the work done under the original contract had only cost £12,295, or £1,700 less than the original estimate, but in carrying out extensions from time to time additional works had been sanctioned, which were not included in Dr. Hopkinson's original scheme; for instance, 43 arc lamps more than was at first provided for had been erected, the result being that up to the present time £15,494 had been expended. The amount of current supplied and work done generally in connection with the electric lighting scheme were as much as the present plant could cope with, and it was therefore desirable that an extra pair of engines should be provided, and it was consequently proposed that powers for borrowing a further £5,000 should be asked for. It was pointed out that the electric light was already a great success, and that in the near future a large profit would be derived from the supply of electric current. Mr. Jacques, a member of the Trustees, stated that he found in actual use that the electric light had proved to be in his case cheaper than gas.

WINDERMERE.—The Windermere and District Electric Lighting Company have given notice of their intention to apply for a Provisional Order for lighting this district by electricity. The Local Board some years ago obtained the necessary powers, but the time for working has expired. The Gas and Water Committee have the matter under consideration.

WOOD GREEN (LONDON, N.).—The Local Board have discussed an application of the Tottenham and Edmonton Electric Light and Power Company for sanction to apply to the Board of Trade for power to supply the district with electric energy. It was decided by the Board to first of all ascertain the names of the gentlemen forming the Company before any decision was arrived at.

WORCESTER.—It has been decided that the Watch Committee of the Corporation shall organise an exhibition of electrical appliances, &c., in the Public Hall, in October next, by which time the Corporation will be in a position to supply electric energy to private consumers. It was pointed out that by holding such an exhibition those citizens who were at present in doubt as to the advisability of putting electric light fittings into their premises would be enlightened, and would be in a position to select from the exhibits of the leading electric light fittings and apparatus makers, who would doubtless take the opportunity of displaying their wares for their own and the public benefit.

COMPANIES' MEETINGS AND REPORTS.

Eastern Telegraph Company (Limited).

The forty-fourth half-yearly general meeting of the Eastern Telegraph Company was held yesterday (Thursday) at Winchester House, Old Broad-street, under the presidency of Sir John Pender, G.C.M.G., M.P.

The SECRETARY (Mr. George Draper) having read the notice calling the meeting, the report of the Directors was taken as read.

The CHAIRMAN stated that the gross revenue for the half-year under review—to March 31st last—had been £389,314, being an increase of £16,461 as compared with that of the corresponding period of 1892. Analysing the message receipts from various sources, they found very little difference between the figures of last year, although there was an increase of about £4,000 in the Trans-Indian traffic and a small increase in the Cape traffic. The new cable of the South African Company to Seychelles and Mauritius was working satisfactorily, and that Company was now receiving a subsidy from Her Majesty's Government at the rate of £28,000 per annum. The results, so far as they had gone were fully up to their expectations. The principal increase in the gross revenue was due to their having received £29,500 from their investment in the shares of the Eastern and South African Company, as against £17,700 in the corresponding period; but, although there was an increase in the amount received this half-year, it was due to their having decided to pay the bonus at the end of the financial year, instead of half-yearly as formerly. The total amount received for the year ended March 31, 1894, was the same as that received in 1893. The total ordinary expenses for the half-year ended March 31st last amounted to £102,219, as against £102,499, or a decrease of £280. The working expenses at the stations had been £76,642 in the past half-year, as against £79,926, or a decrease of £3,284. The principal decrease was in stationery and printing for stations. Several other items also showed a substantial reduction, while in others there had been an increase. The principal item under the latter head was in salaries and wages of their staff at stations. This was due to the operation of the scheme to provide a regular scale of promotion to the superintendents and the other members of the staff. Travelling expenses also showed an increase of £398. This was an item which must necessarily vary and depend in a great measure on the number of men home on leave after serving the specified number of years abroad. With reference to other items shown separately on the revenue account, there was an increase in maintenance ships' reserve fund of £2,755. They had done very little work for foreign Governments and other telegraph companies this half-year, so that the full charge for depreciation on the ships was borne by themselves. Full provision had been made for depreciation on their spare cable, and the currency balances at stations had been written down to their actual sterling value on March 31st last. Expenses attending repairs and renewals of cables had amounted to £49,660, against £32,533, or an increase of £17,127. They had been at work on their own cables, with the exception of a small repair for the Spanish Government, so that credits derived from foreign Governments and other telegraph companies were small as compared with the same period of 1893. They had completely overhauled the steamship "Chiltern," and fitted her with new triple expansion engines and boilers, cable tank, &c., and had applied £18,000 in reduction of same out of the maintenance ships' reserve fund, which, however, remained at the substantial figure of over £53,000. They had at present three ships laid up in London; but, as he had often told them before, and as he now repeated, they were better pleased when their ships were idle, unless they were at work for other people. After providing the usual amount for interest on debentures, debenture stock, and Preference shares, they were able to propose the usual final dividend of 1¼ per cent. and bonus of 1½ per cent., making, with the interim dividends already paid, a total distribution of 6½ per cent. for the year ended March 31, 1894, and to carry the sum of £110,000 to the reserve fund, against £88,000 in the corresponding period of last year. They had also applied a further sum of £53,316 from reserve fund in reduction of the cost of the Aden-Bombay No. 3 cable and other capital expenditure, so that their capital expenditure on account of cables, &c., remained, as it had done for many years, at the same figure. Meantime they had greatly strengthened their position by duplications and in other ways, and had in this manner greatly increased the market value of their property. The total amount applied out of the reserve fund now amounted to £1,345,644. They had added to their capital investments £55,660 in the shares of the Europe and Azores Company. He had already explained to them that that Company was formed to lay a cable from Lisbon to the Azores, bringing those islands into direct telegraphic communication with their general system. In consideration of carrying out this work they had received an extension of their exclusive rights in Portugal, which in a great measure would recoup them for having made this investment. They had not anticipated that the Europe and Azores Company, so long as the cable only reached as far as the Azores, would give much return on the capital invested; but there were other considerations in the concession which might shortly be fulfilled, and he had no doubt that when the matter was fully developed, the Eastern Company's position would be considerably improved by being associated with this latest development of submarine telegraphy. The fact that they were paying the usual dividend and carrying £110,000 to the reserve fund was no small indication of their continued success. He had had a great many years' experience of commercial life, and he could assure them that he had never known such a prolonged term of depression as had existed, not only in London but thoughout the world. There was, however, he had no doubt, a better time coming. The Colonies had plenty of room, and they might depend upon it that the colonists' energies would not long lie quiet. When they became energetic again there would be a great response in

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London, because, after all, a good deal of the money had to come from London. When the revival took place times would be good for their submarine telegraph system. Six months ago he stated that the Eastern and South African Company, in which the Eastern Company were the largest shareholders, had completed the Seychelles-Mauritius cable. That was a great work, and a very important addition to their system. The Azores cable had also attracted a good deal of attention, and it was now in their hands. Submarine telegraphy had become an important factor with all Governments, as was evidenced by the recent conference at Ottawa, at which representatives from this country and from the whole of the British Colonies were present. The principal question discussed at the Conference was the Pacific cable, and he was pleased to say that the conclusion arrived at on this matter showed judgment. A resolution was passed that soundings were to be taken, and that at the proper time the cable was to be laid. If it ever was laid the shareholders might depend upon it that those who had the most experience of cables would have a finger in the pie. The success which had attended their working during the last 25 years had been such that no great enterprise could be undertaken without their being consulted in some way. Their relations with all the Governments were most satisfactory. Next week they were going to celebrate the 25th anniversary of submarine telegraphy. He concluded by moving the resolution.

The VICE-CHAIRMAN (the Most Hon. the Marquis of Tweeddale) seconded the motion.

Mr. BAINES referred to the sound position of the Company, and said he thought that a higher dividend might be paid on the Ordinary shares.

The CHAIRMAN, in reply, stated that the Directors would be only too glad to pay an increased dividend when they felt that they would be justified in doing so. That time, however, was not yet.

The resolution was then unanimously passed.

On the motion of Mr. JOHN NEWTON, seconded by Mr. BAINES, a cordial vote of thanks was passed to the Chairman and Directors for their services.

The CHAIRMAN, in acknowledging the compliment, said it was extremely gratifying to his colleagues and himself to receive a vote of thanks from the shareholders at the instance of two gentlemen like Mr. Newton and Mr. Baines, who had formerly been among their principal critics. If Mr. Baines had all the information which the Directors were possessed of, he was sure that that gentleman would feel satisfied that the policy which the Directors were pursuing was not only the most prudent one, but also the best in the permanent interests of the Company generally.

The proceedings then terminated.

(A full report of this meeting will appear in our next issue.)

West African Telegraph Company (Limited).

The ninth ordinary general meeting of this Company was held yesterday (Thursday) at Winchester-house, Old Broad-street, under the presidency of Sir John Pender, G.C.M.G., M.P.

The SECRETARY (Mr. John Cambrook) read the notice calling the meeting, and the report of the Directors was taken as read.

The CHAIRMAN then said: Gentlemen, before asking you to adopt the report and accounts, I will, as usual, make a few remarks on the accounts and the position of the Company generally. Our gross revenue for the year 1893 amounted to £61,847, as against £60,923 for the year 1892, or an increase of £924. There is an increase in Cape joint-purse traffic and also in certain local traffic; but, on the other hand, there is a decrease in the traffic with the French and British stations and with South America, so that the net increase in the message receipts is £644. Although the loss on exchange is still very heavy—namely, £7,751—it is £293 less than it was in 1892. The total working expenses for 1893 amounted to £18,829, as against £20,019, or a decrease of £1,190; the principal decreases being under the heading of general expenses in London £333 and in working expenses at stations, £819. The most rigid economy is practised, and it is satisfactory to note that those expenses over which the Directors have control show such a considerable reduction. Repairs to cables amounted to £31,234, as against £13,964 in 1892, or an increase of £17,270. Full details of the work done on account of repairs during the year will be found in abstract C of the report. As foreshadowed at the last general meeting, the cost of repairs during the last year has been exceptionally heavy; but, looking to the fact of our relations with the other companies, who are, with us, so much interested in the joint-purse traffic with the Cape, it was absolutely necessary that every endeavour should be made on our part to maintain the through communication. We have, therefore, at considerable cost, diverted the cable, as far as it was considered necessary, out of the region affected by the River Congo, and we can only hope that the cable will now be free from the frequent interruptions which have taken place in that district. In order to meet the deficit and to balance the revenue account we have, as stated in the report, applied the sum of £10,741 from the reserve fund, and we trust that the result of next year's working will prove more satisfactory. The Directors sympathise with the shareholders in their having again to go without a dividend, but they may rest assured that every consideration has been given to the matter, and the cause of the heavy expenditure has been beyond the control of the Directors. It is not a very pleasant report on this occasion that we have to submit. I never present any report or make any statement which results in no dividend without considerable pain. I may tell you that this Company has, so far, very much disappointed us. It has completed the link, it is true, in supplying Africa with telegraphic communication wherever it is brought from the interior; but, unfortunately, our cable in the first instance was not laid in proper water. I do not attach any blame to anyone for that, because we are only finding out from day to day and from time to time the difficulties of submarine telegraphy. If we get a good sound bottom we are sure that our cable will lie safely and work for a very long period of time, but if we get a bottom which is influenced by the current of such a great river as the Congo, we are sure to have disturbances; and in this case those disturbances occurred so frequently that we finally resolved to carry the cable out to sea about 140 miles. We are now, I hope, working more satisfactorily. We have another great difficulty to meet in the exchange. As I have just said, £7,700 has gone in that way, and in a small company that is an enormous loss. How or when that is to be remedied it is difficult to say. There is only one way of dealing with it, so far as we ourselves are concerned, and that would limit traffics—namely, by charging extra rates. We do not, however, find that that answers, so far as regards giving us very much more money, but we keep all these things in view; and my own impression is that if we are anything like fortunate in having our cable free from breakages, and, consequently, from repairs, we shall soon get into a sound state, and be able to meet our shareholders with a great deal more pleasure than we do on the present occasion. I can scarcely say more than that the most rigid economy is being exercised in every possible way, and I am hopeful that the money we have spent will enable us to work so efficiently that we shall soon be able to pay a dividend. With these remarks I beg to move—

"That the report and accounts for the year ending December 31, 1894, submitted to this meeting, be, and they are hereby, received and adopted."

Sir HENRY C. MANCE, C.I.E., M.Inst.C.E., seconded the motion.

The CHAIRMAN expressed his readiness to answer any question, but no shareholder rising to address the meeting, he put the motion in the usual way, and it was carried unanimously.

Sir H. C. MANCE then proposed the re-election of the retiring Directors, Sir John Pender and Mr. Thomas Fuller. He regretted that Mr. Fuller was absent on account of illness, but that gentleman was associated with companies with which their own undertaking was closely allied, and with which they had most advantageous working agreements, and he was a most useful and valuable member of the Board. With reference to Sir John Pender, nothing that he could say would add to the opinion of the shareholders regarding that gentleman's merits as Chairman of the Company. Only those who were closely associated with Sir John Pender could fully appreciate the great attention which he gave to the affairs of the Company. He was sure that no one felt more keenly than the Chairman did in having to meet the shareholders without a dividend, but he (the speaker) was perfectly certain that they would soon rejoin the ranks of dividend-paying companies under Sir John Pender.

Mr. ROBERT K. GRAY seconded the motion, which was unanimously adopted.

The CHAIRMAN: I am very much obliged to you for this further mark of your confidence. I can only say that if good wishes and close attention to the interests of the Company will bring about a dividend soon, you may depend upon it that it will come. This cable forms a very important link in a great system, and there is no link in the chain which ought not to have its fair proportion of remuneration; but when you see the sum of £31,000 paid for repairs on the one hand, and the heavy loss I have mentioned by exchange on the other hand, a very good traffic is required to meet such drawbacks. I might, however, have remarked upon one other point, which is that we are passing through extraordinary financial depression; but, as a cycle of bad times is followed generally by a cycle of good times, I hope that the good times will come, when we shall be able to meet you with a more favourable statement. I will only add that it will be the wish of my colleagues and of myself to bring that about as soon as possible.

On the motion of Mr. ALEXANDER HENDERSON, seconded by Mr. CUNLIFFE OWEN, the auditors, Messrs. Deloitte, Dever, Griffiths, and Co., were re-elected.

The CHAIRMAN: I think I have said before here, and I take the opportunity of repeating it from time to time, that with the way in which our accounts are audited they are practically controlled by the auditors—not controlled in the sense of alterations; but these gentlemen see that every item is dealt with in its proper place, and that no items are put into the accounts which ought not to appear, properly and honestly, where they are shown. They have long been associated with our telegraphic enterprise and understand it thoroughly well, and they do their work as they ought to. That concludes the business of the meeting.

On the motion of Mr. CUNLIFFE OWEN, seconded by Mr. J. T. EAST, a vote of thanks was passed to the Chairman and Directors for their able administration of the Company's affairs.

The CHAIRMAN: It is a great satisfaction to me, even at a meeting like this, to have such an expression of opinion on the part of the shareholders as to the manner in which we discharge our duties. We as much regret the absence of a dividend as any of you, but I hope that this will not last long.

The proceedings then terminated.

NEW COMPANIES, STATUTORY RETURNS, &c.

[In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1894, pages 274-300, *&c., &c.]*

AMERICAN AND PARISIAN MASSAGE COMPANY (LIMITED).—This Company has been registered with a capital of £10,000 in £5 shares, to enter into an agreement with F. Kennedy, and to provide premises for the carrying on of massage and medical electricity.

BELCHER'S PATENT SMOKE-PREVENTER COMPANY (LIMITED).—This Company has been registered with a capital of £1,000 in £1 shares, to acquire certain patents relating to improvements in the furnaces of steam boilers.

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EGYPTIAN TRAMWAYS CONSTRUCTION COMPANY (LIMITED).—This Company has been registered with a capital of £6,000 in £1 shares, to acquire, develop, and deal with tramway concessions in Egypt and elsewhere.

STANDARD WIRE COMPANY (LIMITED).—This Company was registered on July 4th, with a capital of £50,000, in £10 shares, to purchase the business of manufacturing wire, carried on by the Standard Wire Company, at Sowerby Bridge, Yorks.

W. AND F. WILLS (LIMITED).—This Company was registered on July 3rd, with a capital of £10,000, in £5 shares, to acquire the business of mechanical and consulting engineers, millwrights, and iron and brass founders, carried on under the style of W. and F. Wills.

RIVER PLATE ELECTRICITY COMPANY (LIMITED).—The annual return of this Company made up to May 31, 1894, was recently filed. The nominal capital is £500,000 divided into 49,900 Ordinary shares of £10 each, and 1,000 Founders' shares of £1 each, 13,557 Ordinary, and 892 Founders' shares, have been taken up, and 2,400 Ordinary have been issued as fully paid. Upon the remaining 11,157 Ordinary and 892 Founders' shares, the full amounts have been called, resulting in the payment of £110,892, and eaving £1,570 as yet unpaid.

RONALD A. SCOTT (LIMITED).—An agreement, dated June 20, 1894, with Mr. Ronald A. Scott, states that as part of the purchase consideration 1,000 £1 fully-paid shares, Nos. 1 to 1,000, have been allotted to the vendor.

SAXBY AND FARMER (LIMITED).—The first annual return of this Company, made up to June 29th, has been filed. Out of a nominal capital of £25,000, in £10 shares, 2,021 have been taken up, and of these 1,800 were issued as fully paid in part payment of the purchase consideration. Upon the remaining 221 shares the full amounts have been called and paid.

SYNDICATE OF ELECTRICAL ENGINEERS (LIMITED).—The annual return of this Company, made up to March 27th, has just been filed. Out of a nominal capital of £10,000, divided into 1,900 Ordinary and 100 Founders' shares of £5 each, 1,007 Ordinary and all the Founders' shares have been taken up, the latter being issued as fully paid. Upon the Ordinary shares calls amounting to £4 per share have been made, resulting in the payment of £4,003. 10s., and leaving £24. 10s. in arrears.

CITY NOTES.

CAPE TOWN AND SUBURBAN ELECTRIC LIGHTING SYNDICATE (LIMITED).—It is stated that a dividend of 5 per cent. has been declared by the Directors of this Company.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended July 8th were £879, as against £1,069 in the corresponding period of 1893 (which included the Royal Wedding-day, July 6th), being a decrease of £190. The total receipts for the half-year amount to £24,515, as against £23,679 for the corresponding period of 1893, an increase of £836.

CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).—The revenue return of this Company for the quarter ended June 30th is as follows:—Sale of current for public lighting, £3,162, against £2,839 in the corresponding period of 1893; private lighting, &c., £7,153, against £3,074—total, £10,315, against £5,913. The equivalent of 8-c.p. lamps connected in June, 1894, was 99,140, against 45,562 in June, 1893.

DIRECT UNITED STATES CABLE COMPANY (LIMITED).—The Directors of this Company have resolved to recommend a final dividend of 2s. per share, free of income tax, to be paid on and after the 25th inst., and making, with the interim dividends already paid, 2⅝ per cent. for the year ended June 30th. £6,000 is placed to reserve, and a balance of £1,031 17s. 2d. carried forward. The transfer books of the Company will be closed from the 10th to the 24th inst. inclusive.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).—The interest on this Company's Four per Cent. Mortgage Debenture Stock for the half-year ending July 31st inst. will be paid by warrant on August 1st next. The Stock Register will be closed from the 27th to the 31st inst., both days inclusive.

EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY (LIMITED).—The eleventh ordinary general meeting of the shareholders of this Company will be held at the Cannon-street Hotel, E.C., on Thursday, July 26th, at 11 a.m., when the report and accounts of the Directors will be discussed.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic returns of this Company for June, 1894, amount to £24,000, and from January 1st to June 30, 1894, £129,800. In the corresponding months of 1892 and 1893 the amounts were £128,800 and £134,800 respectively.

LONDON TRAMWAYS COMPANY (LIMITED).—A meeting of the shareholders in this Company was held on Tuesday last, and Mr. D. P. Sellar, who presided, dealt at length with the result of the lawsuit between the London Street Tramways Company and the London County Council before the Court of Appeal. He said it was much to be regretted that the plaintiffs were the London Street Tramways, which Company came into existence in 1870, and was therefore not able to appeal to the Act of 1869 to elucidate the meaning of the purchase clause of the Act of 1870. Their own Company and the North Metropolitan Company were in a different position, both being established by an Act of Parliament passed in 1869. Although the purchase clause in their Acts was altered in conformity with the General Tramway Act of 1870, they could still appeal to their Act of 1869 to prove the meaning of the Act of 1870. By the purchase clause of the Act the Company was to get paid "full value" for its tramways, &c., and to have not only payment for goodwill of the business, but also for "prospective value"—that was to say, for future profits; a payment was also to be made to compensate the Company for compulsory sale. In the 1870 Act this clause was altered to "then value," and after "value" came in the excluding clause, "exclusive of any allowance for past or future profits of the undertaking." The fact was, the County Council desired to acquire the most profitable section of the dividend-paying tramway companies, valuing them at structural cost, less depreciation, which was simply a game of "Heads I win, tails you lose."

MANITOBA ELECTRIC AND GAS LIGHT COMPANY.—The interest due on July 1st on the debentures of this Company have not been paid. This is stated to be owing to legal difficulties, which will shortly be removed.

NATIONAL TELEPHONE COMPANY (LIMITED).—The Directors of this Company have resolved, subject to final audit, to recommend at the forthcoming general meeting the following dividends, less income-tax, for the six months ended June 30th last:—At the rate of 6 per cent. per annum on the amount paid up on the First and Second Preference shares; at the rate of 5 per cent. per annum on the amount paid up on the Third Preference shares; at the rate of 5 per cent. per annum on the amount paid up on the Ordinary shares, making, with the interim dividend already paid, 5 per cent. per annum for the twelve months ended June 30th, and leaving a balance of about £67,000. The transfer books of the Company will be closed from July 13th to 26th, inclusive, and dividend warrants will be posted on the latter date.

NOTTING HILL ELECTRIC LIGHTING COMPANY (LIMITED).—A meeting of the shareholders of this Company, called for the purpose of considering some slight alterations to the Articles of Association of the Company, was held on Tuesday last at the offices, Bulmer-place, High-street, W. This Company has declared a half-yearly dividend on its Preference shares at the rate of 6 per cent. per annum.

PRINTING TELEGRAPH AND CONSTRUCTION COMPANY (LIMITED).—The action brought against this Company by Mr. Elvey has been settled, it being agreed that an order should be taken striking Mr. Elvey's name out of the list of shareholders.

SOCIETE FRANCAISE DES TELEGRAPHES SOUSMARINS.—The annual meeting of the shareholders of this Company was held in Paris on the 28th ult., when the accounts were approved, and M. Rouget, the retiring Director, was re-elected. The meeting also ratified the election by the Board as Directors of Messrs. F. Sollier and Le Raguet de Brancion.

ST. JAMES AND PALL MALL ELECTRIC LIGHT COMPANY (LIMITED).—The current sold by this Company during the quarter ended June 24th, last amounted to £7,380, against £5,848 for the corresponding period of 1893.

STOCK EXCHANGE NOTICES.—The Stock Exchange Committee have ordered the £30,000 Four and a-Half per Cent. Debentures, Nos. 1 to 600, of the Direct Spanish Telegraph Company (Limited) to be quoted in the Official List.

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED)—This Company have declared an interim dividend of 12s. per share.

THE TELEGRAPH IN NORTH BORNEO.—Speaking at the meeting on Tuesday of the British North Borneo Company, Mr. R. B. Martin, M.P., who presided, said that the cable had been successfully laid between Singapore and Labuan by the Eastern Extension Telegraph Company, and arrangements had been made with that Company, in condition of their connecting Labuan with the Company's territory, to continue a land-line across to Sandakar. He took that opportunity of complimenting the Eastern Extension Company on the prompt and business-like manner in which this work was carried out; and must also mention that in all their dealings with that Company in this matter they had been met in the most liberal spirit. From all information which they could gather, communication could be established for a moderate sum, which had been voted for the purpose. It was impossible to tell the exact sum, but it would not be more, probably, than £7,000 or £8,000 at the outside. Although this undertaking might not be immediately reproductive, the importance of it must be apparent to all; for instance, it takes three months to get a reply to a letter from Borneo, and formerly it took a month to get a reply by wire. Recently we have been in communication with our Governor, receiving a reply to a message sent off at 5 p.m. at 11 a.m. on the following morning. The track through the country may discover tobacco land or minerals which will recoup the outlay. It will bring us more *en rapport* with the natives of the interior, and will be a great boon to the traders, planters, and others interested in the development of the country. We know that as far as Labuan is concerned the line will be constantly in use, and, being so near it, we hope we shall find our merchants able to use it to a considerable degree. I look for very great advantage, both direct and indirect, from the introduction of the telegraph into our country. The energy displayed by the British North Borneo Company's officers entrusted with the work of helping to connect Labuan with our territory by cable was especially noticed and reported upon by the telegraph company's officials.

WATERLOO AND CITY RAILWAY COMPANY.—A general meeting of the shareholders of this Company is to be held at Waterloo Station, S.W., on Thursday, August 9th, at 2:30 p.m.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended July 6th (after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited), were £2,378.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the two weeks ending June 30th were £2,279, as compared with £2,295 for the corresponding period of last year.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share	Last Divi-dend.	Name.	Previous Week's Price, July 4.		Price Wednesday, July 11.		Rate per Cent. Yielded. £ s. d.	Dividend Due.	Business Done During Week Ending July 11. Highest	Lowest
			TELEGRAPHS.								
£1,012,880	Stock	9 0	Anglo-American	38	41	37	40	6 4 6	Jan., Apr., July, Oct.	37	..
£2,933,560	Stock	18 0	Do. Preferred	72	74	71	73	6 10 6	" "	73¼	72
£2,933,560	Stock	5/0	Do. Deferred	6½	7	6½	7	..	January and July	6¾	..
£184,500	100	4%	African Direct Teleg. 4% Deb. (Reg. & Bearer) xd	100	103	100	103	3 17 8	Mar., June, Oct., Dec.	..	..
130,000	£10	3/0	Brazilian Submarine xd	12	12½	12	12½	5 4 0	January and July	12⅛	12
£18,700	£100	5%	Do. 5 per Cent. Bonds	101	104	101	104	4 16 2	June and December	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906) xd	107	111	107	111	3 16 11	Jan., Apr., July, Oct.	..	..
10,000,000	$100	$1¾	Commercial Cable Capital Stock	139	143	139	143	4 17 11	February and August	..	..
16,000	10	8/0	Cuba Submarine	12	13	12	13	6 3 1	" "	12¼	..
6,000	10	10%	Do. Preference 10 per Cent.	18½	19½	18½	19½	5 2 7	April and October	19¾	..
12,931	5	1/7½	Direct Spanish (fully paid)	4	4½	4	4½	4 8 11	" "	..	..
6,000	5	10%	Do. Preference 10 per Cent.	9	9½	9	9½	5 5 3	Jan., Apr., July, Oct.	..	..
60,710	20	2/0	Direct United States Cable, 1877	8½	9½	8	9	6 13 4	" "	9⅞	8¼
400,000	10	2/6	Eastern	15	15½	15½	15½	4 3 0	" "	15¾	15
70,000	10	6%	Do. 6 per Cent. Preference	15¾	16½	16	16½	3 12 9	May and November	16⅛	16
£1,297,847	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	113	116	114	117	3 3 5	February & August	116	114
£102,100	100	5%	Do. 5 per Cent. Debentures, 1899	107	110	107	110	4 10 11	Jan., Apr., July, Oct.	..	..
250,000	10	6/6	Eastern Extension	15½	15¾	15½	15⅝	4 8 11	February & August	15¾	15¼
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	114	118	114	118	3 7 10	January and July	–	..
£62,700	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900 xd	103	106	103	106	3 17 3	" "	..	..
£95,100	100	5%	Eastern and S. African 5 p. Cent. Mor. Deb., 1900 xd	103	106	103	106	3 17 3	February & August	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures, 1909 (regd.)	105	108	105	108	3 14 1	May and November	..	..
£200,000	£25	4%	Do. 4% Mauritius Sub. Debs.	107%	110%	107%	110%	3 12 9	Jan., Apr., July, Oct.	..	..
180,227	10	2 6	Globe Telegraph and Trust	8¼	8¾	8½	8½	4 11 0	" "	8¾	8¼
180,012	10	6%	Do. 6 per Cent. Preference	15½	15¾	15½	15⅝	3 17 5	Jan., April, and July	15¼	15⅛
150,000	10	5 0	Great Northern xd	20½	21	20½	21	4 0 0	March & September	21	2¼
£190,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	105	108	105	108	4 12 7	May and November	107¾	..
17,000	25	37/6	Indo-European	43	45	44	46	5 8 8	" "	45	41¼
37,548	10	5/0	London Platino-Brazilian	5	7	5	7	..	March & September	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	107	110	107	110	5 9 1	..	..	..
£100,000	£100	4%	Pacific European Tel. 4% Guar. Debs. "Red" 1942 xd	101	104	101	104	3 16 11	April and October	..	..
11,830	8	4/0	Reuter's	5	6	5	6	..	" "	..	..
3,381	£100 Cert.	35/0	Submarine Cables Trust 6 per Cent.	110	115	109	114	5 5 3	January and July	..	..
15,609	10	5/0	West African Telegraph	3	5	3	5	..	March & September	..	..
£249,900	100	5%	Do. 5 per Cent. Debentures	102	105	102	105	4 15 3	January and July	..	..
30,000	10	2/0	West Coast of America	2½	3	2½	3	..	June and December	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902 xd	96	101	96	101	7 18 5		..	..
88,321	10	9d.	West India and Panama	1	1½	1	1½	..	May and November	1⅛	1⅛
31,563	10	6%	Do. 6 per Cent. 1st Preference	10	10½	10	10½	5 14 3	" "	10⅛	..
4,669	10	6%	Do. 6 per Cent. 2nd Preference	9	10	9	10	6 0 0	June and December	..	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917 xd	107	110	107	110	4 5 7	May and November	109¼	..
64,242	15	7/6	Western and Brazilian	6½	7	6½	7	..	..	..	..
33,129	7½	7/6	Do. 5 per Cent. Cumulative Preferred	5½	6½	5½	6½	..	..	..	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	1¾	2½	1¾	2½	..	February & August	..	..
£171,900	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	107	110	107	110	5 8 9	" "	109¼	..
£214,800	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	107	110	107	110	5 8 9	May and November	..	..
$1,211,000	$1,000	7%	Western Union 7% 1st Mort. (Building) Bonds	115	120	115	120	5 16 8	March & September	..	..
£166,900	£100	6%	Do. 6 per Cent. Sterling Bonds	100	104	100	104	5 5 5		..	..
			TELEPHONES.								
44,000	5	10/0	Chili Telephone (fully paid)	1½	2½	1	2	..	May and November	..	..
224,850	10/0	2⅞d.	Consolidated Telephone Const. & Maintenance	1/16	1/16	1/16	1/16	..	Yearly	⅛	..
171,504	£1	6d.	Oriental Telephone and Electric (fully paid)	⅜	⅝	⅜	⅝	..	June and December	..	..
484,597	5	2/6	National	4⅞	5¼	4⅜	4⅞	5 2 7		5¼	4¾
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	15	16	14½	15½	3 17 5	" "	15 1/16	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	14½	15½	14	15	4 0 0	" "	14¾	14⅝
119,234	5	2/1	Do. 5% Non-Cumulative 3rd Pref.	5⅜	5⅞	5½	5⅞	4 0 11	January and July	5⅞	5⅛
1,000,000	Stock	4½%	Do. Debenture Stock, 4½% xd	109	112	109	112	4 0 0		..	..
58,000	5	1/0	United River Plate	1½	2	1	2	..	" "	..	..
£146,733	Stock	5%	Do. 5 per Cent. Debenture Stock xd	90	100	90	100	5 0 0	" "	..	–
			ELECTRICITY SUPPLY COMPANIES.								
40,000	£10	..	City of London Electric Lighting (fully paid)	12½	13½	12½	13	..	..	12¾	12¾
40,000	10	6,0	Do. 6% Cumulative Pref. (fully paid)	13¾	14½	14	14½	4 2 9	..	14 1/16	14
19,900	£5	..	Electricity Supply Co. for Spain	..				..	..	..	..
£30,000	£5	2 0	Charing Cross and Strand Electricity Supply Corp.	4½	5½	4½	5¼	–	..	..	..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900 xd	127	139	..		..	..	..	..
8,322	£5	..	House-to-House Electric	..		..		–	..	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	..		..		–	January and July	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..		..		–		..	..
45,000	£5	2/6	Liverpool Electric Supply (fully paid)	6⅝	6½	6½	6⅝	–	..	6¼	–
111,100	5	..	London Electric Supply	..		..		..	..	..	..
49,900	£10	5/0	Metropolitan Electric Supply (fully paid)	8½	9	8½	9	2 15 7	June and December	8¾	..
£100,000	Stock	5%	Do. 5% Debs. (Bonds of £10, £20, and £10)	108	111	109	112	4 9 3	..	..	..
6,452	£10	..	Notting Hill Electric	4½	5¼	4½	5¼	–	..	–	..
19,950	£5	4 6	St. James and Pall Mall	7	7½	7	7½	..	..	..	..
20,000	£5	7%	Do. 7 per Cent. Preference	8½	9	8½	9	3 17 9	..	8¾	..
59,900	5	2/6	Westminster Electric Supply (fully paid)	6¼	6¾	6¼	6¾	2 19 3	–	6¼	
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
90,000		1 6	Brush Electrical Engineering	2¾	3	2¾	3	6 0 0	..	2 13/16	2 3/16
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	2⅝	2⅞	2⅝	2⅞	5 1 1	March & September	2⅝	..
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	109	112	109	112	4 0 4	January and July	..	..
20,000	5	2/6	Crompton and Co., 7 per Cent. Cumulative Pref.	2¼	3½	2½	3	–	..	..	..
12,139	5	..	Edison and Swan United	–		–		..	..	–	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	..		..		..	–	–	..
120,000	2	..	Electric Construction	¾	⅞	½	⅞	..	–	–	–
12,845	2	..	Do. 7 per Cent. Cumulative Pref.	1¼	1¾	1¼	1¾	..	..	..	–
91,195	2	10/0	Elmore's Patent Copper Depositing	1⅛	1⅜	1⅛	1⅜	..		1 1/16	..
20,000	5	.	Fowler-Waring Cables (fully paid)	¾	1¼	¾	1¼	..	February & August		
50,000	10	15/0	India Rubber, Gutta Percha, &c., Works	23½	24½	23½	24½	5 2 9	March & September	24½	2¾
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	105	106	108	105	4 5 9		105	..
15,995	£10	6/4	International Okonite Ordinary	..		..		..	December and June	–	..
16,000	£10	..	Do. 8 per Cent. Preference	..		..		–		–	–
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid)	½	½	—	½	..	May and November	–	..
78,949	5	3/6	Swan United (£3 10s. paid)	..		..		..	March and July	..	..
37,350	12	36/0	Telegraph Construction and Maintenance	40	42	40	42	5 14 3	January and July	41½	..
£150,000	100	5%	Do. 5 per Cent. Bonds xd	102	105	102	105	4 13 6	..	..	..
37,514	£5	–	Woodhouse and Rawson Ordinary (£3 15s. paid)	–		..		..	–	–	..
41,098	£5	–	Do. Preference (fully paid)	..		–		..		–	..
			RAILWAYS AND TRAMWAYS.								
£630,000	Stock	4%	City and South London Railway	36	38	36	38	1 16 2	May and November	36½	31½
£37,130	Stock	4%	Do. 4% Perpetual Debenture	119	121	119	121	3 6 2	May and November	..	.
7,000	10	5%	Do. 5% Perpetual Preference	12½	13	12½	13	3 16 11	..	13	13
37,500	£10	1%	Liverpool Overhead Railway	8¼	8½	8¼	8½	..	..	8¼	..
0,295	10	5%	Do. 5% Preference	12¾	13¼	12¾	13¼	3 16 2	..	..	..
£125,000	Stock	4%	Do. 4% Debenture	110	112	110	112	3 11 5	January and July ..	–	..

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THE ELECTRICIAN:

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NOTES.

The Committee appointed to report on the distribution of a grant of £15,000 for University Colleges in Great Britain have presented their report, which has just been issued as a Parliamentary Paper. With the exception of a grant being made to Bedford College, London, and the reduction of the original (1891) grant to Nottingham, the list stands in practically the same state as when first drawn up three years ago. It is remarkable that the whole of this particular grant falls to English institutions. Owens College, Manchester, heads the list with £1,800 per annum; the next being the London University College, which is to receive £1,700. Seven provincial colleges follow, each receiving £1,200 or more; and Bedford College, London, ends the regular list with £700. These make a total of £13,300, and the balance is offered to King's College, London, "on condition of its removing within the present year the denominational tests from all its teachers, other than theological." The recommendation made by the Committee that, except in cases of inefficiency, the grants should be continued without readjustment for a period of five years, has been accepted by the Treasury. We gather from a letter written by Dean Wace to *The Times* that the constitution of King's College, London, is such as to preclude the removal of the "religious test" from its staff of teachers, and that the abandonment of the Parliamentary grant on the conditions imposed is inevitable in this institution.

The experienced medical man alone knows the thousand dangers of every breath, every footstep, and, indeed, every act of man's life; and it is well that nervous laymen should remain in ignorance of the calamities which might befall them at any moment. A correspondent points out this week that Hertzian waves might set up or start an arc between neighbouring conductors during a thunderstorm, and he treats the matter as a serious danger. Not long ago a solemn warning was given about the risk of embroidering table-cloths with metallic thread, since it was alleged that a thunderstorm had actually ignited or singed such a fabric, though the house was not struck. The case seems to have been unique; but, so far as we are aware, no instance of the arcing between conductors during a thunderstorm has occurred in ordinary house wiring. Hundreds of armatures of dynamos and motors have been burned out through lightning flashes, but that is another problem. Attention was called some time ago to the sparking of gas pipes during a thunderstorm; but the fact remains that not a single fire has been recorded, in this country at all events, during a thunderstorm that could be attributed to a secondary effect in electric lighting conductors. That such an accident is conceivable is not to be denied, and in the meantime we should like to see some simple and unpatented substitute for wood casing.

Our American contemporary, the *Electrical World*, recently discussed in an editorial note the question of the value of sine curves for the electromotive force of alternators. We have ourselves already remarked on this question, and have expressed our opinion, which we know to be shared by alternator experts in this country, that the elaborate attempts which are being made by some of the American alternator builders to give this property to their machines are utterly useless, and a complete waste of time and energy. Our esteemed contemporary, however, thinks differently, and bases its conclusions on the deductions of Kennelly and some experiments by Dr. Duncan on two-phase motors. It is, therefore, apparently supported by both theory and practice; yet, when we examine the matter a little more closely, we are by no means inclined to agree that our contemporary has sufficient grounds for its conclusions. In the first place, theoretical considerations, especially of the intricate phenomena of alternate current machinery, are apt to ignore those influences which, though difficult to put into exact mathematical form, are just the things which determine the truth or fallacy of the conclusions. Again and again this has happened, and it has been shown that mathematical inference, unsupported by experimental evidence or based on insufficient data, cannot be relied on.

It may, perhaps, be argued that the results of Dr. Duncan's researches afford this necessary experimental evidence. Let us see what these researches amount to. Dr. Duncan commences by observing that "the mathematical treatment is difficult, unless many essential phenomena are omitted." He then describes some experiments on a two-phase 2-h.p. Tesla motor. This motor was run from a 25-h.p. two-phase generator, which was believed to give practically a true sine curve of electromotive force. The results obtained were not

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compared with those which might have been obtained from any other alternator; they therefore stand alone. Moreover, the motor was not even run up to its full capacity, nor was it supplied with its rated electromotive force; so that it was "not, of course, particularly efficient." In all of which, we may ask, is there anything to show that the motor was more efficient than it would have been in any other case? Nor are the practical rules for design, which follow from these deductions, any more comforting to the builder of alternate current machinery. "To satisfy the condition in the armature would require an infinite number of armature windings, but it can be practically satisfied in the higher machines with a reasonable number of windings. It must not be understood that it is specially easy to accomplish this." So much for the true sine armature; as to the field windings, "projecting pole pieces should certainly be avoided." We should not be surprised to hear that the sine curve should be carefully avoided, and that the "best" curve is of a very different shape.

The abstract of the Paper by M. Charles Henry, which will be found in another column, should prove of interest to electricians. The sensitiveness of the eye is subject to great alterations caused by the changes in the diameter of the part of the pupil exposed. These changes are due to the amount and character of the illumination falling upon the eye. The study of what causes these changes is as important for electric lighting purposes as consideration of the efficiency of dynamos. A few per cent. at most can be gained by exchanging a dynamo for one of a better make; whereas, for the same amount of lighting power illuminating two areas, if the distribution is bad in one case and good in the other, it may be that in the latter instance the eye is far more sensitive than in the former, and, in consequence, much less light would produce the same illuminating power. An accurate method of measuring the sensitiveness of the eye when subjected to various kinds of light is, therefore, a great desideratum. Unfortunately, although M. Henry describes a large number of methods, some of them very fairly sensitive ones, for measuring the diameter of the eye, none of these are such that the eye under test can be exposed to the illumination whose character it may be desirable to investigate. In most of these methods the eye is shut off from the light while being experimented upon. A simple modification of Robert-Houdin's method might, however, be adopted, in which this defect would be absent. If two bright beads are used instead of two little holes, the instrument would work just as easily, and the eye would be exposed to the light during the whole time. We have made a few rough trials with such an arrangement, and think that it might be usefully employed in conjunction with a photometer for street lighting. Low lamp standards and clear glass globes would give a high mean illumination as measured by a photometer; but the effect would not only be very unpleasant, on account of the glare, but the pupil would become so contracted that the eye would receive less light in the neighbourhood of a lamp than that which would be indicated by ordinary photometric methods.

The Corean Crisis.—According to a correspondent of *The Times* the Japanese Minister requires the unconditional acceptance, by Corea, of 25 demands, one of which is the concession for a telegraph line.

Cable Interruptions and Repairs:—

	Date of Interruption.	Date of Repair.
Bissao-Bolama	Nov. 24, 1893	July 14, 1894.
Sierra Leone-Accra	July 2, 1894	—

Correspondence.—We have received a letter from Dr. A. Koepsel on the subject of the article by him in *The Electrician*, July 6, 1894. We hope to publish a translation of this letter next week, as it reached us too late for the current issue.

University College, Bristol.—The session 1894-95 for electrical engineering, also for the chemical department, begins on October 4th. Particulars of the course of lectures arranged and other information will be found in our advertisement columns.

University College of North Wales.—Prof. A. Gray will begin in October next a systematic course of instruction in electrical measurements and practical electricity at the above college. The laboratory is now fully equipped with machinery and instruments. Copies of the calendar prospectus, &c., can be obtained of Mr. J. E. Lloyd, M.A., at the College, Bangor.

Obituary.—We regret to announce the death, at the age of 57 years, of M. Paul Lemonnier, formerly a member of the well-known firm of Sautter and Lemonnier, of Paris. M. Lemonnier was very largely interested in the introduction of the Gramme armature and dynamo, and took an active interest in their manufacture during the early years of electric lighting. The death has also recently occurred of M. E. Julien, whose enterprise in connection with secondary battery work is well known to our readers.

A Master-Patent.—One of our American contemporaries announces that a Mr. Van Choate, of Boston, has issued a notice to everybody in general, and to some of the electrical companies in particular, that he controls by patent all multipolar motors and generators, as well as every electric street car now in use. Mr. Choate, our contemporary thinks, is too modest to live in Boston.

Telephonic Communication in Spain.—We learn from Spain that, under the auspices of the same English capitalist who formed the Sociedad de Telefonos de Barcelona, a company has just been formed with a capital of £120,000, to be known as the Compañia Peninsular de Telefonos. The object of the Company is to establish telephone lines in the Peninsula and to acquire the Bilbao-Santander line.

Shoddy Work and Underbidding.—The *Electrical Review* of New York complains that an analysis of some tenders recently offered for the construction of an electric plant in the United States show that some of the bidders actually offered to construct, equip, and place the entire plant in operation for a less sum than the material alone could be purchased for in open market. We are not entirely unacquainted with this sort of thing on this side of the Atlantic.

Prof. von Helmholtz.—We regret to announce that Prof. von Helmholtz has, during the past week, had a paralytic stroke; but the gratifying intelligence has since reached us, by telegram, that he is now better. He had rather a restless night on Sunday, but on the following morning was able slightly to move the limbs of his paralysed left side. The latest information leads us to entertain the hope that the distinguished patient will soon recover from his attack.

Electrolysis of Water-Pipes.—The electrolysis of water-pipes has, it is stated, become a serious matter in San Francisco. A 30in. pipe belonging to the Spring Valley Water Company has lately been repaired so often that a number of measurements have been made of the electrical conditions about it. It is stated that at one point the difference in potential between the pipe and the neighbouring rails of an electric road was 16 volts, and that the current amounted to 116 amperes.

Telephonic Communication in Austria and Hungary.—The Chamber of Commerce of the now flourishing port of Fiume has petitioned the Hungarian Minister of Commerce, asking that a direct telephone line shall be established between Fiume and

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Budapest. The Austrian telephone system is about to be greatly extended. A trunk line is to be run from Salzburg to Linz. Lines are also to be established from Prague to Aussig, and from Brünn to Olmütz.

The Giffard Prize.—It is stated that the Commission of French Civil Engineers appointed to decide as to the competitive subject for the Giffard prize of 1896 have resolved upon the following:—The transmission of power by electricity in various applications, machine tools, railways, tramways, bridges, ships, docks, &c. Those competing must commence the essay by a summary of the present condition of the subject, and give the details of some scheme which has been executed, or the draft of a suggested scheme.

Electrical Utilisation of Water Power in Austria.—Messrs. Ganz and Co., of Buda-Pesth, are at present engaged in establishing an electrical power transmission plant near Sebenico, in Dalmatia, to utilise the power of the well-known Kerka Falls. It is stated that no less than 1,600 H.P. is available, although the present plant will only have a capacity of 300 H.P. The electrical energy thus generated is to be transmitted to Sebenico, at a distance of about 7 miles, where it is to be utilised for lighting and power purposes. The town itself is to be lighted by 3,000 incandescent lamps.

Electric Traction in Japan.—The question of electric traction appears to be disturbing the peace of mind of the Japanese, several schemes having recently been brought forward for the establishment of electric tramways, none of which, however, have as yet been put into practice. The latest proposal is for an electric railway, 20 miles long, from Yorü in Hanzawagun, *viâ* Kumagaye and Oski to Bessho-gasti in Kitá-Sartania-gun. It is intended to utilise certain available water-power in the generation of the necessary electrical energy. The estimated cost of the line is £60,000.

Telephonic Communication in Spain.—During the last few years the adoption of the telephone has made rapid progress in Spain. Already no less than thirty-seven different towns throughout the country are provided with exchanges, and new lines are being established in all directions. Among the latter we may mention that an exchange is about to be established at Mataro, a busy seaport town in Catalonia, about sixteen miles from Barcelona. At the same time a line will be run to the latter town, which will put Mataro in direct telephonic communication not only with Barcelona but also with Tarrasa, Sabadell and Manresa.

Expensive Telephoning.—As our readers are aware, a telephone trunk line has just been opened between Scarborough and Leeds. Owing to local opposition the capital expenditure has been very large, so that it has been thought necessary to impose an unusually high tariff on subscribers and the public who may use the line. Subscribers will have to pay ninepence for every three minutes conversation, while non-subscribers will be charged for the same facility eighteenpence—or at the rate of thirty shillings an hour. A three minutes conversation to London will cost the non-subscriber about nine shillings, and the subscriber half that amount.

Electric Traction at Havana.—The tramways in Havana and the suburbs, which are owned by a company called the Ferro Carril Urbano, comprise a steam tramway from Havana to Vedado, a suburb three miles distant on the sea coast, and three lines of horse trams to Castillo del Principe, Cerro, and Jesus del Monte. The fare is 2½d. or 5d., according to distance. According to the British Consul-General arrangements have been made by an English company for laying down an electric tramway. The projected line is twenty miles long, and its principal object is to connect the main thoroughfares and wharves with the existing tram lines.

Personal.—Mr. Arthur A. Voysey has been appointed to fill the post of electrical inspector to the City Commission of Sewers. The duties comprise the inspection of the public street lighting, and the supervision and testing of meters, on behalf of the City. Mr. Voysey was formerly a student at the Hanover-square School, and on the staffs of Messrs. Siemens and Co. and Messrs. Callender and Co. The salary is £250 per annum. 88 applications for the post were received. Mr. Voysey received 32 votes out of 54. £10 was granted to each of the two candidates left in the final voting—Messrs. Gerhardi, jun., and Carver.——Dr. C. Dieterici, Professor of Philosophy at the University of Breslau, has been offered, and has accepted, the Professorship of Physics at the Technische Hochschule at Hanover.——Prof. F. Kohlrausch, of the Strasburg University, has been appointed to succeed the late Prof Kundt in the Chair of Physics at the Berlin University.

House of Commons Accommodation.—The Select Committee of the House of Commons, which is engaged in considering the accommodation of the House, sat again last Wednesday, when the following among other suggestions was made, with a view to carrying out the desired improvements. It is proposed to construct a large room immediately adjoining the gallery, fitted with separate boxes for telegraphic and telephonic instruments, and seats for the chief messengers. This room, known as the "Instrument Room," should be in telephonic communication with the reporters' writing-room in the House of Lords, and in tube communication with the Star Chamber (junior messengers' room), which should also be enlarged by the partial absorption of the existing passage.

Signal Wires in the Cable Conduit.—The Broadway and Seventh Avenue Railway, of New York City, says the *Street Railway Gazette* of New York, has won a decided victory in its fight with the Empire City Subway Company (Limited) in regard to its right to use the conduit running along its line of road from the Battery to Fifty-first street, for wires and electrical conductors in order to signal to any portion of the road in case of accident or for other cause. Judge Ingraham, in the Supreme Court, gave a decision holding that the subway company has no right to maintain action to enjoin the railroad company from maintaining electrical conductors in its conduit for the necessary and proper operation of its road. Judge Ingraham holds that the licence of the Subway Company is not an exclusive right to maintain subways in New York City.

Electric Lighting in Spain.—Electric lighting is about to be introduced into the Conservatorio de Musicá, in Madrid, tenders for the work having just been invited. A company is in course of formation to establish a central station at Manresa, a busy and thriving town in Catalonia, near Barcelona. A central station has just been completed and put in operation on the banks of the Nervion, opposite Bilbao, and is intended to supply current for lighting purposes to the districts of Baracaldo, Sestao, Portugalete, Santurce, and other places. The plant which has been put down by Messrs. Schuckert and Co., of Nuremberg, Germany, comprises two steam engines and dynamos having an output of 100 kilowatts. Work has also just been commenced on the establishment of a central electric lighting station at Seode, Urgel, for public and private lighting purposes. The plant is being supplied by a German firm, the Deutsche Electricitätswerke of Aix-la-Chapelle.

Telephones in the City.—At a meeting of the City Commission of Sewers, held at Guildhall on Tuesday, Mr. Gordon moved to rescind a resolution of the Commission a year ago consenting to the use for telephonic purposes of certain tubes laid by the City of London Electric Lighting Company on a guarantee being given that telephones with double wires and all the latest improvements would be supplied to the citizens at a cost not exceeding £8 per annum; and to substitute for it an acceptance of the Company's offer to pay 10 per cent. of any annual rental so long as such might be received for the use of any tubes for telephonic purposes up to £10,000, and 20 per cent. on any rental in excess of £10,000, the *minimum* amount to be received by the Commissioners being £1,000 a year. The motion to rescind was adopted by 25 votes to 19, but as this did not constitute the necessary two-thirds majority to rescind the previous resolution the proposal fell to the ground.

Meteorology in France.—The Central Meteorological Office of France has just published its *Annales* for the year 1892, consisting of three large quarto volumes. Vol. I. contains a number of memoirs, among which there is one by M. Fron, on thunderstorms in France during the year. These summaries have been continued for thirty years, and furnish useful data

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for determining the laws which underlie the formation and propagation of those phenomena. M. Moureaux discusses the observations on terrestrial magnetism at the Parc Saint Maur, and gives curves for the self-recording instruments of the most remarkable disturbances, which were considerable during that year. He also contributes a Paper on the magnetic conditions at 100 stations; there are altogether 428 such stations in France; those not yet dealt with will be discussed in subsequent years. Finally, M. Durand-Gréville gives a detailed investigation of the connection between squalls and thunderstorms, and has determined some of the phenomena which regularly accompany the formation and propagation of the latter. Vols. II. and III. deal respectively with the ordinary observations and with rainfall values at a large number of stations.

Proposed Underground Electric Railway for Vienna.—The Anglo-Austrian Bank and Messrs. Siemens and Halske have submitted to the Austrian Board of Trade detailed plans for an underground electric railway in Vienna. The railway is to be of narrow gauge, with double track, and is to commence at the Danube Canal, pass under the central city to where it touches the western suburbs, continue under the Maria-Hilfstrasse to the western terminus, and thence to the outskirts of the city to Schönbrunn and Penzing. The railway would be laid deep enough so as not to interfere with the foundations of houses. The journey between the two termini is to be accomplished within eighteen minutes. A single carriage, to be started at short intervals, is intended to convey 40 passengers in ordinary times, while in the morning and evening, and on Sundays and holidays, cars are to be added. Should leave be given for the construction of the work, building operations are to commence at seven different points at once, so that it would be possible to complete the railway in a year from the date of the concession. As there are no means of rapid communication in the central part of the city, the Viennese look with great favour upon the undertaking.

Magnetic Rotatory Dispersion of Oxygen.—In No. 7 of the pamphlets which the Physical Laboratory of the University of Leyden is issuing under the direction of Prof. Kamerlingh Onnes, says *Nature*, there is an interesting Paper by Dr. L. H. Siertsema on the magnetic rotatory dispersion of oxygen. In most substances the magnetic rotatory dispersion approximately, at any rate, follows the law that governs natural rotation—viz., that the rotation varies inversely as the square of the wave-length. In strongly magnetic bodies, such as solutions of iron salts, the dispersion is much greater, according to Becquerel the rotation being proportional to the fourth power of the wave-length. Oxygen seems to be an exception, for while Becquerel thought he obtained a small dispersion, more recently Kundt and Röntgen obtained no dispersion. The arrangement of the apparatus employed by the author resembles that used by Kundt and Röntgen. The gas under high pressure is enclosed with a polariser and analyser in a long tube, and the rotation is obtained by fixing one end of the tube and turning the other, so that torsion is given to the tube. The tube lies in a long magnetising coil containing 3,600 turns, and through which a current of 70 amperes is passed. Some preliminary experiments made with commercial oxygen at a pressure of about 100 atmospheres, have shown that, contrary to the result given by Becquerel, Verdet's constant for oxygen decreases regularly with increasing wave-lengths, and that for violet it is twice as large as for red.

Submarine Telegraph Commemoration.—The banquet and reception to be held at the Imperial Institute to-day, in commemoration of the 25th anniversary of the establishment of submarine telegraphy to the Far East, will be a great feature of the season, and will be on a larger scale than anything of the kind which has taken place. There will be about 450 guests at dinner, and over 4,000 at the reception. Amongst those who will be present at the latter are their Royal Highnesses the Prince of Wales, the Duke of Cambridge, the Princess Louise, the Duke of Fife, the Marquis of Lorne, their Highnesses the Prince and Princess Edward of Saxe-Weimar, Prince Hermann of Saxe-Weimar, the Maharajah of Kuch Behar, the Turkish Ambassador, the Danish, Portuguese, and Servian Ministers, the Right Hon. Sir W. V. Harcourt, the Marquis of Salisbury, the Speaker, and many members of both Houses of Parliament, as well as distinguished representatives of the Navy, the Army, the Diplomatic Service, the Colonies, &c., &c. Amongst the principal guests at the dinner, who will also attend the reception, are the Italian and United States Ambassadors, the Netherlands, Persian, and Japanese Ministers, Secretaries to Embassies and Legations, the Lord Chancellor, the Lord Mayor of London, and the Mayors of several cities and towns. Elaborate arrangements have been made to provide against crushing or confusion, and a staff of stewards appointed to supervise the arrangements and promote the comfort and convenience of those invited. General directions to the reception guests are issued in circular form, which contains a list of special train arrangements. Twenty-five years ago a reception, at which the Prince of Wales was present, was held at Sir John Pender's house in Arlington-street to celebrate the opening of submarine telegraph communication to India; and it must be a great satisfaction to all those connected with the service to contemplate the enormous extension of the system during the last quarter of a century. The speeches at the banquet will be reported in our next issue.

Electric Traction for Canals.—According to a correspondent of the *Engineer*, the authorities of the New York State canals have taken an important step in granting the Cataract General Electric Company a fifty-year permit to put in some kind of an electric plant along the lines of the State canals, by which boats can be operated with electricity. The Company shall not charge for use of such power by the canal boatmen at a rate exceeding 20 dollars per electrical horse-power for each season of navigation; but that is the maximum charge that can be made, and the rate will undoubtedly be much lower. Even at 20 dollars a horse-power it is claimed that an owner would be saved 50 per cent. a season on the operation of his boat in comparison with the present cost of canal boat propulsion. The operations of the Company are not in any way to interfere with boats navigating the canal by steam or horse-power. The Company made several experiments on the canals last autumn, as previously noted, and the matter will now be pushed forward to a successful solution of the problem. The electrical power will be obtained from the Niagara Falls, and transmitted by wires erected along the line of the Erie Canal. The permit authorises the Company to enter upon all canal lands of the State for the purpose of constructing either on or over or under either canal bank a system for propelling canal boats by electricity, without interfering with the present method of operation. The rates for towage shall be subject to modification and review by the State Superintendent of Public Works, but such rate shall not exceed 20 dollars per electrical horse-power for any season of navigation. An important provision is that the Company may, so long as the wants of the canal are supplied, employ its electric plant along the line of the canal in furnishing electric light, heat, and power for distribution to any point or points beyond the line of the canal, and thus may furnish electricity for lighting and power purposes in all of the cities and villages along the canal. The Company is to furnish the State, free of charge, sufficient power to operate motors to open all gateways leading to and from locks, and also electric lights sufficient to properly illuminate such locks at night. The Company must have its plant for operating boats by electricity in operation on the Erie Canal between Buffalo and Albany within three years from date, or else the privileges accorded by the permit shall be forfeited. In case the Company shall construct along the canals an electrical plant for use, known as the trolley or overhead-wire system, it shall be the privilege of the State to condemn and purchase such property at a price equal to the actual original cost to the original constructor, with the 10 per cent. added thereto. Another electric traction project is that of the Erie Electric Towing and Power Company, which will construct and put into operation as soon as possible half-a-dozen tugboats, operated by electricity, either on the storage or trolley system, with a view of showing the adaptability of electricity to canal navigation. These tugboats will also tow for a moderate consideration any horseboats, the captains of which desire to avail themselves of such method of navigation.

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ELECTRIC MOTIVE POWER.*

BY ALBION T. SNELL.

(*Continued from page 266.*)

Underground Cables, Junction Boxes, Switches and Cut-outs.

Each "district" is usually supplied from an independent pair of conductors coupled at the pit bottom to an omnibus bar or to a separate pair of shaft cables.

The conductors are, therefore, of small size, not often exceeding 19 strands of No. 16 S.W.G.

They are carried on the "sides" or "roofs," being supported by wooden cleats or earthenware insulators or buried in the "floor." The choice of the three methods will be determined by the peculiarities of the "level" in which they are run. The class of insulation will depend both upon the method of erection and the difficulties to be dealt with.

In dry roads, well supplied with timber props and cross bearers, a light vulcanised rubber cable carried in wooden cleats or on insulators will prove to be cheap and efficient. An occasional fall of roof or sides will not as a rule cut the conductor if a little slack be allowed between the supports; and "creeping" of the floor will not affect it. Indeed, in the majority of cases where long lengths of small conductors, about 7/16 S.W.G., have to be carried to the "faces," this is the only practicable method from simple considerations of cost.

Wood casing is out of the question for "road-work" except for the lighting circuit near the pit bottom. Not only from cost, but from the instability of most of the "roads."

In main engine planes which have no "weight" upon them, a permanent job may be made of the erection; and it will generally pay to bury the cables beside the metals and to loosely cover them. But a rough wooden trench with a covering board should be laid to receive the cables, unless they are armoured, for otherwise an unlucky blow from a pick might such cause a breakdown. If heavily armoured concentric cables, as shown in Fig. 102, p. 264, are used, it is sufficient to bury them about 6in. to 12in. below the surface of the road, well to one side, where they will be free from disturbance during repairs to the metals and roads. If conductors are carried along "travelling" roads, it is specially necessary to secure them from damage at the hands of the miners, who are sometimes inclined to get "lightning" from them by means of their picks. If the road be dry and in a fairly settled condition cables may be laid in fine coal dust, covered by rough boards 1in. thick, and then protected by a layer of coal dust of about 6in. deep. This forms a very safe and cheap bed for hemp-braided vulcanised rubber cables, or lead-covered cables served or braided with hemp. It is specially serviceable in travelling roads or where the conductors are laid for a temporary purpose.

Whatever the class of cable or the method of laying it, however, the conductor should not be in continuous lengths of more than about 500 yards, in order that a fault may be readily localised. At the junctions of sections cast-iron boxes (*see* Fig. 105) should be placed with screw terminals on porcelain bases, through which the necessary connections can be quickly made or unmade. On no account should cut-outs be placed at these points unless special provision be made to enclose them in flametight boxes. They should be confined as far as possible to the generating station and pit bottom.

At the far ends of the levels where the distributing mains are joined to the feeders, it is good practice to place cast-iron junction boxes in the "gates," so that any or all of the distributors may be coupled up according to requirements. It is imperative if cut-outs be used here, as is sometimes necessary, that they be placed in flametight boxes, for this position is close to the faces, from which gas may be given off at any time.

The "distributors" are necessarily of a temporary character and will be shifted as the work progresses. They must therefore be light and flexible. If possible they may be carried upon the props, and in the absence of timber may be laid beside the roads, unless they are hung on rough iron spikes driven into the rock. In any case they will often be subjected to rough usage. For attachment to movable machines, such as coal cutters and rock drills, it is usual to provide concentric or else twin cables, insulated with vulcanised rubber and braided with steel wires. Either of these can be made sufficiently flexible, and are also strong enough to stand being hauled across rough shale and coal.

If a distributor feed a dip pump, it should be erected in a semi-permanent manner; since such pumps are liable to be drowned-out, and the plant may have to be withdrawn several hundred feet or yards at short notice. In such cases the conductors should be brought back with the motor and not cut. They should be coiled and hung up at the pumping station, being uncoiled again as the water recedes. The best insulation for this work is vulcanised rubber well braided with hemp and ozokerited over all.

For a polyphase current system it is necessary to run three or four conductors in place of the two required for a continuous current or single phase alternate system. For permanent work, three conductors may be built into a concentric cable, which may be lead-covered and armoured, but with a four wire system two concentric cables of two conductors each are preferable. The method of erection is in no respect different to that adopted with continuous current working. The three wires are carried practically as readily as two.

The use of switches and fuses below ground in places likely to contain explosive gas requires careful regulation, and is likely to become the subject of special legislation in the future. The author states emphatically that in his opinion no switch, cut-out, junction box, or resistance frame that is not absolutely flame and dust-tight should be allowed in a coal mine where naked lights are prohibited. It is madness to forbid the use of a naked light and yet to allow the types of switches and cut-outs sometimes found in pits.

To ensure absolute freedom from firing gas with a continuous current motor is perhaps impossible, but no such difficulty should be found with small stationary devices such as switches, cut-outs, and junction boxes. It is merely a matter of expense, and should be insisted upon in all permanent plants.

Uninsulated Returns—Safety Cables.

It has been the custom at some pits to use old iron ropes as returns. These are simply laid along the roads or hung up by hooks to the side props. The practice, however, is not to be recommended in pits where there is any chance of gas, and in a large plant with a pressure of 500 volts would in any case be impossible. The author coupled a return in this manner at Andrew's House Pit, Durham, in 1887, the arrangement being adopted simply from considerations of first cost. The pressure at the dynamo terminals averaged 225 volts, and the power in this part of the circuit never exceeded 8 E.H.P. The rope lay for a considerable part of its total length of 1·25 mile in water. The leakage of current, inevitable in a pit, decomposed water at various parts, and the iron at the junction to the copper return at the motor corroded rapidly. The trouble was recognised and caused no difficulty; but if the pit had been gaseous, it is probable that an explosion would have resulted.

A bare separate return, if justifiable at all, can only be so on account of cheapness; but the apparent saving is in most cases more than counterbalanced by after troubles.

If, however, a system of concentric mains be used with the outer conductor in metallic contact with iron or steel wire armouring, the conditions are altogether different; and probably as great an immunity from danger due to a broken conductor can be obtained by this arrangement as by any of the patented safety cables.

There are two classes of bare return concentric cables in use. They are shown in Figs. 106 and 107. The former has a lead covering, which is squirted around a copper conductor, the two together forming the outer or return circuit. Armouring can be applied outside, and so add to the conductivity while protecting the soft lead, whose chief function is to keep water from the insulation between the centre and outer conductors.

The second class is cheaper, and the return circuit is formed simply by the armouring, which is placed directly upon the insulation. It is only suitable for use in dry places, where it will give good results. (*See* Fig. 107.)

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The chief advantages offered by these cables, in connection with mining work, is the security they give against *external* sparking, and their mechanical strength, owing to which they may be stapled to rough walls, like gas barrel.

There are also conductors which may be collectively classed as "safety cables." In all of them the object is to entirely obviate sparking at the point of rupture when an active conductor is cut in two. The general method is to provide a small auxiliary cable in parallel to the main conductor. This, in the event of a fall cutting the cables, is arranged to break either *before* or *after* the main conductor is broken; and in each case actuates a magnetic cut-out which opens the main circuit. The idea will be best understood by reference to some of the better known solutions of the safety-cable problem.

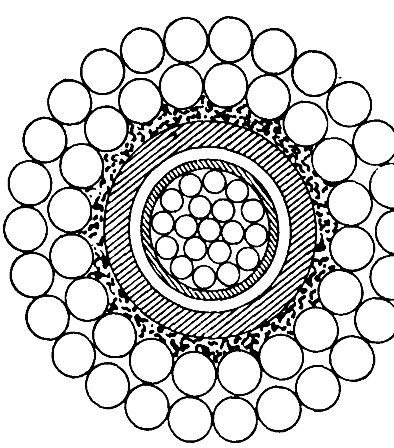

Fig. 106.—Bare return Concentric Cable. The return consists of a spiral of sheet copper under the lead, the lead and the steel armouring.

Mr. Ll. Atkinson, of Messrs. Easton, Anderson and Goolden, was the first to patent a cable of this class. It is not designed for concentric wiring, and hence two wires are required for each circuit. The cable (*see* Fig. 108) consists of two parallel conductors, insulated from each other excepting at the main terminals of the circuit to be protected. The current therefore is in the same direction in each conductor. The outer, which is designed to carry the larger part of the current, is of any ordinary make. The inner is constructed of fine wire in the form of a continuous cylindrical coil, the outer diameter of which is covered by insulation, and forms the core around which the main conductor is laid. It is assumed that when a stone falls on the cable the outer conductor, offering much resistance, will be cut through; but the

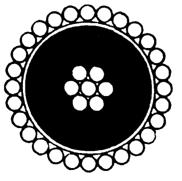

Fig. 107.

loosely coiled centre conductor will be simply drawn out of the insulation. The entire current will then pass through the fine wire, and blow a magnetic cut-out in the engine-room, or other convenient place; the arc being thus transferred from a possibly dangerous spot to a safe one. The efficient action of this cable depends upon two conditions—

1. Perfect insulation between the inner and outer conductor.

2. The continuity of the fine wire circuit being preserved during the fall.

In order to prevent an accidental contact between the two conductors interfering with the safety of the cable, the inventor provides a resistance in series with the fine wire at its negative end, so that the fall of pressure is less along the inside than along the outside. The result is there is always a difference of pressure between the inner and outer conductors at each part of the cable. And a short circuit between the two at any point causes an increase of current in the fine wire which operates the magnetic cut-out.

It may also be reasonably questioned whether a fall which is sufficiently heavy to cut a stout cable in two, will not sever the fine conductor before the spirals have time to draw out.

Generally it is found that cables hung lightly with plenty of slack are dragged down and buried without suffering any damage other than slight surface abrasion; but if they are firmly fixed they may be cut through as if with a knife.

In recent installations a small separated insulated wire has been hung (beside the main conductor) with a few spirals twisted at intervals so as to allow a ready increase of length in the event of a fall, or any undue strain. This is found to be cheaper than the compound cable, and to give equally good results. It should be mentioned that Mr. Atkinson regards the cable as of more importance as a preventative against firing timber from arcs than as an absolute means of preventing sparks. The author is in accord with this view. For the time

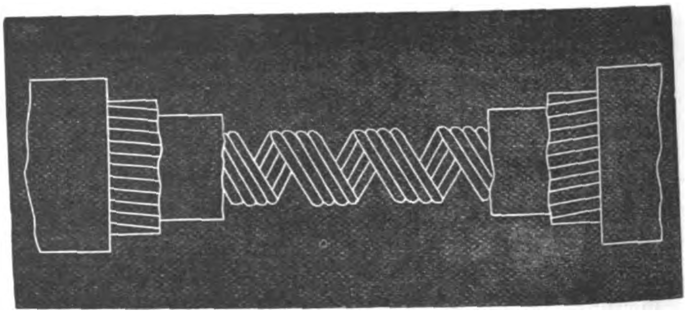

Fig. 108.—Atkinson Safety Mining Cable, showing the outer conductor cut through, and the inner one drawn out.

taken to move the detaching mechanism on the surface will chiefly determine the spark at the break in the cable, though its effect is limited by the resistance of the unbroken fine wire in parallel with the main wire.

The Charleton cable, patented by Messrs. R. J. Charleton, of Newcastle-on-Tyne, is of similar make, but the inner conductor is merely a small wire about No. 18 S.W.G. The currents in the two conductors are in the same direction. The action depends upon the fine wire breaking *before* the large one, when a magnetic cut-out is designed to open the main circuit. Successful working depends upon the maintenance of the insulation between the two circuits, and also upon the time required to move the magnetic cut-out levers. If this be comparable to the period of time elapsing between the cutting of the two cables it appears doubtful whether sparks would not occur almost simultaneously at the break and the cut-out. The problem is complicated by self-induction and capacity, which under

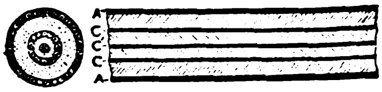

Fig. 109.—Sectional View of Nolet Safety Cable. A, Armouring; C, Main Cable; C[1], Auxiliary Conductor.

suitable conditions might seriously affect the *time* required to open the cut-outs after the breakage of the main conductor. It would be easy however to experiment for any particular case.

Another interesting safety cable is the invention of M. Nolet, engineer of the Cockerill Company, Seraing, in conjunction with M. Jasper, of Liége, and has been applied to several coal mines in Belgium. It provides for a small wire insulated and built into the cable, as in the Charleton cable, but the currents in the two circuits are in opposite directions. A sectional view showing the method of construction is given in Fig. 109.

The fine wire is coupled up as shown in Fig. 110. The function of the small wire circuit is to close the main circuit through the two magnetic cut-outs (one to each of the mains). Therefore, in the event of a breaking of the fine wire, the cut-out will operate and open the principal circuit.

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M. Nolet has recognised that repairs to cables, as generally constructed, cannot be properly carried out without the use of soldering irons, which are inadmissible in a mine. To provide for this contingency his cable is made in short lengths, each section being provided with metal couplings for both of the conductors, as shown in Fig. 110A. The rings for the subsidiary wire are shown at C′, and those for the main conductor at C. The couplings are made to fit together with easy friction, and are so arranged that a sliding movement of about one quarter of an inch is sufficient to open the auxiliary circuit, while a considerable displacement is required to uncouple the outer conductor. The joints are protected by India-rubber tubes.

The construction appears to admit of a *certain* time interval between the opening of the main circuit, and the lifting of the magnetic cut-out, and also provides a ready means of repairing a damaged section. But the cable must be costly, and a slow

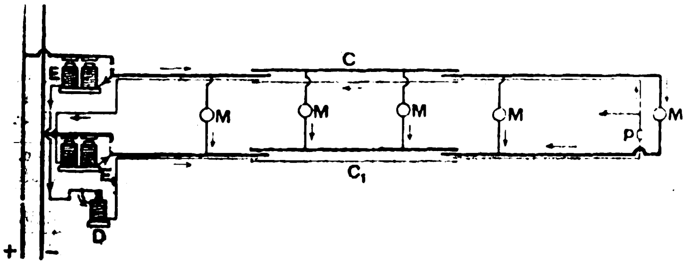

Fig. 110.—Diagram of connections of Nolet Safety Cable. C, main cable ; C_1 auxiliary conductor ; E and E_1, magnetic cut outs ; M, motors. Large arrows show direction of main current ; small arrows that of the shunt current.

movement of the measures, throwing weight on the cable, might interrupt the auxiliary circuit unnecessarily. And it may be questioned whether the device would have time to act in the event of a fall shearing the cable instantaneously, as sometimes occurs.

In the author's judgment, none of these safety conductors give more security than that obtainable with an armoured concentric one buried in the floor or suspended loosely, and with plenty of slack between the supports.

If a fall occurs, it will be brought down and buried. If the armour and outer conductor are cut through, the incision must first take place on one side, and then most probably the severed strands of the outer conductor will be pressed against the inner conductor, and so blow the magnetic cut-out without opening the circuit; because the bottom half of the outer conductor cannot be cut through until the top half is brought into contact with the inner one. The truth of this can be easily demonstrated by cutting the cable through with a cold chisel and hammer.

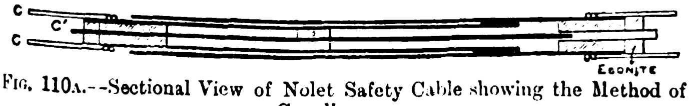

Fig. 110A.--Sectional View of Nolet Safety Cable showing the Method of Coupling-up.

Success lies in hanging the cable so loosely that it cannot be cut through instantly. If this occur, it is doubtful whether the two conductors would always be jammed into good contact by a sudden blow, and so a spark might occur coincidently with the blowing of the magnetic cut-out.

The danger of firing gas through a broken cable is very remote, however. There is, so far as the author knows, no authentic instance of this having occurred, although the possibility is sufficiently evident.

The fact is that cables are not usually run in roads with "weight" on them for obvious reasons, and where it is unavoidable, sufficient slack is allowed to prevent the nuisance of frequent repairs, quite irrespective of the risk of causing an explosion, and, therefore, broken cables are rare.

With the gradual extension of electric work in coal mines for driving portable as well as stationary machines, the risks from this cause will be increased, and it will be wise to recognise the danger and adopt the simple and efficacious remedies suggested by experience. This is specially desirable with new plants.

(To be continued.)

THE "PRACTICAL" WIRING CHART.*

BY A. G. SANDERS, A.I.E.E.

This chart, which is published as a supplement to the present issue, shows at a glance the relations between "S.W.G," "Sectional Area," "Current," "Current Density," "Loss in Volts," and "Weight"; between area in square inches and square millimetres; between solid and stranded cables; and also enable the horse-power lost per mile to be readily found.

The curves are calculated for Imperial Standard Wire Gauge, copper being taken at 98 per cent. purity (Matthiessen standard).

1.—"S.W.G." "Area and Weight."

The relations between S.W.G. Area (in square inches or square millimetres), and Weight in pounds per mile of conductor is found by following any desired size of conductor vertically upwards until the required scale is cut in the lower lines.

2.—"Current Density" and "Loss in Volts."

For any known "Current Density" to find the "Loss in Volts" for any given distance.—If the current density is found in column 2, then column 3 gives the loss in volts for a point 1,000 yards distant (*i.e.*, 2,000 yards of cable, lead and return). Say the distance is 400 yards and current density 1,000 amperes per square inch. Look out in the top line (scale of yards) for 400, follow vertically downwards until the diagonal density line 1,000 is cut, then horizontally to the right, and loss in volts from column 3 is found to be 20.

3.—"Density," "Current," and "Horse-Power lost per Mile."

The "Current Density" and "Current" being known, to find the "Horse-power lost per Mile of Cable."—Find required density in column 2, and corresponding "constant" from column 4; multiply this by the given current, and the result is the horse-power lost per mile. (Thus, at a density of 1,500 per square inch the constant is 0·0897, say the current is 40 amperes, then $0·0892 \times 40 = 3·568$ H.P.)

Also by proportion for any other length.

4.—"S.W.G." "Current" and "Current Density."

(A) *The "Current" and "Current Density" being known, to find the Correct "Size of Cable."*—(Say the current is 20 amperes, and the current density to be 800 amperes per square inch.) Look out 20 amperes in column 1, follow horizontally to right until the diagonal line 800 representing current density is cut, then vertically downwards to bottom line, when the nearest sized cable is found to be 19/19 S.W.G., or No. 7 solid.

If the area is required instead of size of cable this is given immediately above.

(B) *The "S.W.G." and "Current Density" being known, to find the Correct "Current."*—(Say the cable is 7/16 and density 1,300.) Find 7/16 in bottom line, follow vertically upwards until the diagonal density line 1,300 is cut, then horizontally to left, when in column 1 the current is found to be 30 amperes.

(C) *The "Current" and "S.W.G." being known, to find the "Current Density."*—(Say current is 30 amperes, and the cable to be used 19/20 S.W.G.) Find current 30 amperes in column 1, follow horizontally to the right until the vertical line representing 19/20 is cut, then diagonally to column 2, when the current density is found to be 1,500 amperes per square inch.

5.—"S.W.G." "Current" and "Loss in Volts."

(A) *"Current" and "S.W.G." being known, to find the "Loss in Volts," or "Horse-Power," for any given Distance or Length.*—Take the same case as above, but follow diagonal to column 3, which gives the loss in volts for a point 1,000 yards distant (*i.e*, 2,000 yards of cable) as 75 volts. If the distance is any other, say 200 yards, find 200 yards in top line, follow vertically downwards till diagonal density line 1,500 is cut, then horizontally to the right and loss in volts from column 3 is found to be 15 volts.

By following diagonal 1,500 to column 4 a constant 0·0897 is found, which, multiplied by the current, 30 amperes, gives the horse-power lost per mile as 2·676. Also by proportion for any given distance.

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(B) *The "Volts lost" for any Distance being known, and also the "Current," to find the "Size of Cable."*—Say the distance is 500 yards, and loss in volts to be 50, with a current of 20 amperes. In top line find 500 yards, follow vertically downwards until horizontal line giving 50 volts in column 3 is cut, find nearest diagonal to point of inter-section, which gives the current density, in this case 2,000; follow this diagonal either up or down till it cuts the horizontal line giving 20 amperes from column 1, and then vertically downwards to the bottom, when the nearest size of cable is found to be 7/19, or No. 11 solid.

(C) *The "Volts lost" for any Distance being known, and "Size of Cable," to find the "Correct Current."*—Take the above case. Proceed as before, and find the nearest diagonal to point of intersection, viz., 2,000; follow this diagonal up or down until the vertical line giving size of cable is found, 7/19 in this case, then horizontally to left, and the current is found to be 18 amperes (from column 1).

THE APPLICATION OF SMALL-POWER ELECTRIC MOTORS.*

BY DOUGLAS T. HEAP AND ARTHUR C. HEAP.

As the field for the use of electric motors is such a wide one, the majority of the electric supply companies have made a reduction in the price of current required for this purpose. The plan adopted by the St. Pancras Vestry to induce customers to apply motor power, so as to increase the company's day load, is novel. Fig. 1

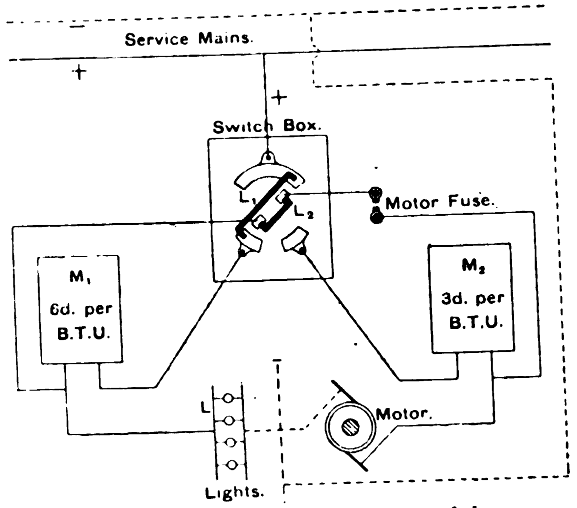

Fig. 1.—Supply to Motors at reduced rate of charge.

shows the connections, general arrangement of the switch, and the method of introducing the meters. It will be seen that there are two positions of the switch handle for the 6d. and 3d. current respectively. Corresponding to these there are fixed meters M 1 and M 2. Externally the two positions of the handle show the rate at which the power supply will be charged, while internally a compound switch bar, having two separate contact levers, L 1 and L 2, insulated from each other, but rigidly connected together, takes up the position given to it by the handle. The cross service wire enters at the upper portion of the switchbox, and is connected to the quadrantal contact in connection with the outer lever L 1.

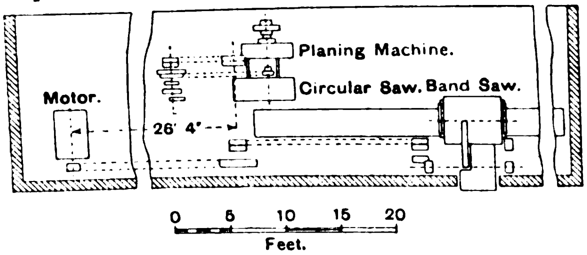

Fig. 2.—Electrically driven Saw Mill, Tring Park.

This, when on the left hand bottom contact, causes the current to pass through the meter M 1. After passing the meter, the current splits up between the lamp circuit L, and the power circuit, the path to the latter being through the smaller lever L 2, through the motor fuse, and by another T-joint, to the power terminals. For the day supply of power the handle is reversed, when L 1 will connect the cross service wire to the meter M 2, disconnecting the main lamp circuit and the smaller lever L 2. It is in this position that the special supply is given at the reduced rate, and the Vestry have arranged for a small number of lamps to be supplied in parallel with the motors where such lamps are incidental or necessary to the work being done by the motor plants. The main lighting, however, can only be obtained when all the supply is paid for at the 6d. rate.

After dealing with the capabilities and characteristics of series, shunt, compound, and differentially wound motors, the authors give the results of some tests of existing plants.

Some difficulty was experienced in getting these figures together, and the results may not appear so good as would have been expected, if efficiency only is taken into account; but the all-round results will be found to be favourable. For arriving at the cost of running, the price of a Board of Trade unit has been taken at 6d. in each test; this is about the maximum charge. The cost given is of the power only.

Test 1.—Crompton Compounded Motor Driving Capstan. Tested at Crystal Palace Electrical Exhibition.

Current, 45 amperes; pressure, 110 volts; revs. per minute, 1,050.

Load.	Volts.	Amps.	Revs. of capstan per min.	Brake horse-power.	Electric horse-power.	Efficiency. Per cent.	Cost of power for 1 hr.
							pence.
Motor only ...	101·25	6·50	...	...	0·88	...	3·95
Motor with gearing	104·20	6·75	...	...	0·94	...	4·25
¼ Load........	104·20	11·50	56·0	0·68	1·60	42·38	7·20
½ Load.........	101·25	20·40	54·5	1·93	2·77	69·80	12·30
¾ Load.........	97·75	31·00	52·0	3·00	4·07	73·80	18·10
Full load......	101·00	43·7	51·0	4·48	5·93	75·00	26·00

This plant started without any trouble at half and full load. The efficiencies obtained will be found to compare very favourably with those given for hydraulic capstans by Mr. John T. Corner in 1892 at the Portsmouth meeting of the Institution of Mechanical Engineers. It was stated that at full capstan power the percentage of main engine power at the capstan engines was 40 per cent.; but when the load was reduced to one-third of the full load the hydraulic efficiency fell to 22 per cent.

Tests 2, 3, and 4; Saw Mill Plant. Thomson-Houston Shunt-wound Motor of 15 B.H.P. Tested at Tring Park. (See Fig. 2.)

Test 2.—Driving Ransome 42-in standard band saw.

Speed of saw (light), 3,428ft. per minute; feed of material, 4ft per minute; gauge of saw, No. 20 S.W.G. (0·036in.).

Load.	Volts.	Amps.	Revs. of motor pr min.	Speed of saw, feet pr. min	Time taken for cut, min.	Electric horse-power.	Cost per foot of timb'r cut, penny.
Motor light ..	153·00	12·0	1,468	...	...	2·46	...
Driving countershaft	130·00	28·0	1,370	...	...	4·85	...
Driving machine thro' countershaft	128·25	42·0	1,242	3452·5	...	7·6	...
Cutting 9in. deal 21ft long	127·20	53·9	1,258	3382·0	5	9·2	0·16
Cutting 4½in. oak, 4ft long	130·00	48·0	1,295	3584·0	1	8·4	0·15

Test 3.—Driving Ransome 30in. Circular Saw.

Gauge of saw, No. 11 S.W.G. (0·116in.). Peripheral speed of saw (light) 10,895ft. per minute. Feed by hand 13·3ft. per minute.

Load.	Volts.	Amps.	Revs. of motor pr min.	Revs. of saw pr min.	Time taken for cut, seconds.	Electric horse-power.	Cost per foot of timber cut, penny.
Driving saw (light)	132	38·25	1,300	1,388	...	6·78	...
Cutting 9in. deal 10ft long	122	105·00	1,160	...	45·0	17·10	0·09
Cutting fir ...	124	105·00	1,178	...	1·5	17·40	...

It will be seen from Fig. 2 that the motor was not in any of the tests driving direct on to the machine, and therefore the power taken to drive the shafting (2·5 E.H.P.) should be deducted if it is desired to ascertain the actual costs. The authors considered it best, however, to give in the tables the figures recorded at the time of the test, so that any misunderstanding might be avoided. The tests have been repeated since the paper was read, and for all practical purposes, the same results have been obtained.

*Abstract of a paper read before the Junior Engineering Society.

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Test 4.—Driving Ransome Wood-Planing Machine.

Two blades, 12in. long; feed, 20ft. per minute (approximately); revolutions of spindle, 3,430 (about) per minute.

Load.	Volts.	Amps.	Revs. of machine per minute (approximate)	Time taken for planing, minute.	Electric horse power.	Cost of planing, penny.
Running light	138	35·0	3,432	...	6·47	0·702
Planing $\frac{3}{16}$in. off 9in. deal 19ft. long...	138	50·8	...	1	9·40	...

Test 5.—Crompton Series-wound Motor of 3 B.H.P. driving Hoist.

Load.	Volts.	Amps.	Speed of lifting ft. per min.	Total weight raised, cwt. lb.	Electric horse-power.	Cost of power for 1 hour, pence.
Running light	99·5	6·5	120·0	...	0·86	3·87
Lifting 1 cwt. 14lb.	99·5	8·0	92·2	1 23½	1·06	4·77
Lifting 2 cwt. 16lb	99·5	10·5	80·0	2 25½	1·40	6·27

This plant is very compact, and is used for hoisting coal into a bunker on an upper floor, from which it is fed through hoppers into the stoke-hold. The motor drives through a worm wheel and single reducing gear, on to the drum of the hoist. With it a ton of coal (in 1cwt. sacks) can be raised in about 10min., including the time taken for hitching the sacks on and off.

Test 6.—Statter Motor of 2 B.H.P. driving Chaff Cutters.

Current, 14 amperes; pressure, 100 volts; revolutions per minute, 1,800

Load	Volts.	Amps.	Revs. of chaff cutter per min.	Time taken for cutting, hour mins.	Trusses cut.	Electric Horse Power.	Cost per truss.
Driving counter shaft	100	4·0	...	...	...	0·538	...
Driving chaff cutter light through countershaft	100	5 0	...	...	...	0·67	...
Driving chaff cutter at work	100	7·6	115·6	1 35	9	1·02	0·8d.

The comparative inefficiency of this plant is partly due to the amount of countershafting being driven, from which two other machines were being at the time of the test run light. Two men were required for working this plant.

Test 7.—Crompton Shunt-wound Motor, of 2 B.H.P. Driving Meat-Chopping Machine.

Current, 25 amperes; pressure, 100 volts; revolutions per minute, 1,520.

Load.	Volts.	Amperes.	Revs. of motor per min.	Revs. of machine per min.	Meat cut, lb.	Time taken for cutting, mins.	Electric horse-power.	Total cost, pence.	Cost per lb. meat cut, penny.
Driving counter-shafting...	101·5	5·0	1,400	...	...	...	0·77	...	...
Driving one machine light.	101·0	9·0	...	...	...	...	1·22	...	...
Driving two machines light	100·5	12·0	...	...	...	...	1·62	...	...
Driving one machine when cutting	99·6	15·6	1,379	272	110	15	2·08	2·25	0·02
Driving two machines when cutting	99·00	20·0	1,370	...	...	...	2·63	...	...

In this plant the motor drives on to a 1½in. shaft, from which the two machines are run. One man can easily attend to them.

Test 8.—Electric Motor Operating Riveting Machine.

General Description of Machine.—The riveting machine consists of a C-shaped steel frame, with long arms, 18⅞in. gap, so that the riveter can be worked on plates, girders, &c. The depth of the frame is 31½in., and the total weight of the machine is 2,204lb. It has two suspension rings, one for use when riveting horizontally, the other when riveting vertically. Two men are required to work the machine, a third heating and carrying the rivets. The time occupied in closing a soft steel rivet 1in. diameter was from 6sec. to 8sec. The pressure indicated by the gauge was 2,845lb. per square inch, the corresponding pressure on the rivet being 89,586lb., or nearly 40 tons. The machine is capable of putting in 80 to 100 rivets per hour. The rivet steel has a tensile strength of 28·5 tons per square inch.

Tests 9 and 10.—Electro-Magnetic Drilling Machines.

General Description of Machines.—These machines, the invention of Mr. Rowan, are made up of three principal parts—the holding-on magnets, the motor, and the drill. The drill is passed through an opening in the centre of the yoke, thus distributing the thrust of the drill over the two magnets. The feed of the drill is performed by a hand-wheel. The motor is usually wound for a 100-volt circuit, and when working the drill, and exciting the holding-on magnets, requires a current of 11 to 14 amperes (about 1·5 to 2 E.H.P.). It is fixed to the framework of the machine, the reduction of speed being obtained by means of gearing as shown. The machines are made in several sizes, some drilling to ½in., some to 1in., and others to 1¼in.

Results of Tests.—(9) At Portsmouth Dockyard, on H.M.S. "Royal Sovereign," 16 holes 1$\frac{3}{16}$in. diameter, through 2⅝in. steel plates were drilled in two hours, including the moving and setting of the machine. (10) At Messrs. Lindsay, Burnet, and Co.'s Boiler Works, Govan, the comparative cost of drilling 56 holes in a furnace tube, by hand labour, and by the electro-magnetic drilling machine was as follows:—

By Hand Labour (piecework)	s.	d.	*By Electro Magnetic Drilling Machine*	s.	d.
took 9½ to 10 hours.			took 3½ hours.		
56 holes at 1s. 4d. per doz.	6	2½	Use of machine at 9d. per hour	2	7½
			1 man at 6½d. per hour	1	10¾
			1 boy at 2¼d. „		7⅞
	6	2½		5	2⅛

These machines when used in conjunction with an electric rivetter, on bridge and similar work, ought to show a considerable saving. The results given under Tests 8, 9, and 10 were supplied by the respective makers of the machines.

Advantages of Electric Motors compared with other kinds of Power Machines.—In comparing the efficiencies of electric motors with other kinds of motive power, such as gas engines, hydraulic engines, &c., it should be borne in mind (1) that an electric motor is only using power as long as the switch is on, and yet it is always available at a moment's notice; the switching on and off being a very easy operation, the waste is reduced to a minimum in careful hands. (2) Since there are very few running parts, the saving in oil consumption is considerable. (3) That there is no heating the pits by gas jets during the winter months.

ON THE ELECTROLYTIC SEPARATION OF GOLD FROM SILVER.*

BY C. SCHNABEL.

At the works of the S. Louis Smelting and Refining Company an electrolytic method of refining has been substituted for the method of parting by sulphuric acid in the treatment of auriferous silver containing $\frac{6}{1000}$ of gold (28·8 grains per pound troy). The silver is cast into plates measuring 10 by 8 by 2½in., two of which are placed together in a linen bag to form one anode, with a rolled plate of fine silver for a cathode. The dissolving vessels are wooden vats, divided into seven cells, and rendered impermeable by a coating of bitumen, each vat containing 70 pairs of electrodes arranged in series. The electromotive force required for each bath is 1½ volt, with a current of 350 amperes per square metre, which is furnished by a dynamo of 100 volts and 200 amperes driven by a 30-H.P. Westinghouse engine. The electrolyte used in the first instance is water containing one-tenth per cent. of nitric acid, which is made up with very weak solution of silver nitrate as the operation progresses. The anodes are entirely dissolved in from 30 to 40 hours; the reduced silver separates in a crystalline form, shooting across from the anode to the cathode, so that short circuiting very frequently occurs. To meet this difficulty an apparatus is used for scraping the deposit off the cathodes at intervals, which, at the same time, keeps up the circulation of the solution in the bath. The deposited silver so removed falls to the bottom of the bath into boxes with double bottoms, perforated and covered with linen, for collecting the precipitate, which is removed once a day. The finely divided gold is kept back in the anode bags, where it is allowed to accumulate for a week before cleaning out. It is then boiled with nitric acid, washed, dried, and melted with a little sand or borax, giving a bullion 999 fine. The silver, after washing and drying is found to be free from gold, and assays 999·5 fine. The silver nitrate obtained from the final treatment of the gold is used to keep up the bath to the proper strength. At St. Louis 933 kilograms silver (about 30,000oz.) are parted by this method daily, and at Pittsburgh a still larger plant of 40,000oz. capacity is in use. At the latter place the finely-divided gold is melted with a small quantity of silver before being subjected to the final boiling with nitric acid.

* From the *Foreign Abstracts* of the *Proc.* Inst.C.E., Vol. CXVI.

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SMALL MOTIVE POWER.

The rental of a "Floor with Power" is a very common occurrence in the industrial north country, the supply of power usually being derived from a shaft-end poked through the party wall or a strap passing through the floor. In the majority of cases the owner of the engine can make a pretty accurate guess as to the amount of power that is likely to be consumed by the tenant, from the number and size of the looms which the latter puts in, and such refinements as transmission dynamometers or meterage of any kind are, of course, undreamed of. The common practice is to charge an annual rental of £10 per reputed horse-power demanded, and the tenant is left to make the best or the worst use of it according as he pleases. Some of the problems of power rental have recently been discussed by M. V. DUBREUIL, in a Paper read before La Société Industrielle du Nord de la France. Taking the case of a man who has 100 H.P. to dispose of, the power being developed by a simple steam engine of good type, and basing his calculations on French prices, which in some respects differ from the English ones, M. DUBREUIL finds that the annual expenses of the owner will amount to £816. Adding a small amount for profit, the rental per horse-power should be £9. Unfortunately, the power consumer will only be able to utilise some 45 per cent. of the power for which he pays; so that, in M. DUBREUIL's opinion, the annual price paid for a useful horse-power will amount to £20. The comparison between the price of

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power obtained in this way with the price of power derived from central stations has frequently been made; the most recent, if not the most exhaustive, series of comparisons having been made by Prof. W. C. Unwin in his Howard lectures before the Society of Arts. In making the comparison with power derived electrically from supply mains, the simplest plan is to assume that the power is metred on the power tariff of 3d. per unit, adding a proper charge for interest on the cost of the motor and for depreciation. In cases where the motor would be required to develop full power for only 1,000 hours per annum, the cost of 1 H.P. will be found to be slightly under £10 per annum. But if the motor is run at full load during an eight-hour day, the price to be paid for a horse-power per annum will reach nearly £25. In most cases the electromotor could be applied to its work much more efficiently than could the end of a shaft poking through the wall, or even a belt coming up through the floor. In this way the power could be used much more economically, resulting in a more favourable price per E.H.P. actually utilised. In fact, in many cases the cost of the useful power would be but slightly less than the cost of power at the meter; while when obtained mechanically it is nearly double. In many other cases the question of efficiency is of small importance as compared with the enhanced convenience, portability, speed, &c., of the electric motor.

In this connection we cannot do better than refer our readers to the interesting Paper, by Messrs. D. T. and A. C. Heap, on "The Application of Small-Power Electric Motors," an abstract of which we publish this week. In such work as driving a capstan, for example, some figures about which are given, a high mechanical efficiency is no more wanted than it is in drawing teeth. What is wanted is force, and plenty of it, properly applied; besides which it is desirable to have a high *plant efficiency*—that is to say, a large capability comprised within a small compass. The convenience of being able to work as readily and as well at low loads as at full load is also of some importance. The same remarks apply to elevators, for which the convenience of electric motors is superior to that of hydraulic motors, where the power required is small. When something more efficient than worm gear can be adopted, the relative advantage of the former will be even greater than it is now. In many of the applications of electric motors the speed of the machine is very high, and it is very convenient to be able to couple the motor directly to its work. In Test 3 of the Paper just referred to, for example, a 30in. circular saw driven by a 15-H.P. motor was tested. Gearing was used, the speed of the motor being 1,300, and that of the saw 1,388 revolutions per minute, running light. In such a case direct coupling should have been the simpler, as it certainly would have proved the more efficient, plan. This, indeed, is one of the most important aspects of the problem of adapting electric power to the driving of machine tools. Not only must the electric motor be specially designed for the class of work it is to undertake, but, in our opinion, the machine tool should also be specially designed, so that it may be directly coupled to the motor. Gearing is a wasteful and clumsy makeshift in the majority of cases, and there are as many reasons for eliminating it from the machine-shop or factory as from the engine and dynamo room. The concluding tests (Nos. 9 and 10) are interesting as showing the superiority and relative cheapness of electrically-performed work over hand work. The tests relate to an electrical rivetter and drilling machine. The mode of estimating the cost of the electric drilling is not at all clear; but, granting that it was no less than the hand labour, the saving of time—3½ hours instead of 9½ to 10 hours—is of the highest importance.

REVIEWS.

Elementi di Fisica. By Prof. Antonio Roiti. Vol. II. Third edition. (Florence: Successori Le Monnier.)

Our Italian *confrères* are in the habit of putting forward the claims of their own language to be considered the most appropriate medium for the expression of scientific ideas. Without going so far as to endorse this claim, we may admit that the fellow-countrymen of Galileo have every reason to be proud of the readiness with which the Italian language lends itself to the terse and accurate exposition of the truths and conceptions of the exact sciences. The present work, which evidently aspires to be in Italy what Müller-Pfaundler's *Lehrbuch* is to Germans, and Jamin's *Cours de Physique* to French students, may be fairly said to be superior, both in scope and in detail, to any similar work yet published in the English language, although not up to the standard of the French and German works referred to. The second volume comprises light, and electricity and magnetism. The chapter on photometry might be enlarged with advantage. Rumford's and Joly's photometers are not mentioned, and Ritchie's name is misspelt Ritshie. The chapters on geometrical optics are, however, excellent, and form the neatest *résumé* of the subject we have yet seen. In the treatment of colour perception Koenig's curves might have been drawn with greater care. The word *rifrangenza* for refractive power distinctly scores for the Italian language. The chapter on the absorption of radiant energy includes calorescence, phosphorescence, fluorescence, a description of the radiometer and the photophone, and a brief summary of photographic theory, to which is added a paragraph on the colour-photographic process due to Lippmann (misspelt Lipmann). The discussion of polarised light is somewhat meagre, but is clear so far as it goes, and as accurate as can be expected with an almost entirely non-mathematical treatment. Passing on to Part VI.—"Electricity"—we find, as might have been expected, a full discussion of Galvani's and Volta's first experiments, and of the ensuing contact controversy. Of modern batteries, only a few leading types are mentioned. On p. 315 is given a very good and interesting map showing the magnetic elements for Italy during 1888. Magnetic shells are treated fully and effectively, with the freest use of symbols to be found in the book. Ewing's investigations on magnetic induction are done justice to as far as space allows; but when we come to the definitions of practical electric units we find the following curious passage about the "volta," the unit of E.M.F.:—*Gl'Inglesi la chiamano* volt: *ma a noi Italiani dovrebbe ripugnare di abbreviare così il nome del nostro celebre Fisico.* This deviation from the name fixed upon not merely by us *Inglesi*, but by the whole civilised world, including many eminent Italian physicists, is then atoned for by calling the unit of capacity the *faraday!* The rationalisation of the electrostatic and the electro-magnetic systems of units by the introduction of μ and k with their proper indices is not even referred to. On p. 431 we find Jablochkoff spelt Jablachkoff, and thus gradually come to suspect a certain carelessness in this manner of recognising foreign authorities, a suspicion which is enhanced by the name Ruhmkorff on p. 481, although we have seldom seen it spelt correctly, viz., Rhumkorff, even in English publications. The volume closes with a thoroughly modern account of Hertz's wave experiments, and a diagram of his original apparatus on the title page shows the importance attached to this youngest branch of electrical science. The illustrations are, on the whole, good and clear, though not as pretentious as those we are getting used to in some present-day text-books.

Electricity One Hundred Years Ago and To-day. By Edwin J. Houston. (New York: W. J. Johnston and Co.)

This book resembles Spenser's Faërie Queene, for it is almost beyond the power of man to read it through. It consists of a lecture, which, when delivered at Brooklyn, was no doubt intelligible and interesting; but "in preparing the lectures for publication" the author has "concluded to permit the text to remain substantially as delivered, preferring to

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add in the way of footnotes whatever additional matter may be required, rather than to materially change the original matter or arrangement." In making this addition the text and the notes have become inextricably confused. The old-fashioned style of printing the notes all together at the end of the book is the only feasible method of arrangement of such notes as these. Seeing that they were of considerably greater importance than the text, both in interest and bulk, we began to read them through, ignoring the three or four lines of large type at the head of the page, but the editing is so bad that even this is impossible. The notes consist for the most part of extracts from old books, and certain anecdotes about Franklin, Muschenbroeck, Jacobi, Volta, &c. They are, in many cases, most interesting, and the author adds to their value by giving references to their sources in proper bibliographical form.

THE DAVY ARC LAMP.

A descendant of Sir Humphry Davy, the inventor of the first arc lamp, has recently entered the field as the inventor of a modern type of lamp, possessing features and details of design of which Sir Humphry probably never dreamed. We are enabled to give, this week, some diagrams of one pattern of the new "Davy" arc lamp. This particular pattern is designed

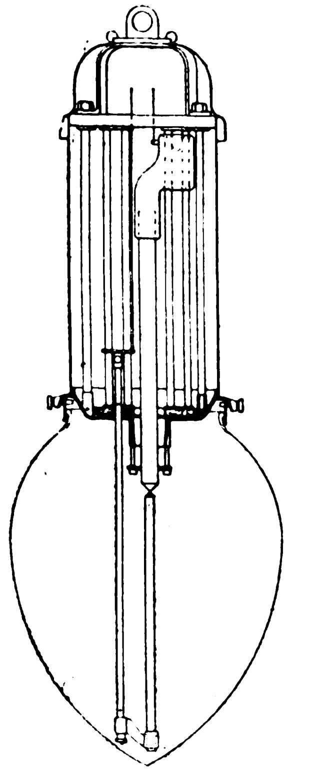

Fig. 1.

for burning a single pair of carbons, with either a continuous or alternating current of 5 amperes, and is specially adapted for interior and exterior lighting for shops and similar buildings. Larger forms of the lamp, for street lighting, are designed to carry two pairs of carbons; and Mr. W. J. Davy, the inventor, has constructed a modification of the lamps, suitable for special purposes, which carries and automatically burns no less than six pairs of carbons. The single and duplex lamps have been running for some time with the alternate current at Portsmouth, as well as in various parts of London; and a well-distributed and steady light appears to be maintained by them. In a trial which we recently witnessed of the multiplex lamp, the carbons having been arranged to fire off in quick succession, it was curious to observe the promptness with which no less than six successive arcs were formed with scarcely a flicker in the light. The utility of so many change-overs may not at first be quite apparent; but there are probably places where more than two pairs of carbons are required, or where the carbons must be exceptionally short.

Fig. 1 gives a longitudinal elevation of the single lamp, the solenoids and grip-brake being removed from the upper part. Both carbons are held in a travelling holder, the two travellers being connected by a flexible band passing over a fixed pulley at the top of the lamp. The upper carbon, in the continuous-current lamp, is made of about twice the section of the lower carbon, thereby ensuring a perfectly fixed position for the arc. In the alternate-current lamp the carbons are, of course, of the same diameter.

Normally, when the lamp is running, the flexible band is gripped by a friction-brake, the details of which are shown in

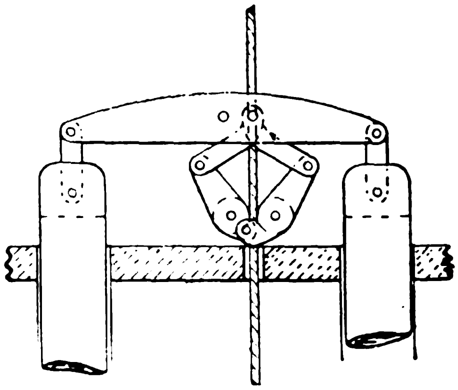

Fig. 2.

Fig. 2. The brake consists of four links, jointed together to form a flexible frame. The upper joint is coupled to the see-saw lever, which is rocked by the solenoids; and close to the lower joint the two jaws, which are designed to grip the band between them, are placed. Upon the rocking lever lifting the upper joint the linkwork extends in such a manner as to grip the band, and, on the motion of the rocking lever being continued in the same direction, the band on the gripped side is lifted, thereby separating the carbons and striking the arc. The see-saw of the rocking lever is regulated by the antagonism between a main solenoid and a shunt solenoid, this method of regulation being a common feature in all modern arc lamps. The mounting of these solenoids, with their cores and the grip

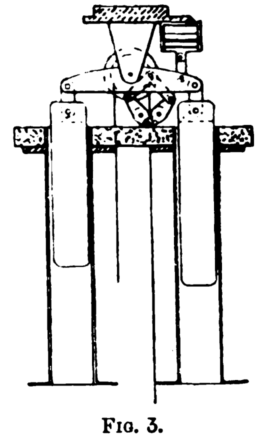

Fig. 3.

brake, is shown in Fig. 3. An air dashpot is fixed to the rocking lever to prevent too violent motion. Feeding takes place when the pull of the shunt solenoid preponderates over that of the main solenoid sufficiently to lower the right hand half of the rocking lever until the grip jaws gently release the band. The band then skids slowly between the jaws, and gives an even feed.

The compactness of this lamp is one of its salient features, and one which will render it useful where longer and heavier lamps would be unsightly; besides which, the simplicity and fewness of the working parts make the lamp cheap, durable, and easy of repair.

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ON THE DAMPING OF BELL MAGNETS AND RING MAGNETS BY SURROUNDING COPPER.

In the American *Journal of Science* for June, 1894, Mr. Arthur Kendrick gives an account of some experiments made to determine the damping action of copper boxes on enclosed bell magnets. The conclusions are of great interest, and will be of value to those wishing to design galvanometers having this type of magnetic system.

The experiments were made with magnets of varying magnetic and inertia moments, and copper boxes of various shapes, and the results, where possible, are embodied in curves. In these curves the author prefers to use as his measure of the damping the ratio of one amplitude to the preceding one, rather than the logarithmic decrement. He makes an error, however, in stating that his damping coefficient is the reciprocal of the log. dec., and that the limits of the values of the log. dec. are ∞ and 1, as against 0 and 1 for his coefficient. In this he has confused the log. dec. with the decrement itself. Curves are first given showing the relation of damping to inertia with constant magnetic moment, and of damping to magnetic moment with constant inertia. These are given for boxes of various dimensions, and appear to show (*a*) that the damping increases rapidly with the magnetic moment; (*b*), decreases with increase of inertia; (*c*), increases with the thickness of the box; (*d*), decreases rapidly with the internal diameter of the box. They also show that the damping was much increased by adding a bottom to the box, although a disc alone held below the magnet had little damping effect. The thickness of the bottom had little influence on the damping, but the proximity of the magnet to the bottom had a large effect.

Brass boxes appear to be much inferior to copper, showing the great influence of the conductivity of the material of the box. Experiments were also made with non-cylindrical boxes and boxes with slits cut in their sides. With a cylindrical box having two sides planed flat so as to produce an oval exterior the damping was reduced, but the position of the longer axis was immaterial. Slitting the box has no effect when the slit is perpendicular to the plane of the magnetic axis, but has large influence when the slit is in that axis.

The author concludes by saying that the observations are not sufficient to establish a mathematical solution of the problem; but he appears to have overlooked the fact that some of the curves can be obtained mathematically. These curves appear to agree very fairly with theory.

THE MEASUREMENT OF THE PUPIL OF THE EYE.*

In connection with the subject of artificial lighting, the various causes which influence the diameter of the iris are of interest, as the efficiency of the eye, and hence of the system of lighting, is directly dependent upon the amount of the pupil exposed to the action of the light rays. Numerous instruments have been proposed for measuring the diameter of the pupil, but none of them can be considered very accurate. Great difficulties are encountered in the direct measurement of the diameter with a graduated scale, owing to the movements of the eye, and the close resemblance between the colours of the iris and the pupil in dark eyes, while even in light-coloured eyes the iris has often a darker border, which can easily be confused with the pupil itself. Parallax errors also arise owing to the distance between the pupil and the graduated scale.

Medical men have often used Follin's scales, consisting of a number of black circles, increasing in diameter from 1 to 13 millimetres, and placed upon a card. The size of the pupil is estimated by comparing it with the circle nearest in diameter. Follin also used to make the measurement by placing in front of the eye a glass micrometer scale, and the reading of the divisions was facilitated by the use of a lens as suggested by Halma Grand.

Lambert and Olbers observed the reflected image of the eye produced by a plane mirror, and measured the diameter of the image by means of a compass. Laurence and Galezowski used a graduated scale provided with two cursors, each carrying a hair. By sliding the cursors along the scale the hairs could be made to approach or recede until their distance was exactly the diameter of the pupil. Coccius observed the pupil through a lens of 74mm. focal length, placed in a box provided with three apertures, one for the eye of the observer, another for the eye being tested, and the third being a lateral opening for the purpose of illuminating a scale divided into half-millimetres fixed on the lower half of the lens. This lens is movable along the axis joining the two eyes, and the observer sees simultaneously the pupil and the image of the graduated scale reflected by a mirror. The observing eye is moved along the axis till the image of the eye under observation is sharply defined against the scale, and the diameter can then be measured.

Doijer used a Ramsden's eye-piece and a glass plate divided into hundredths of a millimetre, and placed at a distance equal to four times the focal length of the lens from the eye under observation, the lens being placed midway between them. The image under these circumstances has the same size as the object, and its diameter can be read off directly on the graduated scale.

Helmholtz has pointed out a most ingenious device which has been found useful for pupillometers. When any object is looked at through the line of separation of two plane-glass plates with surfaces in contact along one of their edges, two images are seen instead of one, the distance apart being dependent on the index of refraction, the thickness of the plates and the angle of incidence of the rays and the angle of inclination of the plates. These quantities are easy to measure, and when the two images are just in contact the separation is equal to the diameter of the object. Landolt has improved this rather complicated instrument by using two thin wedges of glass placed over each other, with their edges in contrary directions. These prisms are movable by means of an adjusting screw, which can be graduated.

All the above instruments are founded on the principles of physical optics. In 1856 Fick introduced an entirely new kind of instrument depending on physiological optics. The principle here involved has since been made use of by Robert Houdin and by Dr. Badal. It can be stated as follows. When two luminous points, the line joining which is perpendicular to the axis of vision, produce on the retina two circles of diffusion which just touch each other, the distance between the points is just equal to the diameter of the pupil. This can be proved as follows:—

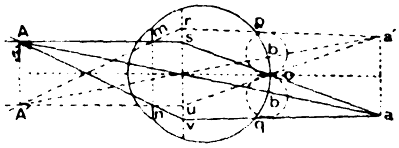

Fig. 1.

If the eye is looking at a distant object it is focussed so that the image of it is formed on the retina *p o q*. Nearer objects, such as A A', will not be focussed, and the light from one such as A will be distributed over a circle, *o b q*, on the retina. If *m n* is the diameter of the iris and if *r s u v* is the plane of the simple lens equivalent to the eye, then the lines of the figure show how the eye tends to produce an image of A A' at *a a'*, and that owing to the interposition of the retina two diffusing circles are formed. Now if *m n* is the same diameter as A A', the two circles will just touch at O, which is the focus of distant objects on the axis of vision, and which therefore receives all rays parallel to the axis. If *m n* is larger than A A the two circles will overlap, while if it is smaller the two circles will be quite distinct. By adjusting the distance A A' till the circles just overlap it is thus possible to measure *m n*, the diameter of the iris.

It may be objected to this proof that the eye cannot be regarded as a simple lens. It is really composed of a combination of lenses, the substances of which have different indices of refraction; and as the iris is within one of these lenses a magnification is produced which prevents the measurement made in this way being correct. The author of the Paper goes

* Abstract of a Paper by M. Charles Henry, entitled "Pupillométrie et Photométrie," appearing in recent issues of *La Lumière Electrique*.

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fully into the question, and arrives at the conclusion that the image measured in this way is $1\frac{1}{7}$ times the true diameter of the pupil, and thus shows that it is necessary to multiply the measurement actually obtained by $\frac{7}{8}$ in order to get the true result. When this correction is made these pupillometers give a perfectly accurate result. They are simple in construction and rapid in action. The errors arising from parallax and from confusing the border of the iris with the pupil, which are so serious in most pupillometers, are entirely overcome in this.

The simplest form employed in the author's experiments was one due to Robert-Houdin, and is illustrated in Fig. 2. It consists of a shallow copper cylinder 12 millimetres deep, the front being provided with an opening and a small hole, *b*. A screen pierced with a small hole, *a*, and provided with an index, *c*, slides over this opening by turning about an axis, *d*, in the circumference of the circle. The distance between the two holes *a* and *b* can be read off on the scale by the index *c*. All lateral light can be shut off by the use of a dark cloth. Other instruments have been devised on the same principle. One due to Gorham consists of a metal tube closed at one end with the exception of a radial opening. A metal disc pierced with holes arranged radially in pairs at various distances apart is attached at the closed end of the tube in such a manner that it can be turned so as to present different sectors to the radial opening at the end of the tube. In this manner, by looking along the tube and turning the disc, two bright spots of light are seen, and the distance apart of the spots seen can be regulated by simply turning the disc. When two of the holes are such that the circles of diffusion touch each other, it is known that the distance

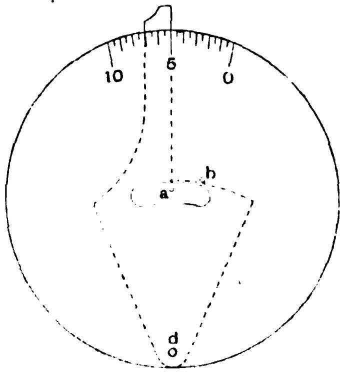

Fig. 2.

apart of these holes is equal to the diameter of the pupil. M. Gorham proposed to use this instrument as a photometer by measuring the size of the pupil when the tube is turned towards different lights. The distances of the lights were adjusted till the diameter of the pupil was the same whichever light was looked at, and it was assumed that under these circumstances the square of the ratio of the distances was equal to the relative candle-power of the lights. This assumption is, however, doubtful, as the contraction of the pupil does not depend merely on the intensity of the illumination. Before concluding the account of the various pupillometers yet devised the method of photographic records used in 1887 by Bellarminoff must not be forgotten. This scientist used a chronophotographic apparatus, by means of which the diameter of the pupil could be ascertained at any instant during the course of the tests. This method undoubtedly is the most accurate, but it is too complicated and costly for use.

As regards the direct action of light upon the iris, some experiments made by Brown Séquard in 1847 appear to prove that only the luminous rays have any effect, heat rays and chemical rays being inactive. The eyes experimented upon were those of fish and bratracians. They were extracted from the orbits immediately after death, and the pupils were found to contract on the approach of a candle, and to expand again in the dark, the effects being reproducible some times as frequently as 100 times in an hour. The interposition of a plate of alum did not alter these effects, showing they were not the result of heat rays. The persistence of the pupil movements, long after the nerves had lost all sensitiveness to irritation, seemed to prove that the action was muscular and not nervous. Moreover, utilising the fact discovered by Brücke that the cornea and crystalline of the ox and the rabbit absorb the violet and ultra-violet rays, light was allowed to fall on the eyes of frogs after having been previously filtered by passing through the eye of a rabbit. The pupillary contraction was found to take place just as before. All the evidence is thus in favour of the view that only the luminous rays are capable of producing the movements of the iris. Experiments of a like nature on human eyes are, however, still wanting, and it is to be hoped that some will before long be made.

Actual measurements of the diameter of the pupil of the eye have been very rarely made. Lambert, in his book on photometry published during the last century, gives a few measurements and conclusions founded on them. The principal of these conclusions is that if the eye be exposed to different degrees of illumination, the area of the pupil exposed does not vary inversely as the illumination, but in such a manner that the product of the illumination and the area exposed becomes less and less the feebler the illumination. M. Charles Henry is trying to reproduce these experimental results of Lambert with better and more reliable apparatus.

HEINRICH HERTZ.*

(*Continued from page 299.*)

The last research carried out in Berlin is entitled "On the Behaviour of Benzine as an Insulator and Absorber." All insulating materials exhibit in a greater or less degree the often very troublesome property of absorbing and retaining a portion of the electric potential acting upon them. In the older theories this process of "absorption" is represented by assuming that the electricity partially wanders from the charged condenser-plates into the insulating material between them, and is there retained. But it was soon observed that the property of absorption is essentially connected with want of homogeneity of material, so that homogeneous crystals, for example, exhibit the phenomenon only in a small degree. In order to obtain more definite results Hertz undertook experiments with liquids which can easily be rendered perfectly homogeneous, and he found in commercial benzine a medium which insulated sufficiently well for his purpose. It then appeared that the dielectric power of benzine increased under the continued action of electric forces. The cause of this was traced to the increase in the amount of suspended or dissolved impurities which were set free; under the influence of electric charges, therefore, the liquid is "electrically cleaned." It was evident, also, that the power of absorption decreased after this prolonged cleaning, so that this property must really be attributed to want of homogeneity. No migration of free electricity takes place, but the electric stress takes hold of the separate foreign particles embedded in the medium, and arranges them in a sort of strained or polarised condition. Hertz showed that this was the case by suddenly letting the liquid flow out of the trough which he had used as a condenser in these experiments, or by lowering into it two metallic plates connected with an electrometer, which clearly indicated the presence of this polarised state in the medium.

Although somewhat anticipating its chronological order I will here mention a short communication "On the Dimensions of a Magnetic Pole in Different Systems of Units," in which Hertz took part, although quite objectively, in the then burning question of the dimensions which should be chosen for electric units. He shows that the so-called "electro-magnetic system" is not more justifiable than the "electrostatic system," simply because it does not lead to want of agreement between the theories of Maxwell and Clausius; he then points out the cause of this want of agreement, and shows that the ratio of units in the two theories is exactly inverted if the magnetic measure of the current is taken as a starting point instead of the electric one.

We come now to the unique and splendid theoretical investigation of the year 1884, which is certainly the most important one in connection with the further development of Hertz's ideas, namely "On the Relations between Maxwell's Fundamental Equations of Electro-dynamics and those of Opposed Theories." We may characterise this as Hertz's greatest contribution to theoretical physics.

As the title itself indicates Hertz now declares himself definitely opposed to the orthodox theories of electric phenomena which at that time were put forward in Germany, and he passes over to the camp of Maxwell's followers. But why does he take this step? He

* Memorial Address by Prof. Hermann Ebert, delivered at the meeting of the Physical Society of Erlangen, March 7, 1894. Translated by James L. Howard.

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was not attracted by the fact that in Maxwell's theory at that time the part which explained light as an electro-magnetic phenomenon was still shrouded with a certain degree of mystery. He was not allured by the wide perspective and the multitude of new problems towards the solution of which a research-loving mind would be attracted; no, it was after a prolonged struggle with his inward conviction that he freed himself from the old ideas which had become fast-rooted even in him. He proves, firstly, that the systems of equations of the older theories are incomplete; that from them certain members are missing, the absence of which even a supporter of the theory of distance-action would concede to be a defect. But if these terms are added the formulæ begin to be unwieldy and awkward; in place of finite expressions we have infinite series which certainly converge towards a finite limit, but which appear so opposed to nature that the dissatisfaction on arriving at such formulæ is not compensated by the fact that we at last possess the complete expressions for the observed phenomena. Hertz then obtains from the unwieldy formulæ a system of equations of great clearness and simplicity, a system which is immediately greeted as a known one in Maxwell's theory. The necessary improvement in the older theories leads, therefore, to that of Maxwell, and this must be chosen as the starting point in all further progress. But even Maxwell's formulæ are here expressed in a clearer form, and this is an important advance in the theory. Maxwell, free as he was, could not completely emancipate himself from the older views, and his formulæ possess a slight unwieldiness and want of simplicity, traceable to the fact that the fundamental idea of his theory is not yet logically and clearly expressed by them; they still contain traces of conceptions belonging to the older systems—rudimentary conceptions, as Hertz occasionally and significantly calls them. Hertz has definitely removed these rudimentary notions, thus clearly exhibiting the kernel of Maxwell's theory. Already in this Paper of 1884 we meet with that system of six partial differential equations which served afterwards as Hertz's guide along the tedious and devious path of his experimental researches.

Hertz had thus acquired new views from his theoretical considerations, and with this discovery in theory his life-work was indicated for him. He must now strive to prove experimentally the superiority of Maxwell's theory and to trace all the immediate consequences of it. That the task of finding out the best method was no easy one even for a Hertz we may infer from the fact that he was occupied during three years merely in preparing the necessary apparatus.

One of the most important consequences of Maxwell's theory was that disturbances of electrical equilibrium produced at any place must be propagated as waves through space with finite velocity; indeed, with the velocity of light. This was plainly a fact to work upon. If this propagation was to be traced through the space inside a laboratory the disturbances must be rapid, and if a definite effect was to be observed they must also follow each other at regular intervals; that is, periodically varying electrical conditions, or electric oscillations must be set up, the period of which would have to be very small so that the corresponding wave-length, taking into account the extraordinarily high velocity of propagation, should be only a few decimetres.

The method of exciting electrical oscillations was indeed known, and that of producing rapid electric disturbances had already been investigated in Helmholtz's laboratory. As far back as 1870 Von Bezold had actually measured the length of electric waves and observed their interference in wires, and yet some links in the chain were wanting. One, or rather two, further conditions were necessary. We are fortunate in possessing Hertz's own account of the origin of his epoch-making work. In the introductory notice to his collected Papers on electric waves* he gives a classically beautiful picture of the gradual advance of a genius in research, in which his modesty compels him to omit much that we ourselves must fill in, namely, the importance of his earlier work.

He tells us that his interest in electrical oscillations was originally awakened by the Berlin prize of 1879, which was to be awarded for an experimental proof of a relation between electro-dynamic forces and dielectric polarisation in insulators. Prof. von Helmholtz advised young Hertz to devote himself to this research. Hertz discovered, however, that the then known oscillations were too slow to ensure success, and he therefore gave up the research; but from that time he was on the look-out for everything connected with electrical oscillations. Consequently he immediately recognised the importance for his purpose of an observation which in itself appeared very trivial. One of those accidents occurred which often point the inquiring observer to the right path, and lead to important consequences. Hertz tells the story himself very neatly. In the collection of physical apparatus at Karlsruhe he found an old pair of so-called Riess's or Knochenhauer's spirals; short, flat coils of insulated wire, with the turns all in the same plane. Hertz showed them in lecture and performed experiments with them. He thereupon noticed that the discharge of a very small Leyden jar, or of a small induction coil, passed through the one sufficed to excite strong induced currents in the other, provided that a small spark-gap was inserted in the circuit of the first one. Hertz thus made the discovery of the "effective spark-gap" which rendered his later quantitative measurements possible. Although a spark discharge had previously been somewhat justly considered very complicated, and above all things a very variable phenomenon, and consequently experiments in which sparks played any part were usually looked upon as "impure" and regarded with suspicion, Hertz found a definite effect his, provided only the discharging condensers (his Leyjars, for example), must be of small capacity; and, above all things, the paths of the discharge were of simple form and short, not consisting of long coils of wire, as in the induction coil. If these conditions were fulfilled an electrical motion excited a perceptible electrical *resonance* in a circuit of similar shape and size to its own. We have here the real kernel of Hertz's discoveries, and I might sum up the experimental evidence of all later researches in the following sentences:—

1. If we allow small condensers with small capacities to discharge through short and simply-constituted circuits with a moderately long spark-gap, we obtain a sharply-defined discharge of very short duration, which is the long-sought-for sudden disturbance of electrical equilibrium. This was a discovery which could be foreseen by no theory, a newly-discovered property of electric sparks, on which, however, all the later work depends. But theory showed further that at the same time success was assured on the second point, since oscillations of the required period were obtainable; so that Hertz had now a powerful exciter of electrical vibrations.

2. Such vibrations are capable of exciting in another discharge circuit of like form resonance phenomena of sufficient intensity, even when the two circuits are separated from each other by great distances. Hertz had therefore found a receiver by means of which he could detect the waves produced by the exciter and propagated to any distance.

In the work which next appeared, "On very Rapid Electric Oscillations," we find him occupied with these phenomena; he is studying his apparatus, and gradually constructing and perfecting it. As an exciter of oscillations he uses wire rectangles or simple metal rods, to the ends of which metallic cylinders or spheres are connected; the exciter is broken in the middle by a spark-gap with small spherical knobs, between which the spark passes. The exciter is charged by an induction coil, the complicated form of whose discharge only plays a secondary part, and scarcely comes into consideration. The receivers are mostly simple rectangles of wire, likewise provided with spark-gaps; their length is so arranged that they show the maximum resonant effect with a given exciter, they are "electrically tuned." When a resonant vibration is set up in them, sparks pass across the gap, and the greatest length of the spark measures the intensity of the effect.

Such is the principle of the new and simple means which Hertz has introduced into the physical laboratory, and with which so many physicists are at present working in various directions, and endeavouring to penetrate into the unknown. It was owing to a strange accidental circumstance that these discoveries, and the later work of Hertz, met with immediate recognition rather than to their intrinsic value—how often the greatest discoveries remain long unheeded! Hertz found in his earlier experiments on electric resonance a phenomenon which attracted his notice by its definiteness and simplicity, and charmed him by its novelty and its inexplicable character. It was seen that the length and brightness of the resonator sparks were strongly influenced by the sparks in the primary circuit. If the latter were visible from the resonator spark gap they appeared small and hardly perceptible, but they became immediately larger and brighter as soon as a screen was placed between the two spark-gaps. In his work, "On an Influence of Ultra-violet Light on the Electric Discharge," he depicts in almost dramatic fashion how, by carefully thought-out experiments, he finally came to the conclusion that this singular action on spark discharges is traceable only to ultra-violet light. Many experimenters continued these researches and discovered remarkable new facts concerning them; indeed, Hertz introduced quite a new branch of experimental physics, that of the action of light on electricity. If these experiments did not immediately lead to the discovery of a closer relation between the two phenomena, they served to make Hertz popular, so that everything coming from him was eagerly read.

Few people, however, thought at that time that this pretty, though only subsidiary, effect was not the main discovery, or that we were on the eve of much greater conquests in the domain of electric oscillations. We find Hertz busy once more with his apparatus. In the following year appeared "On the Action of a Rectilinear Electric Oscillation on a neighbouring circuit." This was the most difficult and the most important of Hertz's experimental researches; it is often overlooked in descriptions of his work, and yet it forms a necessary step to the following conquests. Hertz had become familiar with the phenomenon of resonance; he had now

* "Electric Waves," by H. Hertz, translated by D. E. Jones. Page 1. (Macmillan.)

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to deal with the propagation of oscillations through space. The apparatus was already furnished; as exciter he made use of a straight metal rod with a spark-gap in the middle and a spherical conductor at each end to give it capacity. When sparks pass rapid electrical surgings occur; we have a rectilinear oscillation whose effect is radiated out into surrounding space. As receivers he used tuned circles of wire, likewise provided with very small spark-gaps whose length could be measured with a micrometer. These were brought into all kinds of positions with respect to the exciter, and Hertz studied and measured the effects. These effects were very different at different points in the neighbourhood and in the various positions of the receiver, but a law was soon found to apply to them. "The discovery and disentanglement of these extremely regular phenomena gave me peculiar pleasure," says Hertz. By an argument which was ingenious, though simple in its results and indisputably clear throughout, he established in each case how the electrical radiation must act at the different points in the neighbourhood of the oscillation, in order to produce the observed effect on the receiver, and he finally succeeded in giving a clear and intelligible account of the propagation of the radiation through space. Many remarkable phenomena then presented themselves, of which the older theories could offer no explanation. In the same year, 1888, he showed in his Paper on "The Forces of Electric Oscillations, treated according to Maxwell's Theory," that this theory gives exactly the same distribution of forces as his experiments had yielded, with all their peculiarities and apparent anomalies. Hertz set out in this Paper from the simplified form of Maxwell's theory which he had established in 1884.

Great discoveries now followed one after another, each representing a new triumph of Maxwell's theory, and, above all, of the newer views. The papers which were presented to the Berlin Academy between November 10, 1887, and December 13, 1888, mark a new era.

The Berlin prize problem now received a definite solution in the research "On Induction Phenomena produced by Electric Disturbances in Insulators." It was shown that "alternating conditions of electric stress or dielectric polarisation" produce electro-dynamic action and inductive effects, analogous to those set up in a conductor by a rising or decaying voltaic current. The older theories had for the most part disregarded the intervening medium, according to them the effect travelled directly across it; whereas Maxwell's theory had these electro-dynamic actions as one of its most important consequences. At the same time the old controversy concerning the action of "unclosed circuits" was set at rest.

Three months later appeared the Paper "On the Velocity of Propagation of Electro-dynamic Actions." In this research an experimental proof was given of the fact that electro-dynamic actions are propagated through space with finite velocity. For the velocity of electric waves in air a quantity of the same order as the velocity of light was obtained. For the velocity of propagation along stretched wires he found a value different from that in air; theory required them to be the same. In consequence of an error in calculation the velocity of waves in wires was found smaller than the velocity of light. But he here showed himself an unbiassed lover of truth. Although convinced of the truth of the theory he submitted his actual results, and confessed that he had here met with an unsolvable difficulty. Let us quote his own words on the subject, written four years later in the introduction to his book after he had explained the discrepancy:—"I have described these results in great detail because I wished to convince the reader that I was not merely endeavouring in this research to support a preconceived opinion by the most convenient and suitable interpretation of experiment. On the other hand, I have carried out the experiments, which in themselves were not easy, with the greatest possible care in the face of a preconceived opinion. And yet, with all my good fortune, I have had decided misfortune just in this experiment. For, instead of reaching the true result with small trouble, which a properly-arranged plan would probably have enabled me to do, I have apparently taken great pains, and fallen into error."

It was not discovered until later that the deviations from the theory were caused simply by the walls of the room, which reflected the electric waves impinging on them. Edouard Sarasin and De la Rive have finally shown that the velocity of propagation in wires has the same value as in air, each being that of light, by repeating Hertz's experiments on a large scale, and with every precaution, in the large machine shop of the Geneva Waterworks. The result is, therefore, quite decided for us now; but the disturbances which crept into Hertz's own experiments have given us a proof of his conscientiousness.

The account of the research "On Electro-dynamic Waves and Their Reflection" was published in the same year. Although Hertz had hitherto only succeeded in working with waves propagated along a wire, he now demonstrated the existence of similar waves in free space. Opposite the radiator a large screen of zinc plate, 8ft. square, was suspended on the wall; the electric waves emitted from the radiator were reflected from this plate, and on meeting the direct waves interference phenomena were produced, consisting of stationary waves with nodes and loops. When, therefore, Hertz moved the circle of wire which served as a receiver to and fro between the screen and the radiator the sparks in the receiver circuit disappeared at certain points, reappeared at other points, disappeared again, and so on. Thus there was found a periodically alternating effect corresponding to nodes and loops of electric radiation, showing clearly that in this case also the radiation was of an undulatory character, and the velocity of its propagation finite.

In the Paper "On the Propagation of Electric Waves along Wires" he shows that alternating electrical movements with frequencies as great as those under consideration (about a hundred million per second) are confined to the surface of the conductor along which they are propagated, and do not penetrate into its interior. This is a very important experimental confirmation of a theory of Poynting, founded upon the ideas of Faraday and Maxwell, concerning electric currents. According to this theory an electric current is a phenomenon which has its seat in the region outside the wire conveying it rather than in the interior of the wire. The magnetic effect of a current shows us that something goes on in this outside space which is very closely connected with the passage of the current. We are not to look for something flowing along the wire, but must rather consider that the energy enters the wire from without, and is thereupon converted into the special form of heat. It is thus not the copper core of a cable which conveys the energy from the sending to the receiving station, but the insulating layers surrounding the core; the terms "conductor" and "non-conductor" exactly change places. It is certainly true, as Hertz very pointedly remarks, that this apparent paradox only arises because we neglect to state what we mean by the term *conduction*. In reality the electric fluid of the older theories is abolished, in its stead have been introduced electric and magnetic forces existing independently in space, and advancing through it, carrying their energy with them, and for these the circumstances of conductivity are exactly the inverse of those for the hypothetical electric fluids.

In the course of his experiments Hertz had learned the method of producing, and working with, very short electric waves of 30cm. length. The oscillations corresponding to them could be collected by a concave cylindrical mirror and concentrated into a single beam of electric radiation. According to Maxwell's electro-magnetic theory of the phenomena of light such a beam must behave like a beam of light. That this is the case was shown by Hertz in his Paper "On Electric Radiation," the communication which has become the most popular one, and has created the greatest astonishment far and wide. The modest man says, in the introduction to his collected Papers, "These experiments succeeded each other quickly, and without any difficulty. The experiments with the cylindrical mirrors soon attracted notice, and they have been often repeated and verified. They have met with an approval quite beyond my expectation."

He showed how such electric radiation was propagated in straight lines like light, that it could not pass through metals, but was reflected by them; that, on the other hand, it was able to penetrate through wooden doors and stone walls; he also proved, by setting up metallic screens, that a space existed behind them in which no electric action could be detected, producing in this way electric shadows; and, by passing the rays through a wire grating, he succeeded in polarising them, just as light is polarised by passage through a Nicol prism. But the most striking experiment was that in which he directed the electric ray on a large pitch prism, weighing about 12cwt.; the ray was deviated, being refracted like a ray of light in a glass prism. Thus he gave to the whole its finishing touch, and the edifice was now completed.

In the communication which appeared three years later, and thus was dated from Bonn, "On the Mechanical Effects on Electric Waves in Wires," he demonstrated that not only does a wave of changes of electric state travel from the radiator through space with the velocity of light; but that along with it and inseparable from it there exists a magnetic wave, as theory requires.

In his last experimental work he finally returns to the phenomenon of discharge in gases, and shows, almost at the same time as E. Wiedemann and Ebert, that cathode rays can pass through thin films of metal, but are stopped by a dielectric film, no matter how thin it may be.

And now inexorable death set a limit to the further progress of the clever experimenter. We are indebted to him for two other Papers of a theoretical character, "On the Fundamental Equations of Electro-dynamics in Bodies at Rest and in Motion," which mark a great advance in the mathematical theory of electric and magnetic phenomena.

On his deathbed he completed a book, "On the Principles of Mechanics," to the early appearance of which the scientific world looks forward with intense interest.

Let us once more pass in review the chief results of his discoveries. He has freed us from the bondage of the theories of action-

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at-a-distance, and concerning electrical and magnetic effects he has shown that they are propagated from particle to particle through space with finite velocity. This is a result of great and general, one might almost say philosophical, significance. The mysterious darkness which surrounded those secret distance-actions of former times has been cleared away; the dogma, honoured by science until now although unwillingly tolerated by reason, that something can act where it is not, has lost its application to the case of electric and magnetic actions. Further, the identity of the form of energy in the case of two powerful agents in nature has been conclusively established; light and electrical radiation are essentially the same, different manifestations of the same processes. The old elastic-solid theory of optics is thus resolved into an electromagnetic theory. The velocity of propagation of light is the same as that of electro-magnetic waves, and these obey the laws of optics; the scope of optics is enormously widened; to the ultra-violet, visible and infra-red rays with their wave-lengths which can be reckoned only in thousandths of a millimetre, are to be added waves many metres in length; the spectrum is infinitely extended, even if the rods and cones of our eyes do not respond to the new vibrations.

But in another direction we owe much to Hertz's investigations; we are, it appears to me, brought much nearer by them to a solution of the burning question, "What is electricity?" Hertz shows that there is no real electricity which can be regarded as a fluid as in the older theories; what we wished to explain by assuming it are conditions or states of a medium which, although hypothetical, manifests itself by its effects, "the ether," which permeates all matter. Led to this hypothesis, the phenomena of magnetism, electricity, and light apparently find at last a single explanation in a "Mechanics of the Ether." Whenever such an edifice is completed we shall be considerably nearer the possibility of finding a single explanation for the whole of nature. These are the results of the most recent discoveries, in which Hertz has played a most conspicuous part.

If we glance over the list of his contributions to science we ask in astonishment, "Is it possible that one man in the space of thirteen years could furnish such a wealth of new discoveries or open so many new avenues of research?" If the intense suffering of Hertz and his premature decease awaken our deepest sorrow, if the thought of what this mind might have explained makes us rail against the bitter fate that tore him from us, we may still say his was a short but happy and richly-rewarded life; the fame of our Hertz is secure, and will shine out during centuries of increasing intellectual development, whatever great deeds they may hide in their bosom; the influence of his discoveries will make itself felt as long as electro-magnetic waves continue to heat and illumine the earth.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *July* 7, 1894.

Long-Distance Electric Roads.—Every now and then we hear of a new scheme for a long-distance electric railway, the latest project being for one between Washington and New York, whose promoters have applied for incorporation. None of these ambitious schemes have thus far gone beyond the promotion stage, unless we except the feeble attempts made by the Chicago-St. Louis line, whose prospectus dwelt in such glowing terms on the profits to be derived from transporting World's Fair visitors. In some cases the scheme for a long-distance line conceals another purpose, the real object being to secure franchises on better terms for short lines, which are represented as sections of a trunk line which is never built.

Purifying Water and Deodorizing Garbage.—Some of the members of our Tammany City Government seem to be greatly interested in a process for purifying the municipal water supply and deodorizing city garbage by electrical means. In the former case sea water through which an electric current has been passed is mixed with the regular water supply in homeopathic doses. We cannot learn how the process is to be applied to deodorize a garbage island that has become a pestilent nuisance; but this use has been proposed. As residents in the vicinity have applied for an injunction against further dumping there, though in the face of the promise of wonders when the electrical apparatus gets started, we fear that this latest political contribution to electrical science may not have an opportunity to demonstrate its merits in this respect.

Electro-Medical Science.—An employé of the Edison lamp works of Harrison, N.J., a few days ago was rendered unconscious by a shock from an electric current, in which state he remained for several days, notwithstanding the efforts of his physician. Finally, becoming convinced that the patient did not recover on account of being "full of electricity," the doctor, applying his electrical knowledge, connected one end of an insulated wire to a water pipe and the other end to a damp sponge, which was rubbed over the body of the injured man. After the first application an improvement was noticed, we learn, and in a short time the patient recovered consciousness and is now convalescent. All of which is hailed by the newspapers as a new curative principle for the treatment of electric shocks.

CORRESPONDENCE.

ENGINE REPAIRS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am glad to find from Mr. A. Lazenby's letter that the difficulties with closed type engines referred to by me in "Electric Motive Power" are now lessened in the improved types of the Willans engine; and I note that in condensing engines the temperature of the lubricant in the crank chamber does not often exceed 150°F.—Yours, &c.,

Suffolk House, Cannon-street, E.C., ALBION T. SNELL.
July 16, 1894.

LIGHTNING AND WOOD CASING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to your remarks on page 157 regarding the phenomenon of sparking resulting from Hertzian waves impinging upon separated main leads terminating in twin flexible conductors, I should like to point out that danger is also incurred where insulated conductors of opposite poles are placed in contact with each other at the points of crossing in wood casing. In some wiring I have inspected, the first fuse protecting these points was either the main, or was of such large diameter as to render it doubtful if it would act at the comparatively small current that would result from an arc so formed. If the fuse did not blow, and the arc was maintained, the wood casing in the immediate neighbourhood of the latter would probably become ignited.

If this occurred during the night, or at any time with no one at hand to switch off, or if no main switch were provided, it might be difficult to extinguish the fire or limit the damage.

As far as my experience goes, this faulty method of wiring appears to be on the increase; and it would be advisable for fire offices to insist on the separation of conductors until protected by a small fuse.—Yours, &c., CHAS. A. GAWTHORP.
July 6, 1894.

LARNE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your "Note" with reference to Larne in *The Electrician* of the 13th inst. is inaccurate, as there has been no new penalty clause added to our agreement. At the meeting you refer to, the engrossed copy of the agreement was before the Board for signature; but a Commissioner objected to its being completed on the ground that the penalty clause of the draft copy had been omitted in the fair copy, and it was then decided to consult the Board's solicitor, by whom the agreement had been prepared. The solicitor attended a special meeting on the 7th inst., and was able to show the doubting Commissioner that his suspicions were groundless, and that there was no necessity to make any alterations or additions to the agreement. It was then signed by the Chairman and two Commissioners. The discussion over this lighting agreement has been vigorously carried on since last October, and, apparently, there are some members of the Board who do not think the matter has received adequate attention even now. The arc lights referred to are of 1,200 c.p. each, and not of 1,700 c.p. as printed.—Yours, &c., ARCHER TURNER,
Electric Light Station, Larne. Manager and Engineer.

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LEGAL INTELLIGENCE.

Latter v. Goolden.

This was an action before Mr. Justice Lawrance and a common jury, to recover damages for an alleged libel, and the defendants in answer pleaded privilege.

The case was of some importance in its relation to the question of giving "characters" to discharged employés The plaintiff was a lad in his seventeenth year. In June, 1891, he became a junior clerk in the service of Messrs. W. T. Goolden and Co., at Hanover-road, W.. at 8s. a week. He remained there until February, 1892, when Mr. Ravenshaw gave him a week's notice to leave. The father of the plaintiff was a workman employed in the Royal Mint, and he obtained a nomination for his son as a boy workman in that establishment, and when that situation was obtained the salary would be 15s. a week. The lad passed the preliminary examination, and the only question which remained was that of character, and there were communications between the Civil Service Commissioners and Messrs. Goolden and Co. upon this subject. The plaintiff did not obtain his appointment. It was known that there had been complaints at Messrs. Goolden's as to money having been filched from the pockets of coats that were hung up in the offices, and it was believed that what Messrs. Goolden wrote to the Commissioners connected the plaintiff in some way with this misconduct. Under these circumstances the father of the plaintiff wrote to Mr. Ravenshaw, who replied: "Your son is leaving my office as I have no further use for his services. We are getting rid of several boys, having more than we require, and your son not being an apprentice has been included in the list. I shall be glad to give your son a character for neatness and punctuality." The principal difficulty in the way of the plaintiff was to prove the publication of any libel.

A gentleman at the head of the department of the Civil Service Commissioners, who had to do with this matter, said that the documents which he was called upon to produce, and which was said to be libellous, contained a series of questions and answers in reference to character, and he declined to produce the document, it being confidential.

Mr. Justice LAWRANCE: That will not do.

WITNESS: And that it would be against the interest of the public service that it should be produced.

Mr. HALL, for the plaintiff, submitted that great injustice would be done to his client if that document were not ordered to be produced.

Mr. POWELL, for the defence: You have not yet heard our case.

Mr. Justice LAWRANCE regretted it, but he could not interfere as to the production of the document, for his hands were tied. The defendants were entitled to shield themselves behind this technicality, and there must be judgment for them.

Judgment was therefore given for the defendants, but the question of costs was reserved.

Coad v. Saunders.

In the City of London Court the plaintiff, Mr. T. Coad, electrical engineer, sued the defendant, Mr. Albert Saunders, solicitor, to recover £140, made up of £100 and £40. The first sum, it was alleged, the defendant had agreed to pay for the patent rights of an electrical apparatus invented by the plaintiff, and the £40 was claimed as the balance of an alleged loan. There was a counter-claim by the defendant for £152 in respect of money lent.

Having partly heard counsel for the plaintiff, the Recorder suggested that it was a case either for settlement or for reference to an arbitrator. A consultation then took place between the judge and counsel, and it was stated that the parties had agreed to a reference of all matters in dispute to the Registrar.

A formal verdict was returned for the plaintiff, subject to the reference.

Abell Electrical Engineering Company v. Pownal.

At the St. Helens County Court, before Judge Shand, on Wednesday, the plaintiff Company claimed £2. 17s. 6d. from Robert Pownall, alleged to be due for electrical apparatus supplied. It appeared that the defendant was the tenant of a farm at Sutton, and conceived the idea of working his fowl incubators by electricity. He consulted the manager of the Abell Electrical Company upon the matter, and at his request certain apparatus was supplied. The defendant afterwards alleged that the apparatus would not work, and refused to pay the account. He contended that the machine was a failure owing to bad workmanship, and said it had ruined 600 eggs, for which he paid a considerable sum.

As the plaintiff Company was in liquidation, and the proceedings were not instituted by the Official Liquidator, a nonsuit was entered.

Fire Pail Indicators.—It is stated that the superintendent of a large New England factory places all his fire pails on hooks which work on steel springs. The hook is strong enough to lift the pail when nearly empty, but a full pail forcibly depresses it. A metal point is so placed that when the spring in closing presses the point it closes a battery circuit and rings a bell in the office of the superintendent. He is thus constantly advised if the water in the buckets has evaporated, or if some one has borrowed the pails.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

The 1894 Edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is NOW READY. This valuable book contains 1,000 closely-printed pages, and several new and useful features have been added. The price of the Directory and Handbook is 7s. 6d. Postage in the United Kingdom, 9d.; abroad, 1s. 4d.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," being four Lectures delivered before the Royal Institution in April-May, 1894, by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is in preparation, and will shortly be published.

"ELECTROMAGNETIC THEORY," by Oliver Heaviside, is now ready, price 12s. 6d. (abroad 13s.). Prospectus on application.

"THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application to the Publisher.

"DRUM ARMATURES AND COMMUTATORS."—This book, written by Mr. F. Marten Weymouth, is also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"INVENTIONS, RESEARCHES AND WRITINGS OF NIKOLA TESLA," by T. Commerford Martin, may be obtained from the Publisher of *The Electrician*, and a copy will be forwarded post free on receipt of 16s. 6d.

"HOW TO WIRE BUILDINGS."—Copies of this work, by Augustus Noll, will also be sent by the Publisher post free on receipt of 6s.

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. (abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application to the Publisher

TENDERS INVITED.—The Corporation of Edinburgh invite tenders for work in connection with the electric lighting of the city under contracts 13, 14, 15, 16, and 17, which refer to the supply and erection of Willans engines, alternators, &c., switchboards, instruments, arc lamps, Ferranti rectifiers, and insulated concentric cables. Copies of the specifications can be obtained from the resident electrical engineer, City Chambers, Edinburgh, and all other information required will be supplied by Prof. A. B. W. Kennedy, consulting electrical engineer to the Corporation, 14, Old Queen-street, Westminster, S.W. Tenders have to be sent in to Mr. W. Skinner, W.S., Town Clerk, City Chambers, Edinburgh, not later than Monday, the 30th inst., for contract No. 15, and by Monday, August 6th, for contracts Nos. 13, 14, 16 and 17. Further particulars are given in our advertisement columns.

TENDERS ACCEPTED.—The Leith Dock Commission have accepted the tender of the Brush Company for the supply of electric light plant and fittings for a portion of the docks, and also the estimate of Messrs. R. Bruce and Son for the erection of an engine house, the latter for the sum of £640.

——— Tenders for wiring Wellington Court, Knightsbridge, have been received as follows:—

Roger Dawson (Limited), London (accepted)	£1,050	0
Spagnoletti and Crookes	1,090	0
Crompton and Co.	1,114	0
H. Joel and Co.	1,200	0
B. Verity and Son	1,261	0
Bolding and Co.	1,292	10
Vaughan and Brown	£1,380	0
Raynes, Smith and Co.	1,394	0
Planet Electrical Engineering Company	1,474	0
Bergthiel and Young	1,647	0
Julius Sax and Co.	1,668	0

——— The Bolton Corporation have accepted the tender of Messrs. Siemens Bros. and Co., for supplying and laying the necessary mains for the extensions in Knowlsey-street, as set out by the Corporation's Electrical Engineer, Mr. J. H. Ryder. It has been decided to substitute a powerful arc lamp for the gas lamps now lighting the Town Hall Square. The Electrical Engineer reported to the last meeting of the Corporation that applications had been received for about 2,000 8-c.p. lamps from the Corporation's mains.

——— The Stafford Town Council have accepted the tender of Mr. T. Smith, of Rodley, for an overhead traveller for the sum of £185. Dr. Hopkinson recommended the acceptance of the tender of Maignen's Filter Company for apparatus to be erected for softening the water before use in the steam boilers for the sum of £220. River water is to be used for this purpose at a saving of £350, as against the use of Corporation water.

REMOVAL NOTICES.—Mr. Charles Escaré, jun., owing to increase of business, has removed from Albert-place, Tottenham Court-road, to 128, Wardour-street, London, W.

——— Messrs. Siemens Bros. and Co.'s new address at Glasgow is 261, West George-street.

——— The Bournemouth and District Electric Supply Company (Limited) give notice of a change of address from Observer Chambers, Albert-road, Bournemouth, to Verulam-road, Yelveton-road, Bournemouth.

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BOXES FOR ELECTRICAL GOODS.—Messrs. H. Nixdorff and Co., of 30, Maidstone-street, Hackney-road, N.E., who are wholesale packing and postal box manufacturers, have sent us samples of several sizes of strongly-made wooden boxes specially adapted for the carriage of light goods, such as electrical, mathematical, and optical instruments and instrument parts, incandescent lamps, small apparatus, lantern slides, &c. The boxes are especially handy for sending through the Parcel Post. They are made in any sizes, and those with an inside measurement of 3in. by 3in. by 2½in., made from ⅛in. timber, are supplied at 15s. per gross; 8½in. by 6½in. by 4in., with ¼in. timber, at 42s. per gross.

ELECTRIC ELEVATORS.—The following is an extract from a letter sent to a contemporary by Mr. Morgan I. M. Williams:—"The following figures of the cost of operation of an electrically-driven passenger elevator, erected for Mr. E. D. Stern, of Carlton House-terrace, at the commencement of the present year, may be of interest. The elevator is fitted with a 600lb. car, having a rise of 40ft., and is designed to work at the rate of 60ft. per minute, self-acting safety appliances of latest type being provided. It is operated from within by a simple regulating switch, and everything has, so far, given great satisfaction. The current is supplied from the mains of the local supply company, whose invoice shows cost of current for working during the last three months 9s. 2d., during which time the lift has been in regular use, the number of trips being probably about 400. The cost of an average journey amounted to from ¼d. to ½d., according to load."

EXPORTS OF TELEGRAPH WIRE AND APPARATUS, &c.—The present activity in the extension of the telegraphic system in various parts of the world is well shown by the official returns now available regarding the exports of telegraph wire and apparatus connected therewith from this country during last month. The exports have jumped in value from £90,077 in May last to no less than £341,646 last month, the latter figures comparing with £28,274 in June, 1893, and £24,177 in June, 1892. The returns of the exports during the first six months of the year are also now available, and these also must be considered satisfactory from every point of view. For the six months ending June last the exports have reached a total value of £883,741, as compared with only £479,195 in the first half of the year 1893, and £675,835 in the first six months of 1892.

ALLGEMEINE ELEKTRICITÄTS GESELLSCHAFT.—We have received an elaborately got-up and sumptuously-bound copy of the "Electric Lighting and Transmission of Power Manual, for Preparing Approximate Schemes and Estimates," which has recently been published by the above firm. The work is in English, and the phraseology is far superior to the average translation of German trade literature. It is furnished on the insides of the covers and on the facing pages with three large coloured maps, showing the chief towns, railways, &c., of the world. The frontispiece consists of a number of artistic coloured pictures of the offices, works and central stations belonging to the Company. The contents of the book comprises "A Synopsis of Electric Lighting Projects," and enters into mechanical and electrical design. Another section gives "Directions for Preparing Approximate Estimates," and comprises a number of neatly-arranged tables of the approximate costs of plant. The two tables of "Rates of Freight" should also prove useful. The remaining sections are devoted to descriptions of various electrical and mechanical machines, apparatus and fittings. The book is copiously and artistically illustrated.

"DUROL."—Messrs. W. Holz and Co. have just issued a circular giving particulars of "Durol," a hardening composition for steel. Accompanying the circular are instructions for using the material.

"MOUNTAIN, MOOR, AND LOCH."—We have received a copy of a useful publication issued by Sir Joseph Causton and Sons, entitled "Mountain, Moor, and Loch, illustrated by Pen and Pencil," giving descriptions of the West Highland Railway route. The book is issued with the object of reaching intending tourists through the beautiful district served by the West Highland Railway. The illustrations commence with a view of the Great Northern Station at King's Cross, and continue throughout to illustrate the route by rail and boat.

GERMAN CENTRAL STATIONS.—We have been shown a copy of an imposing volume prepared by the Helios Company, giving illustrations and descriptive particulars of the central stations erected by the Company at Cologne and Amsterdam. The work is by Mr. Carl Coerper, and has been translated from the German by Mr. Clarence P. Feldmann. As a specimen of the printer's art we have seen nothing better for years, and the lithographic engravings are on a large scale, and very clear and instructive. Several fine phototype views of the central station buildings are included in the work, to which we hope to make further reference at a later date. The agents for the Helios Company in this country are the International Electric Company, of Redcross-street, E.C.

ABERDEEN.—A proposal of the Gas and Electric Lighting Committee of the Town Council to increase the charge for electric current for public lighting from 2¼d. to 3¾d. per lamp per hour is to be discussed at the forthcoming meeting of the Council. This will bring the total cost of lighting the public lamps to about 4½d. per hour.——The presence of Prof. A. B. W. Kennedy in the neighbourhood has induced the Directors of the Northern Co-operative Company to have a careful examination and test made of the work which has been carried out in connection with the electric lighting of the Company's central premises. Prof. Kennedy congratulated the Company upon the enterprise they had shown in the matter of the electric light, and felt no doubt that the experience which had been gained by other public bodies would be realised in this case. The electric light had been proved to be a great advantage over gas lighting, especially in buildings where large numbers were employed, and where, especially during the winter months, a large amount of light was necessary.

AMBLESIDE.—The Local Board have received intimations from the Troutbeck Bridge Electric Lighting Company, and also from the Holloway Electricity Supply Company, that it is their intention to apply for a Provisional Order for lighting the district by electricity. The Local Board have withheld their consent to both applications.

ANNUAL DINNER.—The employés of Messrs. King, Mendham and Co., of Bristol, held their annual dinner at Weymouth on Saturday last.

ARBROATH.—The Northern Electric Light Supply Company having notified the Town Council of their intention to apply for a Provisional Order to light the district by electricity, the Provost stated that it would be necessary for the Council to apply for the order themselves in order to keep the lighting of the district in their own hands.

BEDFORD.—Correspondence has passed between the local authorities and the officials of the Bedford Electric Light Company, in reference to the obligations of the Urban Sanitary Authority in connection with their Electric Lighting Order, 1890. The concluding communication from the Company threatened to compel the authorities to lay down suitable and sufficient generating plant for the purpose of general supply in the various parts of the borough. A discussion arose on the subject of the letters, and it was decided that the Mayor should confer with the Secretary of the Company in the matter.

BOLTON.—In connection with the arrangements by which the Corporation supply electric light fittings on the hire purchase system, it has been decided to supply these fittings to consumers on the plan of one-eighth of their cost to be paid down and the remaining seven-eighths by equal quarterly instalments. Applications have at present been received for current equal to about 1,200 8-c.p. lamps.

BOURNEMOUTH.—The Bournemouth and District Electric Supply Company notify that arrangements have been concluded with the Brush Provincial Company, who have agreed to provide the necessary funds for extensions which the Directors of the Bournemouth Company have decided to carry out. Alterations have been made in the *personnel* of the directorate, which now consists of Mr. A. H. Sanderson, Dr. Hosker, and Mr. R. Percy Sellon. Mr. Sanderson is Chairman of the Board, and both he and Mr. Sellon are Directors of the Brush Provincial Company. It is pointed out that the Brush Provincial Company are owners of a large proportion of the Bournemouth Company's Ordinary shares, and that therefore the interests of the two concerns are identical.

BOWNESS.—The Local Authorities have received notice from the Troutbeck Bridge Electric Lighting Company that they intend applying to Parliament for powers to supply the district with electric current.

BRECHIN.—In reference to the intimations sent in by the Northern Electric Light Supply Company, of Aberdeen, and the Scottish House to House Electricity Company, of Glasgow, of their intention to apply for Provisional Orders for supplying Brechin with electric current, it has been decided by the Local Authority to leave the discussion of these matters with the Lighting Committee.

BROADSTAIRS (KENT).—The Broadstairs and St. Peter's Local Board have been notified by the Brush Provincial Company that they intend applying for a Provisional Order for power to supply electric energy for public or private purposes within the Local Board's district. It was decided after a short discussion that the Board should oppose the application.

BROMSGROVE.—Messrs. Hemming and Co. have applied for leave of the Local Board for laying down electric lighting plant, with the ultimate intention of applying to the Board of Trade for the necessary licence. The subject is to be further considered at the next meeting of the Board. Messrs. Hemming and Co., in their letter to the Board, state that in their belief it would be possible to supply electric current at the same price as is now charged for gas in the district.

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BROUGHTY.—The Police Commissioners have been notified by the Northern Electric Supply Company of the latter's intention to apply for a Provisional Order for lighting the district by electricity. The Gas Committee have been instructed to consult an electrical engineer on the subject.

CARDIFF.—The work required for lighting Cardiff by electricity is nearly complete, only the erection of a few lamp-pillars remaining to be done. Nearly the whole of the machinery has been delivered, and it is expected that a start will be made on September 1st. Current is to be supplied at 6d. per unit; 48 arc lamps are, at the commencement, to be used for public lighting.

CHURCH LIGHTING.—St. James's Church, Taunton, has recently had its lighting arrangements remodelled, arc lamps having been replaced by clusters of glow lamps, of which 55 are in use. These are suspended from the crown of the arches in the nave and chancel. The lamps are of 32 c.p., and the electroliers are of wrought ironwork. The work has been carried out by Mr. F. M. Newton, the fittings being supplied by Messrs. Lea, Sons and Co. The current is taken from the Corporation mains.——West Hackney Church (London, N.E.), is to be lighted electrically when certain alterations to the interior of the church have been completed.

COATBRIDGE.—It has been decided to empower the Lighting Committee of the Town Council to spend £58 by way of experiment in lighting the streets with arc lamps, whereby it is expected a saving of from £25 to £30 will be effected.

COLLIERY LIGHTING.—The Alloa Coal Company have just lighted their Devon Colliery at Sauchie by electricity. Four 2,000-c.p. arcs light the pit-head; the engine-rooms, workshops, offices, &c., being lighted by 16 and 50-c.p. lamps. The whole of the pit-bottom, engine-rooms, stables, and main roads are lighted by incandescents. The Company have also introduced the electric light at their Bannockburn Colliery, both installations being carried out by Messrs. T. Laurie and Co., of Falkirk.——The Clay Cross Colliery Company are putting down a complete lighting plant for 200 16-c.p. incandescents to light their surface works and pit's bottom, the order having been placed with the Acme and Immisch Electric Works (Limited).

DENBIGH.—The gas works company, having refused an offer of 3s. 8d. per thousand cubic feet for the gas for lighting the public lamps, this scale having been suggested by the Lighting Committee of the Town Council, it was agreed to consider the best steps to be taken to secure an electric lighting installation for the town.

DEVONPORT.—At the last meeting of the Town Council the remarkable proposal was made that a contract should be entered into with the local Gas Company for lighting the public lamps by gas for seven years. It was pointed out by several members of the Council that the rapid progress made in electric lighting should cause the Council to pause before tying their hands for seven years to the Gas Company, especially in view of the fact that at the present meeting notices were received from several electric lighting companies of their intention to apply for Provisional Orders to light the district by electricity. It was decided to make the contract with the Gas Company determinable at the end of three, five, or seven years.

DUBLIN.—The Scottish Provident Institution, which has a large business in Dublin, has recently taken new premises at College-green. The handsome building, which is just completed, is lighted throughout by electricity, the work having been carried out by Messrs. Porte, Sykes and Co.

ECCLES.—The Electric Lighting Committee of the Town Council have been authorised to visit Whitehaven for the purpose of obtaining information regarding the proposed electric lighting scheme.

EDINBURGH.—The consideration of a proposal to extend the electric lighting area to an additional number of the principal thoroughfares in Edinburgh was, at the last meeting of the Town Council, deferred.

EXHIBITIONS.—It is intended to hold an International Exhibition of Arts, Industries, &c., at Bordeaux, in 1895, under the patronage of the French Government.

———— A committee has been formed in Paris with the object of organising an international electrical exhibition, to be opened on July 1, 1895, and to remain open to October 31st of that year. The exhibition is to be divided into two sections, one comprising generating apparatus, and the other to contain various electrical apparatus and machinery. The two sections, one of which will be situate on the Champs de Mars and the other on the Champs Elysées are to be connected by an electric railway.

———— An exhibition is to be held at Rouen in the year 1896 on the lines of the great exhibition held in the same city in 1884. Details are not yet supplied.

FORFAR.—The proposal of the Northern Electric Supply Company to obtain a Provisional Order for lighting Forfar is to be opposed by the Corporation.

GERMAN ENTERPRISE IN TURKEY.—The Acting British Consul-General at Constantinople refers, in a despatch to the Foreign Office, to a German association established at Constantinople during the past two or three years to actively push the sale of German machinery in all parts of Turkey. This association represents over 100 German firms, and sells none but German goods. It has premises in Galata, where specimens of various machinery can be seen, including engines, pumps, agricultural machinery, tools and implements, &c. An engineer is in charge, who explains the use and mechanism of the different machines to intending purchasers. The British Consul-General, in forwarding these particulars, invites British machinery makers to adopt the German method if they do not wish Turkish trade to pass entirely out of their hands.

GLASGOW CORPORATION ELECTRIC LIGHTING UNDERTAKING.—The Treasurer to the Glasgow Corporation Gas and Electric Lighting Committee recently reported that the electric lighting revenue for the year 1893-94, which ended on May 31st, amounted to £15,953. 19s. 7d., as compared with £6,189. 15s. 1d. for the year 1892-93, thus showing an increase for the past year amounting to £9,764. 4s. 6d. Some weeks since the Electrical Engineer to the Corporation (Mr. William Arnot) submitted plans showing what further plant could be accommodated within the Waterloo-street Station; and at a joint meeting of special sub-committees on extension of generating plant, distributing mains, and street lighting, recently held, it was resolved, after giving due consideration to the plans, to recommend that two additional steam engines and dynamos, with relative connections, &c., be put down within the station at an estimated cost of £6,000, that the engineer be instructed to prepare the necessary specification and, thereafter, to obtain and submit tenders for the execution of the work. After considering as to the additional boilers which it would be necessary to provide, the Sub-Committees agreed to delay further consideration of the matter until the Chairman (Councillor Burt) and the Engineer had obtained and submitted further information in regard thereto. On June 27th, at a meeting of the Electric Lighting Sub-Committee, the Engineer submitted the tenders which he had received for the two additional steam-engines and dynamos wanted for the Waterloo-street station, and the same having been opened and considered, it was agreed to recommend that the offer sent by Messrs. Siemens and Co. (Limited), be accepted, the amount of the tender being £4,885. On the same day the recommendation was approved of by the General Committee on Gas Supply and Electric Lighting, and it has since been passed by the Town Council.—It was decided some time back by the Glasgow and South-Western Railway to appoint a mechanical and electrical engineer for the St. Enoch's station installation, at a salary of £200 per annum. It has now been decided to defer the consideration of the matter, although we understand a number of applications have been received for the post.

GLOUCESTER.—With regard to the alterations now being effected in the Shire Hall, a question was asked at the last meeting of the County Council whether the electric light was to be adopted; but the architect, Mr. Medland, said it was doubtful if there was sufficient available power for the purpose.

GRANGE.—The Windermere and District Electric Supply Company have sent to the Local Board formal notice of their intention to apply for an electric lighting Provisional Order for this district.

GREENOCK.—At Tuesday's meeting of the Greenock Police Board attention was drawn to the communication from the Caledonian Electric Supply Company, of Edinburgh, notifying their intention of applying for a Provisional Order to supply electric current within the Greenock district. The Board instructed the Clerk to intimate to the Company that they would oppose the application.

HAMPSTEAD.—The Electric Lighting Committee of the Vestry have proposed a new scale of reductions in the charge for electric current supplied to private consumers as follows:—

Annual Bill. £	Proposed reduction.	No. of units metered.	Net cost per unit.
25	3 per cent.	1,000	5·82 pence
50	5 "	2,000	5·7 "
100	10 "	4,000	5·4 "
250	15 "	10,000	5·1 "
500 and over	20 "	20,000	4·8 "

A suggestion that the charge be 4d. per unit for current supplied during light load was referred back to the Electric Lighting Committee for reconsideration.

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HANLEY.—The Local Government Board have sanctioned the borrowing of £10,000 for electric wiring and fittings for various Corporation properties.

IPSWICH.—At a recent meeting of the Suffolk Joint Committee a proposal to light the lunatic asylum by electricity was, under a misapprehension, rejected. At the meeting of the Committee on Monday last it was pointed out that instead of £1,700, only between £200 and £300 was to be spent on the lighting of the asylum, and the expenditure of this sum was approved.

IRELAND.—The Irish Electricity Supply Company are busy notifying the various townships of their intention to apply for Provisional Orders for lighting the various districts by electricity. The natural motive power possessed by the town of Ballena will, it is stated, decide the Company in commencing its operations in that town.

LEICESTER.—In an advertisement pointing out that cables are now being laid for the supply of electric current throughout the centre of the town and through many of the principal thoroughfares, Mr. Albert Colson, engineer and manager to the Corporation, informs intending consumers that the Lighting Committee of the Corporation are prepared to carry out and supply everything required in connection with house wiring and electric light fittings, for samples of which the Committee have provided show-rooms. ——The Midland Railway Company are extending their installation at the Leicester Station. For some time the extensive range of offices have been lighted by electricity, and extra plant has recently been laid down for lighting up the goods yard. The installation is complete, and the testing of the work has proved satisfactory.

LLANDUDNO.—The Llandudno Electric Supply Company have notified their intention of applying for a Provisional Order to light this district by electricity.

LONDON COUNTY COUNCIL.—The Public Control Committee have received a number of letters, resolutions, and petitions against the exorbitant price charged for gas by the Gas Light and Coke Company, who supply consumers north of the Thames. These petitions have been received from nearly all the local boards and vestries throughout London. The difference in the price of gas on the north and south sides of the Thames is no less than 8d. per thousand cubic feet. The Committee propose that applications should be made to the Board of Trade to hold an inquiry into the present management and working of the Gas Light and Coke Company, with a view of ascertaining whether there is any reason why the gas supply to consumers north of the Thames should be charged for at a higher rate than that supplied on the south side, and whether measures cannot be taken to secure uniformity of charge for all gas supplied within the London district. After some discussion the Committee's report was adopted.

LUTON.—The Bedford Electric Lighting Company have notified the Town Council of their intention to apply for a Provisional Order to supply electrical energy within the Council's district. Notice was given to the Company that the Council would oppose the application. It has been decided to oppose a similar application from the Municipal Electric Lighting Company.

MARGATE.—It seems probable that Margate will shortly be the only seaside resort unprovided with the electric light. It is singular that a town which has in the past done so much to cater for holiday traffic should be so backward in its lighting arrangements. The lighting of the esplanade at Hastings has had the effect of awakening public interest at Margate in the electric lighting question.

MESSINA (SICILY).—A report presented by the United States Consul at Messina to his Government states that much dissatisfaction is expressed by the citizens of Messina at the miserable light provided by the local gas company. There is here a great opportunity for any enterprising electric lighting company, as in Italy the people are willing to adopt the latest and best illuminant. The introduction of gas pipes is attended with much difficulty, owing to the fact that the buildings are almost entirely of stone. No such difficulty confronts the introduction of the electric light, as most of the buildings afford every facility for carrying electric wires through the various compartments. The Tramway Company have expressed a willingness to adopt electric traction on its lines running from Messina to Faro Point, a distance of 9 miles, and to Barcelona, a distance of 30 miles. The tramway system is at present operated by engines. Labour is cheap, land is cheap, and Cardiff coal can be bought at 16s. 6d. per ton. The business men of the city have promised earnest co-operation to make an installation of electric plant in Messina a success. The Consul advises personal attention to the matter on the part of companies disposed to enter into contracts with the local authorities, or to establish independent companies. He deprecates correspondence, as very few of the inhabitants understand English. He expects the gas interest to fight hard for its monopoly, but that success would ultimately attend the efforts of the electric lighting pioneer.

MORECAMBE.—With regard to the alleged nuisance caused by the Morecambe Electric Light and Power Company's station, at the last meeting of the Local Board it was announced that the medical officer of health would present his report in a few days, when the matter will be at once discussed by the Local Board.

MONTROSE.—The question of the introduction of the electric light into this town was again under consideration by the Police Commissioners last week, when it was proposed that application be made to the Board of Trade for a Provisional Order to enable the Corporation to supply electric current within the burgh. It was pointed out that already two companies had given notice of their willingness to supply the district, and that unless the Corporation took the matter in hand promptly the opportunity of keeping the electric lighting in the Corporation's hands would be lost. After some discussion the motion was carried.

MUSIC-HALL LIGHTING.—The Empire Music-hall at Aberdare has now been lighted by electricity, arc lamps being used for the auditorium, and incandescents for the footlights and stage.

PROPOSED BOARD OF TRADE DEPARTMENT FOR THE UNITED STATES.—It is believed that a movement is on foot in the United States to establish a Government Department corresponding to the Board of Trade Department in this country, and performing similar functions. It is to be termed the "Department of Commerce." It is pointed out that at present it does not appear to be the duty of any officer of the Government to procure and lay before the Congress the systematised statistics of the course and magnitude of the United States' internal commerce. Large sums of money are expended with the governing supervision of any department of State. This applies particularly to schemes of river and harbour improvement, and engineering schemes generally. It is intended to place matters of this character under the control of the new department.

PROVISIONAL ORDERS.—The Buxton Provisional Order has received the Royal assent.

RHONDDA VALLEY.—The electric light is becoming very extensively used in this district. Colliery owners are especially taking up the question of introducing the light into the mines. One of the latest additions is at the extensive collieries and works of the Ocean Company at Treorky, which have been partially lighted for some years, and have now been almost completely fitted throughout for the electric light. Ten years ago Messrs. Crompton and Co. supplied a large portion of the plant, and this is still at work. The dynamos are of the Bürgin type. At the Dare pit, which has also been supplied with plant by Messrs. Crompton and Co., extensions are in contemplation, and already about 300 16-c.p. incandescents are in use. At this pit the underground stables are also lighted electrically.

ROYAL COMMISSION ON LABOUR.—The fifth and final report of this Commission has just been issued in the form of two volumes. Evidence has been taken under eight headings:—(1) Conditions of Labour, (2) Associations and Organisations of Employers and Employed, (3) Relations between Employers and Employed, (4) Conciliation and Arbitration, (5) Limitation of Hours of Work by Legislation, (6) Irregularity of Employment, (7) Labour Department and Labour Statistics, and (8) the Employment of Women.

SHOREDITCH (LONDON, N.E.).—A report of the Electric Lighting Committee asks the Vestry to employ Messrs. Kincaid, Waller and Manville, as consulting engineers, to carry out the electric lighting and dust destructor scheme (the contractors for the dust destructor cells preparing their own plans and specifications upon requirements to be specified by Messrs. Kincaid, Waller and Manville), at a commission of 3 per cent. on the amount of the tender accepted on the original specification (no commission to be payable on extras), such commission to cover the preparation of plans and specifications (except as above stated), and the superintendence of the whole of the work as engineers to completion, and advising on the acceptance of all tenders. The contractors for the dust destructor must guarantee a specified amount of steam, but Messrs. Kincaid, Waller and Manville are to be responsible for the effective and successful execution of the whole of the work. A formal agreement is to be entered into embodying those terms. ——The Vestry have decided to apply to the London County Council for sanction to borrow £12,300 for the purchase of that portion of the Pitfield-street site which is to be used for the electric lighting station.

ST. BRIDE'S INSTITUTE.—This handsome building, now approaching completion in Bride-lane, Fleet-street, is to be lighted throughout by electricity. The institution is devoted to the printing arts, and is expected to prove a model technical educational institute. The electric lighting will be extended to the swimming bath, which is 75ft. long by 25ft. wide.

ST. HELENS.—A serious accident recently occurred at the Bold Colliery, St. Helens, where safety lamps are used. Gunpowder is not used at this mine, but roburite and carbonite charges are fired by an electric battery connected by a cable run through the workings. In connection with the accident, one of the men employed in the mine was charged last week with endangering the lives of the

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men by incompetently working the electric battery. A "shot lighter" is employed, and, instead of waiting for this man to make the connection, the defendant attached the roburite charge to the electric wires, and when the second wire was attached and the circuit completed an explosion took place which might have resulted seriously, and which did, in fact, cause serious injury to the man now charged. The man, who had been rendered unfit for work for six weeks, was fined 14s. 6d.

St. Pancras (London).—The London County Council have agreed to lend the Vestry £14,300 for electric lighting purposes, at 3½ per cent. interest, payable quarterly, the principal being repaid by half-yearly instalments during 42 years ——At the meeting of the Vestry on Wednesday last it was moved by Mr. Churchwarden Thornley that Mr. C. H. F. Barrett, late chief clerk in the Department of General Business at the offices of the Vestry, should be promoted to the office of Vestry Clerk, rendered vacant by the death of Mr. T. Eccleston Gibb.

Tottenham.—The Generel Purposes Committee of the Local Board recommend the Board to decline to give their consent to the application of the Tottenham and Edmonton Electric Light and Power for o Provisional Order to light part of Tottenham by electricity, and further recommend that a Committee of the whole Board consider the advisability of the Board applying for a Provisional Order to themselves light the district.

Whitechapel (London, E.).—At the next meeting of the Streets Committee the expert's report on the electric lighting scheme is to be submitted and discussed.

Winchester.—A report is shortly to be presented to the Town Council in reference to the electric lighting scheme, regarding which the Electric Lighting Committee have been in communication with the Brush Company.

Windermere.—The Windermere District Electric Supply Company have notified the Local Board of their intention to apply for an electric lighting Provisional Order for supplying the district. The Board at its last sitting came to the conclusion that a company who would be prepared to safeguard the interests of the local authorities would probably receive the support of the Board in its application.

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by Mr. J. C. Chapman, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

Note.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

June 28, 1894.

12,541. F. H. Nalder, C. W. S. Crawley, and A. Soames. London. Improved apparatus for intermittent measurements of alternating currents.

12,549. M. Immisch. London. Improvements in cables for telephonic and telegraphic purposes.

12,552. G. H. Nisbett. Liverpool. Improvements in protecting, and in fittings for connecting lead covered, or other armoured electric cables with naked or other conductors.

12,557. G. Trouvé. London. A system of luminous electric skipping rope. [Date applied for under Patents, &c., Act, 1883, Sec. 103, June 18, 1894, being date of application in France.]

12,566. A. E. Williamson. London. A dust-proof electrical switch.

12,605. W. A. Nikolajczuk. London. Improvements in, or in connection with, long distance telephones.*

June 29, 1894.

12,620. J. T. Niblett and M. Sutherland. London. Improvements in electric arc lamps.

12,650. B. M. Drake and J. M. Gorham. London. Improvements in storage battery plates.

June 30, 1894.

12,707. J. B. Verity. Birmingham. Improvements in or connected with electric lampholders, sockets, or connections.

12,748. W. Newbigging. London. Improvements in mounting electric and other lamps.

July 2, 1894.

12,767. W. H. Willatt. Hull. Improvements relating to electric incandescent lamps.

12,817. A. Zobel and F. Buchmüller. London. Improvements in electric incandescent lamps.

July 3, 1894.

12,861. E. Poppowitsch and H. Wüstenfeld. London. New or improved electrical fishing apparatus.*

12,870. C. Hamilton. Glasgow. Improvements in electric switches.

12,875. J. F. Kelly and W. Stanley. London. Improved alternating current meter and method of measuring alternating currents.*

12,877. H. H. Lake. London. Improvements relating to the operation and control of steam machinery or other mechanism by means of electricity, and in apparatus therefor. (J. D. Williamson, jun., United States.)*

July 4, 1894.

12,928. J. A. Edmondson. Leeds. Improvements in or in connection with the commutator brushes of dynamos.

12,946. S. Sealy-Allin and W. H. Wood. London. Improvements in arc electric lamps.

12,965. G. B. Blanchard and A. Ballance. London. An improved contrivance for automatically switching on and off electric currents suitable for many purposes.

12,972. S. Doubrava and J. Donát. Manchester. Improvements in electric arc lamps, and current regulators therefor.*

12,973. C. Hampel. Liverpool. An improved device for casting electric accumulator plates.

12,982. J. Brockie. London. Improvements in electric arc lamps.

12,991. J. A. Macmeikan. London. An automatic cut-out for electrical heating and cooking appliances.

12,993. A. Cruickshank. London. Improvements in the electrolytic separation of gold from ores.

July 5, 1894.

13,018. H. V. Keeson. London. Improvements in electrical firing keys.

13,042. G. B. Blanchard and A. Ballance. London. An improved contrivance for automatically switching on and off electric currents, also suitable for many purposes.

13,063. G. J. T. J. Parfitt. London. Indicating lamp failures in electric lighting circuits and apparatus therefor.

July 6, 1894.

13,078. E. R. Cummins. London. An electric-resistance switch improvement for lowering incandescent lamps.

13,082. C. Shore. Rochdale. A method of and apparatus for fixing or erecting telephonic, telegraphic, or other wires.

13,110. C. P. Shrewsbury, F. L. Marshall, J. Cooper, and J. L. Dobell. London. Improvements in the manufacture, from carbonaceous matter, of plates, slabs, rings, crucibles, rollers, bars, rods, pipes, and other articles, for electrical, electrolytical, and other purposes.

13,115. G. A. Nussbaum. London. Improvements in telephonic transmitters.

13,136. H. A. Taylor and J. A. L. Dearlove. London. Improvements in or appertaining to submarine telegraph and like cables.

13,148. H. T. Harrison. London. Improvements in electrical measuring and recording instruments.

13,157. G. E. Heyl. London. Improvements in means for insulating electric cables.

13,158. G. E. Heyl. London. Improvements in electric fuses.

13,160. G. G. M. Hardingham. London. Improvements in the manufacture of electric cables. (The firm of Felten and Guilleaume, Germany).

July 7, 1894.

13,182. C. Richardson and E. Herbert. Manchester. Improvements in electric light ceiling roses.

13,208. W. H. Allen, R. W. Allen, and C. C. Hawkins. London. Improvements in field magnets for continuous-current dynamos.*

July 9, 1894.

13,216. W. H. and J. I. Ryder. Birmingham. Magnetic separator.

13,259. R. Pippette. London. Improvements in automatic electric exchange.

13,267. J. Hopkinson. London. Improvements in galvanometers.

July 10, 1894.

13,319. P. Kirkegaard. Manchester. Improvements in electric arc lamps.*

13,331. L. W. de Grave. Derby. An electrically-controlled lubricating device.

13,342. T. C. Batchelor. London. Improvements in, or relating to, joints chiefly for wires and the like.

13,358. H. H. Lake. London. Improvements relating to electrolysis and to apparatus therefor. (J. L. Roberts, United States.)*

13,363. W. A. B. Buckland. London. An improved plate for secondary voltaic batteries.*

July 11, 1894.

13,405. A. Cheetham and F. Brown. Birmingham. Improvements in and relating to induction coils for medical purposes.*

13,410. C. M. Dorman and R. A. Smith. Manchester. Improvements in electrical switches.*

13,416. A. Young. Edinburgh. Continuous electric brakes for railway trains.

13,422. W. P. Thompson. Improvements in or connected with electric relays. (C. E. Marchal, P. C. H. Rigollet, and the Société E. Ducretet and L. Lejeune, France.)

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13,433. C. J. A. Munier. London. Improvements relating to electric telegraphy.

July 12, 1894.

13,478. S. G. Brown. Chelmsford. Electric arc hood.

13,485. G. Leclercq. Westminster. A call bell ringing at will during a more or less long while, without the person ringing it being obliged to stay near it all the time it works. (Fritz Marti, France.)

13,493. A. Sinding-Larsen. London. Improvements in process and apparatus for electrolytical decomposition of alkali salts. (Date applied for under Patents Acts 1883, Sec. 103, December 12, 1893, being date of application in Norway.)*

13,523. C. Coerper. London. Improvements connected with reflectors for electric arc lamps.*

July 13, 1894.

13,549. C. Anderson. Leeds. Improvements in apparatus for working electric tramways.

13,568. F. Tallack, F. W. Tallack and L. Héndlé. London. An improved combined electric switch and regulator.

13,579. J. C. Frost. London. Improvements in coin-controlled electrical apparatus. (Date applied for under Patents, &c., Act, 1883, Sec. 103, December 30, 1893, being date of application in United States.)*

13,581. S. P. Thompson. Liverpool. Improvements in electric cables. (Date applied for under Patents, &c., Act, 1882, Sec. 103, December 19, 1893, being date of application in United States.)

13,594. H. Helberger. London. Improvements relating to the insulation of wires for electric heating apparatus.

July 14, 1894.

13,623. F. E. Waltham. Westminster. An invisible electric switch and bracket combination.

13,634. J. W. Rogers. London. Improvements in arc lamps.

13,636. H. Whawell. London. Improvements in perforators used for transmitting telegraphic messages and cablegrams.

13,640. A. Owen. London. Improved medico-electric pad or bandage.*

SPECIFICATIONS PUBLISHED.

Note.—All Specifications can now be obtained at the uniform price of 8d. each.

1893.

7,806. Anders and Köttgen. Telephonic apparatus.

12,257. Binswanger and Coates. Electricity meters.

12,516. Graham. Telephone.

15,610. Baily and Guthrie. Electrolytical decomposition of brine, &c.

15,736. G. and T. Edward. Covering telegraph, &c., cables and wires.

15,781. Rennoldson. Electric wiring system.

16,028. Siemens Bros. and Co. (Limited). (Siemens and Halske.) Compensating variations of load at electrical stations.

16,175. Lundberg. Electrical fittings.

16,197. Schoop. Electric traction apparatus.

17,445. Scott. Insulators for pipe conduits.

1894.

140. Callender. Telephone exchange systems.

4,197. Busch. Electric switches and fuses.

5,796. Petersen. Underground conduit systems for electric railways.

6,046. Lienard, L. A. P. and H. E. A. Effecting electrolysis of saline solutions.

7,645. Brand and Franklyn. Underground conduits for electric railways.

7,679. Coerper. Reflectors for electric arc lamps.

8,273. Claremont. Shade tilt for electric light pendants.

9,761. Craney. Electrolytic apparatus.

9,949. Craney. Electrolytic apparatus.

9,967. Day. (Higham Electric Company.) Electric arc lighting.

WATERLOO AND CITY RAILWAY COMPANY.—The report of the Directors of this Company, which, with the accounts, is to be submitted to the shareholders at the first half-yearly general meeting, to be held at the Waterloo Station, S.E., on Thursday, Aug. 9, at 2:30 p.m., is as follows: The prospectus which was issued by the Directors pursuant to the authority given to them by the shareholders at their meeting on Feb. 22 last resulted in applications for shares of the Company in excess of the number available for issue. An official quotation has been obtained from the Stock Exchange. The agreement between the Company and the London and South-Western Railway Company, which was sanctioned by the shareholders in February last, has received the approval of the Railway Commissioners, and the Board of Trade have given the necessary certificate for the payment of interest on capital during the construction of the railway, in accordance with the Company's Act of 1893. The contract for the construction of the railway from the Mansion House to Cross-street, Waterloo Station, has been let to responsible contractors, who commenced operations on June 18th last. The terminal stations in the City and at Waterloo will form the subject of separate contracts. The Directors recommend the adoption of the provisions of the Forged Transfers Acts of 1891 and 1892.

COMPANIES' MEETINGS AND REPORTS.

Electrical Power Storage Company (Limited).

The fifth ordinary general meeting of this Company was held at 4, Great Winchester-street, yesterday (Thursday). Mr. John Irving Courtenay (Chairman and Managing Director) presided.

The SECRETARY (Mr. J. W. Barnard) having read the notice convening the meeting, the report of the Directors was taken as read.

The CHAIRMAN said: I propose to offer but few observations, as the Directors' report and statement of accounts speak for themselves. We recommend a dividend of 5 per cent. and carry forward a substantial balance to next year. The reserve fund stands at £9,315. 7s. 1d., and it is satisfactory that we have been able to bring it up to that amount. I am glad to be in a position to state that the volume of business has very considerably increased, and that the actual cash turn-over is larger than it was last year, although the reduction in the list prices of 20 per cent. has been in operation during the whole of the year under review. In this business there is an increasing competition; but the E.P.S. batteries have held their own thoroughly well. The policy adopted by the Directors and Manager has been to continually improve the quality of the Company's manufactures, and the results show the E.P.S. batteries to be the most appreciated and reliable in the market, and that the sound commercial policy is to improve them in various details (though no startling new departure has been made), rather than to spend money and time in spasmodic efforts to obtain entirely new types or designs. One of the most important features to be noted is that the life of E.P.S. secondary batteries is steadily lengthening, so that in fact a sum equal to 5 per cent. per annum on the cost price is now amply sufficient for the maintenance in perfect working order of the batteries used under ordinary conditions. Those who remember the pessimistic views expressed only a few years ago as to what would be the safe annual percentage to cover maintenance will feel gratified at the practical illustration given by this Company of the correctness of the views of its representatives. I remember being told that it would never pay any Company to guarantee the maintenance of storage batteries at twice the figure now commonly adopted, but our manager has always contended that it could safely be done at about the present prices. Numerous fresh uses continue to be found for the employment of secondary batteries, and the number of our customers is larger than ever. We are not as yet able to point to a decided success in the application of E.P.S. batteries to traction; but we *must* make a success of this important branch of the industry, and I have full confidence that Mr. King will not fail in his efforts to this end, though undoubtedly the difficulties in the way of its development have been great. As stated in the report, unremitting attention has been given to the improvement of the batteries for traction purposes, and to appliances in connection therewith, and I hope that vehicles belonging to our friends, the Pioneer Electric Carriage Company (Limited), fitted with the latest type of E.P.S. traction battery, will ere long be seen in the streets of London. During the year various improvements have been made in the plant and in the arrangement of our works at Millwall, with the object of cheapening production; but I do not consider it advisable to indicate more fully the direction these improvements have taken. Our works have been to a certain extent remodelled, and several suggestions made by the Board of Trade for the greater comfort and health of our workmen have been carried out. The Company's Continental patents have been admirably protected by the Hagen Company and their legal and technical advisers, who have been most successful in upholding the patent rights. With these remarks I beg to move the adoption of the report and accounts.

Sir DANIEL COOPER, Bart., G.C.M.G.: I beg to support the motion—

"That the Directors' report and statement of accounts to May 31, 1894, be, and are hereby, approved and adopted, and that a dividend of 5 per cent. on the paid-up capital be declared payable forthwith."

After the remarks of the Chairman this resolution needs no observation from me.

The CHAIRMAN then put the resolution in the usual way, and it was carried unanimously. Continuing, he said: Having been associated with Mr. Fredk. Green for so many years, I may be allowed to propose his re-election, which is the next resolution.

Mr. J. W. BARCLAY seconded the motion, which was unanimously adopted. He afterwards proposed—

"That Messrs. James Meston and Co., 85, London-wall, E.C., be and are hereby re-elected auditors of the Company for the ensuing year for a fee of £60."

Knowing Messrs. Meston and Co. as I do, I am satisfied that they will not only protect the shareholders, but also the Directors in auditing the accounts.

Mr. FRANK KING seconded the motion, which was unanimously adopted.

In moving a vote of thanks to the Chairman, Mr. J. W. BARCLAY said that he took that opportunity of expressing the thanks of the shareholders to the Manager (Mr. Frank King) and the staff generally for the excellent results which the shareholders had had put before them, and which they consider due to the vigorous manner in which the business of the Company had been conducted.

The CHAIRMAN: In responding for the vote of thanks I have only to say that we all rejoice at the fact that we have had a very successful year,

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There is no doubt that the past has been the best year we have ever had, and I trust that the same energy which Mr. King and his staff have brought to the work of the past year will bear fruit in the coming year. We do not fear competition, although we shall have plenty of it, but we are quite ready to meet it, and I believe we shall come through and win in the end.

Mr. KING said he would have much pleasure in conveying to the staff the fact of the shareholders' appreciation of their efforts during the past year.

The proceedings then terminated.

The following is the Directors' report :—

The net profit for the year is £4,936. 4s. 11d., which, with a balance of £158. 19s. 5d. from last year's accounts, amounts to £5,095. 4s. 4d., out of which the Directors recommend the payment of a dividend of 5 per cent. on the Ordinary share capital, which will absorb £4,101. 10s. 2d., leaving £993. 14s. 2d. to be carried forward. Provision has been made for the effective maintenance of buildings, plant, tools, &c., at a cost of £2,297. 6s. 2d. The sum of £3,323. 1s. 4d., the proceeds of sale of the Company's shares in the Société Française, together with a further sum of £4,000 out of the profit on the year's working, and £1,500 written off patents in 1892-3, have been applied to the formation of a reserve fund for diminution in value of assets, as shown in the balance-sheet. The Directors report the continued success of the Company's operations, and that there has been during the year a substantial increase of orders and of the uses to which batteries are being applied. The reduction in the selling price of the Company's manufactures has operated towards increasing the number of users, and so extending the goodwill of the business. Constant attention has been devoted to improving the conditions under which E.P.S. batteries are manufactured, and the Directors are sanguine of further success in this direction. The development of electric traction has received the unremitting attention of the manager. The Company and its licensees have been successful in patent litigation abroad.

Elmore's French Copper Depositing Company (Limited).

A general meeting of this Company was held yesterday at Winchester House, Old Broad-street, Mr. J. H. Duncan (the liquidator) presiding.

The CHAIRMAN stated that the specific object of the meeting was to appoint a Board for the reconstructed Company, but the shareholders would no doubt like to hear a statement as to what had been done with reference to the Company. Meetings were held in December last at which a scheme of distribution was approved, but the Long Vacation ensued, and the order of the Court was not drawn up until February 15th. The French Company had now got into thorough working order, and by the beginning of next month would be on an extended scale of working, having laid down considerably increased plant of an improved nature. The results of the first six months of the year had been seriously affected by competition, one large company having put down its price to so low a figure that this Company had not cared to follow them. However, he thought that this had now been brought to a point, and that in the remainder of the year they might expect things to go smoothly. In other respects things had been going extremely well in France, and the Company was becoming established on a good commercial basis. He suggested that in selecting Directors they should appoint a gentleman representing the Committee, one to represent the old administration, with the view of securing continuity of information, and a third who would represent the creditors.

A discussion followed, and, in the result,

On the motion of Mr. F. L. RAWSON, seconded by Sir JAMES MACKENZIE, Messrs. Duncan, Strettell, and Shurmer were appointed Directors ; but a further meeting was directed to be called to alter their appointments to that of trustees.

Major Jones (the late Chairman) was proposed as a Director, but he said he must decline to accept office on account of the state of his health.

Eastern Telegraph Company (Limited).

The forty-fourth half-yearly ordinary general meeting of the Eastern Telegraph Company (Limited) was held on Thursday, July 12, 1894, under the presidency of Sir John Pender, G.C.M.G., M.P.

The SECRETARY (Mr. George Draper) having read the notice convening the meeting, and the minutes of the last general meeting having been read and confirmed,

The CHAIRMAN said (the report having been taken as read): Before asking you to approve of the report I will, as usual, make a few remarks on it and also upon the working of the system in the last six months.

The gross revenue for the half-year under review amounted to £389,314 as against £372,853, or an increase of £16,461. Analysing the message receipts from various sources we find very little difference between the figures of last year, although there is an increase of about £4,000 in the trans-Indian traffic and a small increase in the Cape traffic. The new cable of the South African Company to Seychelles and Mauritius is working satisfactorily, and that Company is now receiving a subsidy from Her Majesty's Government at the rate of £28,000 per annum. The result so far as it has gone is fully up to our expectations, but the next time I have the pleasure of addressing you we shall have had a good 12 months' experience of the working of that system, and I think we shall be able to show that it is a link which will rather strengthen our position than in any way weaken it. The principal increase in the gross revenue is due to our having received £29,500 from our investment in the shares of the Eastern and South African Company, as against £17,700 in the corresponding period ; but, although there is an increase in the amount received this half-year, it is due to their having decided to pay the bonus at the end of the financial year, instead of half-yearly as formerly. The total amount received for the year ended March 31, 1894, is the same as that received in 1893. The total ordinary expenses for the half-year ended March 31, 1894, amounted to £102,219, as against £102,499, or a decrease of £280. The details are as follows: General expenses in London £8,912, as against £9,368, or a decrease of £456. The working expenses at stations amounted to £76,642, as against £79,926, or a decrease of £3,284. The principal decrease is in stationery and printing for stations. In the corresponding period there was included 15 months' supply of stationery for our stations, owing to our having altered the date of sending out supplies to a more convenient time in the year. For the purposes of comparison we shall in future show the proportions each half-year. Several other items also exhibit a substantial reduction, while others show an increase, the principal item under the latter head being in the salaries and wages of our staff at stations. This is due to the operation of the scheme to provide a regular scale of promotion to the superintendents and the other members of the staff. Travelling expenses also show an increase of £398. This is an item which must necessarily vary, and it depends in a great measure on the number of men on leave after serving the specified number of years abroad.

In reference to other items shown separately on the revenue account there is an increase in the following :—Maintenance ships reserve fund stands at £5,000 against £2,245, or an increase of £2,755. We have done very little work for foreign Governments and other telegraph companies this half-year, so that the full charge for depreciation on the ships is borne by ourselves. Speaking of the money which the ships have been earning, I may mention that this is rather a new feature in our system of working, and we now avail ourselves of it as much as we possibly can. As we have thoroughly-appointed ships, we cannot employ them better when we do not want them ourselves than in engaging them to other people who pay us for them. However, as I have said before, the best mode of employing our ships, so far as we ourselves are concerned, is to keep them lying idle, but fitted up and appointed and ready to sail when required. Full provision has been made for depreciation on our spare cable, and the currency balances at stations have been written down to their actual sterling value on March 31st last. The expenses attending repairs and renewals of cables amounted to £49,660, as against £32,533, or an increase of £17,127. Full details of the work done by our ships during the half-year will be found on Abstract C of the Report. It will be seen that they have been at work on our own cables, with the exception of a small repair for the Spanish Government, so that the credits derived from foreign Governments and other telegraph companies are small as compared with the same period of 1893. We have completely overhauled our steamship "Chiltern," and fitted her with new triple expansion engines and boilers, cable tank, &c., and have applied £18,000 in reduction of same out of the maintenance ships reserve fund, which, however, remains at the substantial figure of over £53,000. We expect from our experience in the case of other ships that we have similarly fitted that the saving in the consumption of coal will very soon compensate us for the large outlay we have incurred in putting in these new engines and boilers, &c. We have at present three ships laid up in London; but, as I have often told you before, and as I have just now repeated, we are better pleased when our ships are idle, unless, of course, they are at work for other people.

After providing the usual amounts for interest on debentures, debenture stock, and Preference shares, we are able to propose the usual final dividend of 1¼ per cent., and a bonus of 1¼ per cent., making, with the interim dividends already paid, a total distribution of 6¼ per cent. for the year ended March 31, 1894, and to carry the sum of £110,000 to the reserve fund, against £88,000 in the corresponding period of last year. We have also applied a further sum of £53,316 from reserve fund in reduction of the cost of Aden-Bombay No. 3 cable and other capital expenditure, so that our capital expenditure on account of cables, &c., remains, as it has done for many years, at the same figure. Meantime, we have strengthened our position by duplications and in other ways, and have thus greatly improved the value of our property in the market. The total amount applied out of the reserve fund now amounts to £1,345,644.

As will be seen from the balance-sheet, we have added to our capital investments £55,660 in the shares of the Europe and Azores Company. I have already explained to you that this Company was formed to lay a cable from Lisbon to the Azores, bringing those islands into direct telegraphic communication with our general system. In consideration of carrying out this work we have received an extension of our exclusive rights in Portugal, which in a great measure will recoup us for having made this investment. We did not anticipate that the Europe and Azores Company, so long as the cable only reached as far as the Azores, would give much return on the capital invested ; but there are other considerations in the concession which may shortly be fulfilled, and I have no doubt that when the matter is fully developed, the Eastern Company's position will be considerably improved by being associated with this latest development of submarine telegraphy.

Now, gentlemen, I have given you the hard facts. I am now going to make a few remarks generally on the position you occupy to-day. I think that when I say the report is favourable I am not stating anything but what you will receive as correct. The fact of our paying you your usual dividend, and carrying £110,000 to the reserve fund is no small indication of success, and I may remind you that this result has been obtained notwithstanding very bad times. I have had a great many years' experience of commercial life, and I can assure you that I have never known such a prolonged term of depression as has existed, and which still exists, not only

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in London, but also throughout the world, I may say. There is, however, an elasticity in these things, and there is a boom coming. Our Colonies have got a considerable amount of "elbow room," and you may depend upon it that their energies will not long lie quiet. When they begin to display their energies again there will be a great response in London, because, after all, a great deal of the money that will then be required will have to come from London. When the revival does take place the times will be good for our submarine telegraph system.

Six months ago I stated that the Eastern and South African Company, in which we are the largest shareholders, had completed the Seychelles and Mauritius cable. That is a great work—a very important addition to our system—and one which, as I have just now intimated, is likely to add to our exchequer in the future. The Azores cable also is one which has attracted a good deal of attention. It is now in our hands. As I told you when we first entered into that transaction, we did so more with a view of securing advantages in the next ten years from the Portuguese Government for our Eastern system. Those advantages are most valuable, and will compensate us largely for the work we have done, even if nothing further comes from it; but I may say that when I next have the pleasure of addressing you, six months hence, if we are all spared again to meet here, I think I shall be able to show you that we have not been asleep on our Azores link, and to prove to your satisfaction that we are asssociated with a system which will make the Azores Company an important string to our bow. The amount of information given at the last two meetings leaves me comparatively little to say now. Six months ago I was able to tell you that the important work on which we had been engaged was completed, and to-day I have to announce that the Seychelles cable is working well, and that the Azores Company is doing its best. However, if we cannot get sufficient traffic with those islands we shall try and get it in some other way, and I think that we are in a fair way of doing some good in that quarter.

I cannot allow an opportunity of this kind to pass without remarking that the nations of the world—not only of Europe, but of the world—attach great importance to submarine telegraphy. You have all heard of the Conference that was held the other day at Ottawa, at which representatives from this country and from all the British colonies were present; and the principal question discussed was the Pacific cable. We must take credit for ourselves that we probably know more about cables than they do; and I am pleased to say they passed a resolution that soundings are to be taken, and that at the proper time this cable is to be laid. I think we may claim that after 25 years of successful and harmonious working, not only with the public but with most of the Governments of the world, that we may claim to have some say in an undertaking of such magnitude; and I may say further, that when it is required to be done, we can do it better and cheaper than any other existing company. I think that the experience we have got, and the statements we shall be able to make, will assure those statesmen who are taking a part in the project that the people to do the work are those who know the most about it. It is a bold thing for a man to do standing at a public meeting in London to say that he compliments the representatives of this country and of the colonies; but, still, I cannot help recognising that in discussing this question they have come to a very sound conclusion—that is, not to decide upon laying the cable until they know a great deal more about it.

Our relations with all Governments are of a most satisfactory kind, and I find that the longer we live the more respect we command, and the more useful we become to the nations of the world. It will be our policy to maintain such relations as will benefit the telegraphing public of the world, and at the same time not forgetting the interest of our own shareholders.

You are aware that next week we are going to celebrate the 25th anniversary of submarine telegraphy. The matter is so important that we could not allow this period to pass by without showing that we appreciate, as the world appreciates, the great work which has been done; and when we are able to say that after 25 years we occupy a position such as that which I have mentioned to you to-day, I think you will unite in congratulating ourselves on the great success which has attended our operations. I hope to have the pleasure of seeing on that occasion many who are present with us to-day, because we shall try, as far as possible, to make the occasion a proper recognition of our silver wedding, and we shall make it as general as possible. If there are any old shareholders present who have been overlooked they will receive an invitation if they will apply at the office. I have talked a little longer than I intended to, but I always think when I come here and we have our shareholders around us that we cannot spend an hour better than in giving them as much information as possible about the affairs of the Company in which they are all interested. With these remarks I now beg to move the following resolution:—

"*That the printed report and accounts of the Directors to March 31, 1894, submitted to this meeting, be and the same are hereby received and adopted. That a dividend on the Preference shares of the Company to June 30, 1894, at the rate of* 6 *per cent. per annum, be paid, less income-tax; and that, in accordance with the Directors' recommendation, a dividend be and is now declared of 2s. 6d. per share, with a bonus of 3s. per share, both free of income-tax, on the Ordinary shares of the Company, making with previous distributions by way of dividend on account, a total payment of 6½ per cent. on those shares for the year ended March 31, 1894.*"

The VICE-CHAIRMAN (the Most Hon. the Marquis of Tweeddale): I beg to second the motion.

The CHAIRMAN: Before I put the resolution to the meeting I shall be glad to answer any question which any gentleman may desire to put to me; but if no shareholder has anything to say I will ask you to approve of the resolution.

Mr. BAINES: I should like to make one or two remarks. I am very pleased at hearing such a satisfactory report this afternoon, but at the same time I must draw attention once more to the fact that the dividend for the Ordinary shareholders remains the same. The Company has earned a very large sum of money, but half-year after half-year we see £60,000, £80,000, £100,000, and £110,000 put aside for certain contingencies. Under those circumstances, after the duplication and triplication of so many cables, I do not think it is very difficult for this Company to pay 6½ per cent. I believe that in former times the prospect was held out of our receiving something very different. Circumstances have arisen to prevent that prospect from being realised, but at the same time I think that the time has arrived when the interests of the Ordinary shareholders should receive the serious consideration of the Directors. A dividend of 6½ per cent. is not a despicable thing—on the contrary, it is very respectable; but at the same time this Company, in my opinion, is capable of paying a still better dividend. I think if you pursue the course which you have shadowed forth in your remarks of economising in the management we shall also be benefited. In the conduct of a Company like this there is considerable expenditure, and I see that you have adopted a course of economy in connection with several items; but I think that that may be carried still further, and that by that means you may be able to pay an additional dividend of at least ½ per cent., if not 1 per cent. I referred just now to the large sums which are set apart. Those large sums have been earned by the original shareholders, and according to my view they ought to go to the shareholders in the shape of dividend. They are, however, devoted to other purposes. You have greatly strengthened the security of our property, and it has been in my mind several times whether the shareholders ought not to have in their pockets money which has been used for capital purposes. It is a risky proceeding to go on increasing your business to such a very large size, because you are liable to a great clamour being raised against you. You might give the shareholders shares *pro ratâ* according to their holdings, and thus obviate the clamour which might arise if you were to pay a very large dividend. I really think that the Directors should consider whether the interests of the Ordinary shareholders ought not to receive some larger attention than they do at present in the way of dividend.

The CHAIRMAN: I quite understand the views of Mr. Baines; but at the same time, if Mr. Baines understood matters as well as we do—if he were acquainted with them as well as we are—he would see that we are pursuing not only a prudent policy, but the very best policy in the shareholders' interests. We have not yet got a sufficiently large reserve fund, in my opinion, for our future requirements; but, while we are increasing it, and steadily increasing it, we are paying you 6½ per cent, which is equal to 8 per cent. 20 years ago. I say that 6½ now is quite equal to 8 per cent. at that time. I think that when the shareholders look at their dividend coming round steadily, as it does, and observe the market value of their shares, they recognise that the steady improvement which is going on in the value of their property is better for them, and this will be made more secure to them by the prudent way in which we are acting as regards the question of dividend. If we had acted in earlier days up to Mr. Baines' suggestion we should not be occupying the position we do to-day.

Mr. BAINES: I am speaking of the present time.

The CHAIRMAN: Men and companies nowadays are very much estimated according to their standing, and we shall be valued not only according to our position, but for the valuable work we are doing and providing for. If we can keep up a steady dividend such as we are now paying, and put by such sums as we are at present reserving, I think it is better for your interests. It is far better to put these sums to our reserve fund instead of dividing them, and then, perhaps, bringing down your dividend afterwards to 3 or 4 per cent. With regard to your idea about issuing shares, bear in mind that if you were to do so a dividend must be paid on such shares, and you would thus put an additional rope round the Company's neck.

Mr. BAINES: Oh, no.

The CHAIRMAN: Just bear in mind one thing. Legally, we could not do this to begin with; but what I want to impress upon you is that the course which we have pursued of duplicating and triplicating our cables, and not increasing our capital for such purposes, has been the most prudent and successful policy that we could have pursued in your interests. We intend to maintain that policy. We hope to continue the dividend we are paying now, and if our reserve fund should become very large and we saw that it was possible and advisable to give a little more to the shareholders, we should be only too glad to do so. That time, however, has not come yet. We have not such a reserve fund in hard cash at the present time as would justify us in distributing more. Besides, our experience has not yet told us what the life of a cable is. As long as we pay you this dividend and show you how we are handling the money I think that you ought to be satisfied. Years ago, Mr. Baines, we used to have these discussions, but I feel now, after 25 years' experience, you will tell us that our policy has been the right one, and that you were wrong in recommending us to do what you advised at that time (laughter). I do not want you to say outright that we have been cleverer than you; but the fact is that we were possessed of information which justified the course we have pursued, while you did not have that information, and could not give us sounder judgment than you did on these matters. I am quite sure that the bulk of the shareholders will support the policy of the Directors.

Mr. BAINES: In the course of your remarks you have assumed a position which I did not take up. In earlier years I did not advise an increase of dividend; it is only now that I have done so.

The CHAIRMAN: All that I can remember of those days is that we did not have a meeting but what there was not a great deal of fault-finding; but we were pursuing a straight policy. You come back, after an absence of 14 years, and come to these meetings, and instead of telling us that we have managed well and put the Company in a grand position, you come in a querulous way. You do not improve the value of your property in that manner. I am sure that in your quiet moments you must come to the

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same conclusion as the rest of the shareholders—that we have benefitted you in a much greater degree than we should have done had we followed your advice.

Mr. BAINES: You are taking up a position which I never assumed. What you are saying may go down with some of the shareholders; but you really put me in a false position.

The CHAIRMAN: Well, I will sum up what you want. You want a bigger dividend, and you want to effect a change in our system by issuing a certain amount of bonus shares. We cannot do that. Look round and learn some little experience from the number of companies that have been what I may call playing with dividends and playing with their capital. We have not been doing so; we have been dealing with these companies in a practical form, and we have brought before you to-day practical results. That is the course which we have pursued and intend to pursue (hear, hear). At the same time I do not object to your having made your remarks, but we must now proceed with the business. Those who are in favour of the resolution will please to hold up their hands. To the contrary. Carried unanimously. I think that that concludes the business of the meeting.

Mr. JOHN NEWTON: I have much pleasure in rising to propose a vote of thanks to the Chairman and Directors for their services in the past half-year, and I may say for their services in the past 25 years. I was formerly associated with shareholders in adverse criticism of the Directors. I was at that time greatly disappointed that we did not get the 15 per cent. dividend, the prospect of which had been held out to us in the prospectus. But prospectuses are always deceptive. We all know in this case that the prospects held out to us were based on figures which were never realised. I am perfectly satisfied to be on the side of those who are to-day congratulating the Directors. At the former time to which I have referred our shares were standing in the market at about eight, whereas they are now quoted at nearly 16; and, whereas our dividends then were 5 per cent., they are now 6¼ per cent., which is equal to 8 per cent., if not more, in proportion. Gilt-edged securities used to pay 5 per cent. in those days, but they now only give 3 per cent. I think there is a great deal of cause for congratulation for all concerned in this Company, whether shareholders, Directors, or staff; and I do not think the shareholders will second Mr. Baines in his remarks about economy. I believe that those who know the subject thoroughly will be aware that the more you economise the greater your dividend will not become. The work must be done well, and well-paid services and the results we get are connected, depend upon it. I have great pleasure in proposing a vote of thanks to the Chairman and Directors for their services in the past half-year, and, as I have said, for the past 25 years.

Mr. BAINES: To show that I have no ill-feeling towards the Board I have great pleasure in seconding Mr. Newton's resolution, and in doing so I acknowledge the services which the Directors have rendered to the Company. The Company, however, is now in such a strong position that I think the time has arrived when the shareholders might expect to receive a little more in the way of dividend. I second the motion, and I have no doubt that it will be thoroughly supported.

Mr. DAWES put the motion to the meeting, and it was carried unanimously.

The CHAIRMAN: Gentlemen, Boards of Directors are human. We all like a little patting on the back when we have done our work well, and when that patting is done by gentlemen who formerly took a very active part in rubbing us down the wrong way the operation becomes still more pleasant (laughter). I thank Mr. Newton, who has been a very just critic, I may say, all these years, and when he comes forward so generously and acknowledges the work which has been done by us, my colleagues and myself are pleased, and thank him for the way in which he has dealt with us. I am quite sure, also, that if Mr. Baines will continue to honour us with his presence at these half-yearly meetings he will become as great an admirer of the Board's actions as Mr. Newton has become (laughter). In parting with Mr. Baines to-day I may say that it is a very natural wish that you should want an increased dividend, and he thinks that he sees some money in our hands that might be applied in that way; but, as I have said before, there are wheels within wheels, and if he had all the information that we possess affecting the policy we are pursuing, I rather think that he would endorse our views and be contented to leave things as they are. When the time comes and a change can be made which will be beneficial to you all, and the Board are justified in making it, you may rest assured that the thing will be done. I thank you again, gentlemen, for this renewed mark of your confidence.

The proceedings then terminated.

Anglo-American Telegraph Company (Limited).

The report of the Directors of this Company, to be presented at the ordinary general half-yearly meeting of the proprietors, to be held at the Cannon-street Hotel, E.C., on Friday, the 27th inst., at two o'clock, is as follows:—

The total receipts from January 1st to June 30th, including the balance of £844. 2s. 4d. brought forward, amounted to £135,390. 3s. 11d. This sum, however, is subject to revision, as the financial result of the judgment given in favour of this Company against the Paris and New York Telegraph Company cannot yet be estimated. The traffic receipts show a decrease of £16,791 as compared with the corresponding period of last year. The total expenses of the half-year, including the repair of cables, &c., amounted to £55,716. 15s. 6d., being a decrease of £4,465. 17s. 8d.

The Directors, under the powers conferred upon them by the Articles of Association, have, before declaring the net profits, set apart the sum of £12,000 to the renewal fund, leaving a balance of £67,673. 8s. 5d. One quarterly interim dividend of 9s. per cent. on the Ordinary stock, and of 18s. per cent. on the Preferred stock, was paid on May 1st, absorbing £31,500, and a second quarterly dividend of 10s. per cent. on the Ordinary stock, and £1 per cent. on the Preferred stock, amounting to £35,000, will be paid on August 1st, leaving a balance of £1,173. 8s. 5d. to be carried forward.

The Company's repairing ss. "Minia" has been employed during the past half-year by the Western Union Telegraph Company for the repair of cables belonging to that Company, the payments for which appear in the revenue account. She is at present engaged in the repair of the 1874 cable, broken on July 9th last year, 575 miles from Heart's Content. The new cable between Ireland and Newfoundland is in process of being laid.

The appeal in the proceedings between the Anglo Company and the Paris and New York Telegraph Company was heard in Paris in June, and judgment given on 10th inst. in favour of the Anglo Company, with costs to date. By this judgment the damages are to be assessed by experts, and are limited to the period between December 31, 1886, and May 21, 1891, the date on which the French Minister declared that the French Company's concession would be forfeited if it attempted to renew the contracts. The question of appeal is under consideration.

Direct United States Cable Company (Limited).

The following report is issued by the Directors of this Company for the six months ended June 30th, and will be presented at the thirty-fourth ordinary general meeting of the Company, to be held at Winchester House, Old Broad-street, E.C., on Tuesday, the 24th inst., at 2 o'clock:—

The half-year's revenue, after deducting out-payments, amounted to £34,843. 9s. 4d., as compared with £40,836. 17s. 4d. for the corresponding period of 1893, being a difference of £5,993. 8s. against the half-year under review, which is attributable to the prolonged commercial depression. The working and other expenses for the same period, including income-tax, amounted to £18,750. 3s., leaving a balance of £16,093. 6s. 4d. as the net profit of the half-year, making with £3,080. 10s. 10d. brought forward from the previous half-year a total of £19,173. 17s. 2d. For the corresponding period of 1893 the working expenses and other payments amounted to £18,898. 5s. 7d. Three quarterly interim dividends, amounting to £25,801. 15s., have been declared and paid during the financial year, and a final payment of 2s. per share is now proposed, making, with the three interim dividends, 2⅝ths for the year, being a total distribution of £31,872. 15s. After transferring £6,000 to the reserve fund account, which now stands at £281,551. 3s. 7d. the balance of £1,031. 17s. 2d. on the revenue account is proposed to be carried forward.

Sir John Pender, G.C.M.G., M.P., and James Pender, Esq., J.P., retire by rotation, and, being eligible, offer themselves for re-election as Directors, and Mr. John G. Griffiths, F.C.A., and Mr. John Sawyer, F.C.A., auditors, desire to offer their respective firms for election.

National Telephone Company (Limited).

The following is the report of the Directors of the Company for the 14 months ended June 30th last, to be presented to the shareholders at the fourteenth ordinary general meeting to be held at the Cannon-street Hotel, London, E.C., on Wednesday next, the 25th inst., at one o'clock:—

The income accrued in respect of the business of the 14 months amounts to £800,544. 15s. 8d., as compared with £583,590. 2s. 11d. for the preceding 12 months, being an increase of £216,954. 12s. 9d. The rentals carried forward for unexpired terms of running contracts amount to £345,358. 18s. 5d., as compared with £285,020. 7s. 8d. for the preceding year, or an increase of £60,338. 10s. 9d. The working expenses and other charges for the 14 months (excluding debenture and other interest) amount to £410,115. 3s. 10d., as compared with £311,644. 10s. 2d. for the preceding 12 months, being an increase of £98,470. 13s. 8d. The net result for the 14 months, after deducting the Post Office royalties, amounting to £73,945. 15s. 3d., is a profit balance of £316,483. 16s. 7d., as compared with a balance of £217,725. 2s. 11d for the preceding 12 months, being an increase of £98,758. 13s. 8d.

During the year the purchase of the Irish Telephone Company and some smaller undertakings has been completed, and the income arising from them has been brought into the accounts for the first time.

Out of the available balance of £262,311. 12s. 5d. shown by the net revenue account an interim dividend at the rate of 6 per cent. per annum on the First and Second Preference shares, and 5 per cent. per annum on the Third Preference and Ordinary shares, has already been paid. The Board will recommend a further payment at the rate of 6 per cent. per annum on the First and Second Preference shares, and 5 per cent. per annum on the Third Preference and Ordinary shares, making the dividend for the 14 months at the rate of 6 per cent. per annum on the First and Second Preference shares, and 5 per cent. per annum on the Third Preference and Ordinary shares. The Board also propose to transfer £63,429. 1s. to the reserve fund, so as to bring it up to £225,000, and to carry forward the balance of £1,765. 3s. 11d.

The negotiations with the Post Office in relation to the acquisition of the trunk lines of the Company have revealed many unforeseen difficulties of detail. These have occupied much time to solve in a manner satisfactory to both parties, but happily are now practically overcome, and the agreement itself is in such form as will enable the Postmaster-General to lay it on the table of the House of Commons in accordance with his promise to that effect.

Redemption of the Existing Debenture Debt of the Company.—The condition of the Money Market had for some time been such as to force upon the attention of the Board the question whether in the interest of the shareholders they must not avail themselves of the option reserved to the Company to redeem the £1,000,000 of Four and a-Half per Cent. Deben-

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ture stock already issued. They came to the conclusion that they should do so, provided the terms upon which the success of a new issue could be practically secured would afford sufficient inducement. They ascertained that this could be effected by conversion into a Three and a-Half per Cent. Debenture stock, and accordingly the arrangement has been carried out upon the conditions of the prospectus advertised in the newspapers, and posted to the proprietors.

Four Directors retire, and being eligible offer themselves for re-election; viz., Mr. George Franklin, Mr. William Cuthbert Quilter, M.P., Mr. William Alexander Smith, and Mr. Alderman Joseph Thompson. The auditors, Messrs. Welton, Jones and Co. also offer themselves for re-election.

Various minor alterations in the Articles of Association are also to be submitted to the meeting for approval; these, if carried, will have to be confirmed by a special meeting to be subsequently called.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1894, pages 274-300, *&c., &c.*]

ECONOMIC ELECTRIC SPECIALTY COMPANY (LIMITED).—This Company was registered on July 11th, with a capital of £50,000, in £1 shares, to enter into and carry into effect an agreement made between Messrs. H. T. Middleton and Co., Edwin Blakey, and this Company, and to carry on the business of manufacturers of and dealers in electric, telegraphic, and scientific machines and instruments, electrical, mechanical, metallurgical, chemical and general engineers and manufacturers, and dealers in and suppliers of electrical engineering and other goods and apparatus. The subscribers (with one share each) are: James E. Hay, Charles Hoppe, Alfred H. F. Young, Sidney H. Nugent, Arthur T. Way, John Jackson, and William Lee.

J. C. AND J. S. ELLIS (LIMITED).—This Company was registered on July 13th, with a capital of £10,000, in £10 shares, to acquire the business carried on by J. C. and J. S. Ellis at Sheffield and London, and to carry on the business of general engineers and ironfounders.

HUGHES, SUTTON AND DIGBY (LIMITED).—This Company was registered on July 16th, with a capital of £5,000, in £1 shares, to acquire the business of engineers and contractors, lately carried on by George H. Hughes and Peter Gotto, at 8, Highgate-road, Kentish Town, London, N.W., and to carry on the business of hydraulic, electrical, mechanical and sanitary engineers, &c., to construct, lay down, establish, fix and carry out all necessary cables, wires, lines, accumulators, lamps and works for generating, accumulating and distributing electricity, and to carry on the business of electricians, suppliers of electricity for the purposes of light, heat, motive power and otherwise, and manufacturers of and dealers in all kinds of electrical apparatus and appliances. The first Directors are: George H. Hughes, Richard J. Sutton, and Thomas J. Digby.

JONES BROTHERS AND CO., BIRMINGHAM (LIMITED).—This Company was registered on July 11th, with a capital of £2,000, divided into 1,000 £7 per Cent. Cumulative Preference and 1,000 Ordinary shares of £1 each, to acquire the business of general brass founder carried on at Birmingham by Thomas W. W. Perry, and to carry on the business of general brass founders, manufacturers of electrical appliances, electrical engineers, manufacturers of and dealers in machinery, engines, tools, implements, utensils, and appliances, and founders, manufacturers, workers, and smelters of iron, tin, steel, copper, and other metals.

SPANISH TELEPHONE COMPANY (LIMITED).—This Company was registered on July 16th, with a capital of £16,000, in £10 shares, to acquire all the share capital, Ordinary and Preference, now issued of and in the Compañia Peninsular de Teléfonos, for the price of £32,000, to negotiate concessions, leases, or contracts for telephones, telegraphs, or other undertakings, and arrange for the construction and working of the same, and to carry on any business in connection therewith. The subscribers are:—Ernest Rüffer (500 shares), Henry Rüffer (500), Horace E. Walton (1), Walter H. Stevens (1), Alfred P. Garnett (1), Charles H. Garnett (1), and Frederick W. Rosey (1). The first Directors are: Ernest Rüffer, Henry Rüffer, and Francis R. Y. Radcliffe.

E. AND E. TAYLOR (LIMITED).—This Company was registered on July 14th, with a capital of £5,000, in £10 shares, to acquire the business of a hydraulic and electrical engineer, general ironfounder, &c., carried on by E. and E. Taylor, at Moorgate-street, London, E.C., and at the Brady-street Ironworks, London, E.

DALZIEL'S ATLANTIC TELEGRAM COMPANY (LIMITED).—The annual return of this Company, made up to May 14, 1894, has been filed. The nominal capital is £25,000 in £100 shares. Of these 228 have been taken up, and 150 issued as fully paid. The full amount has been called on one share, while calls amounting to £63 per share have been made on 77 shares, resulting in the payment of £4,719 and leaving £232 in arrears.

TELEGRAPH MANUFACTURING COMPANY (LIMITED).—The annual return of this Company, made up to June 18th, has been filed. Out of a nominal capital of £50,000, in £10 shares, 3,290 have been taken up, and of these 646 have been issued as fully paid. Upon the remaining 2,644 shares the full amounts have been called and paid.

THETFORD ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The annual return of this Company, made up to September 30, 1893, was only recently filed. 368 shares out of the nominal capital of £5,000, in £10 shares, have been taken up. Upon these shares the full amounts have been called, resulting in the receipt of £3,615, and leaving £65 as yet unpaid.

WEST COAST OF AMERICA TELEGRAPH COMPANY (LIMITED).—The annual return of this Company, made up to June 12th, has been filed. The whole nominal capital of £300,000 in £10 shares has been taken up and fully paid.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The annual return of this Company, made up to May 31st, was recently filed. Out of a nominal capital of £1,500,000, divided into 66,871 shares of £15 each and 66,258 shares of £7. 10s. each, 64,242 shares of £15 each, and all the latter class have been taken up, the full amount called, and £1,460,565 paid. A sum of £565 has been paid on 75 forfeited shares. Share warrants comprising 5 shares each to the total amount of £1,725 are outstanding, and comprising 1 share each to the value of £180 are also outstanding, while share warrants comprising 3 shares or £45 have been surrendered since the filing of the last summary.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The annual return of this Company, made up to May 23rd, was recently filed. The nominal capital is £2,445,630, divided into 200,000 Ordinary, 34,563 First Preference, and 10,000 Second Preference shares, all of £10 each. 88,321 Ordinary, all the First Preference, and 4,669 of the Second Preference have been taken up, the full amount called, and £1,275,530 paid.

CITY NOTES.

ANGLO-AMERICAN TELEGRAPH COMPANY (LIMITED).—The Directors of this Company have, after placing the sum of £12,000 to the credit of the renewal fund, declared an interim dividend for the quarter ended June 30th of 10s. per cent. on the Ordinary stock and £1 per cent. on the Preferred stock, less income tax, payable on August 1st to the stockholders registered on July 10th.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).—The coupons on this Company's Five per Cent. Debentures, 1884 issue, due 31st inst., will be paid on and after that date at Parr's Banking Company and the Alliance Bank (Limited), Bartholomew-lane, London, E.C. Coupons must be left at the above bank three clear days for examination.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The accounts of this Company for the year ended June 30th show a balance, after providing for the Debenture interest and the full dividend on the Five per Cent. Preference Shares, sufficient to allow the payment of a dividend on the Consolidated Ordinary Stock at the rate of 1 per cent. per annum, carrying forward a balance of £1,335 to the new account. The dividend for the corresponding period last year was at the rate of ½ per cent. per annum, the balance carried forward being £898. It will be seen that an additional £450 is carried forward, and that the Company leaves the fractional dividends behind. The progress shown is very satisfactory, and augurs well for the new electric railway enterprise now in course of construction.——The traffic returns of this Company for the week ended July 15th were £882, as against £776 in the corresponding period of 1893, being an increase of £106. The total receipts for the half year amount to £1,761, as against £1,845 for the corresponding period of 1893, a decrease of £84.

CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).—The warrants for the interim dividend due on this Company's Preference shares, at the rate of 6 per cent. per annum for the six months ended June 30th last, have been posted.

INTERNATIONALE ELEKTRICITATS GESELLSCHAFT.—At the recent annual meeting, held in Vienna, a dividend of 6 per cent. was declared.

METROPOLITAN ELECTRIC SUPPLY COMPANY (LIMITED).—This Company have during the week invited applications for £150,000 Four and a-Half per Cent. First Mortgage Debentures (part of a total authorised issue of £250,000) at the price of £105 per £100 debenture. These debentures are redeemable at the option of the Company, on six months' notice after January 1, 1916, at £110 per debenture. The new stock is secured on the real estate of the Company, and is made a floating charge on the general undertaking. Holders of existing Five per Cent. Registered Debentures can exchange at par for the new stock, or will be paid off at the end of six months. The subscription list for the debenture issue opened and closed yesterday (Thursday).

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED) The transfer books of this Company will be closed from the 16th to the 24th inst. inclusive, preparatory to the payment of the interim dividend of 12s. per share.

VENEZUELA TELEPHONE AND ELECTRICAL APPLIANCES COMPANY (LIMITED).—Coupon No. 8 of the Five per Cent. First Mortgage Debentures of this Company, payment of which is due July 31st, will be paid from that date at the Consolidated Bank, Threadneedle-street, London, or at the banking house of Messrs. Westendorp and Co., Amsterdam.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended July 13th (after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited), were £2,295.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the two weeks ending July 15th were £2,007, as compared with £1,893 for the corresponding period of last year. The receipts for March, estimated at £5,646, realised £5,656.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, July 11.	Price Wednesday, July 18.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending July 18. Highest	Lowest
			TELEGRAPHS.			£ s. d.		Highest	Lowest
£1,012,880	Stock	9/0	Anglo-American	37 40	37 40	6 4 6	Jan., Apr., July, Oct.	..	..
£2,933,560	Stock	18 0	Do. Preferred	71 73	71 73	6 10 6	,, ,,	73	71
£2,933,560	Stock	5/0	Do. Deferred	6½ 7	6½ 7	..		6⅞	6 13/16
£184,500	100	4%	African Direct Teleg. 4% Deb. (Reg. & Bearer)	100 103	101 104	3 16 11	January and July	102¾	..
130,000	£10	3/0	Brazilian Submarine	12 12½	12 12½	5 4 0	Mar., June, Oct., Dec.	12¼	..
£18,700	£100	5%	Do. 5 per Cent. Bonds	101 104	101 104	4 16 2	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	107 111	107 111	3 16 11	June and December	..	—
10,000,000	$100	$1¼	Commercial Cable Capital Stock	139 143	139 143	4 17 11	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	12 13	12 13	6 3 1	February and August	..	..
6,000	10	10%	Do. Preference 10 per Cent.	18½ 19½	19 20	5 0 0	,, ,,	..	..
12,931	5	1/7½	Direct Spanish (fully paid)	4 4½	4 4½	4 8 11	April and October	..	—
6,000	5	10%	Do. Preference 10 per Cent.	9 9½	9½ 9¾	5 2 7	,, ,,	9	—
£30,000	Stock	4½%	Do. 4½% Debentures of £50 each	..	103% 106%	4 4 11	..	..	..
60,710	20	2/0	Direct United States Cable, 1877	8 9	8½ 9½	6 6 4	Jan., Apr., July, Oct.	8 11/16	..
400,000	10	2/6	Eastern	15½ 15¾	15⅝ 15⅞	4 3 2	,, ,,	15⅝	15⅝
70,000	10	6%	Do. 6 per Cent. Preference	16 16½	16¼ 16¾	3 11 8	,, ,,	16¼	16
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	114 117	115 118	3 7 10	May and November	116¼	115¼
£102,100	100	5%	Do. 5 per Cent. Debentures, 1899	107 110	107 110	4 10 11	February & August	..	..
250,000	10	2/6	Eastern Extension xd	15½ 153	15⅜ 15⅝	4 9 7	Jan., Apr., July, Oct.	15⅝	15⅜
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	114 118	115 119	3 7 3	February & August	118	..
£62,700	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103 106	103 106	3 17 3	January and July	103¼	..
£95,100	100	5%	Eastern and S. African 5 p. Cent. Mor. Deb., 1900	103 106	103 106	3 17 3	,, ,,	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures, 1909 (regd.)	105 108	105 108	3 14 1	February & August	..	
£200,000	£25	4%	Do. 4% Mauritius Sub. Debs.	107% 110%	107% 110%	3 12 9	May and November	108¼	108
180,227	10	2 6	Globe Telegraph and Trust	8¼ 8½	8⅝ 8⅞	4 12 9	Jan., Apr., July, Oct.	8¾	8⅝
180,042	10	6%	Do. 6 per Cent. Preference	15¼ 15½	15⅜ 15⅝	3 16 10	,, ,,	15½	15¼
150,000	10	5/0	Great Northern	20½ 21	20½ 21	4 0 0	Jan., April, and July	.	..
£190,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	105 108	105 108	4 12 7	March & September		..
17,000	25	37/6	Indo-European	44 46	44 46	5 8 8	May and November	45	..
37,548	10	5/0	London Platino-Brazilian	5 7	5 7	..	,, ,,	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	107 110	107 110	5 9 1	March & September		.
£100,000	£100	4%	Pacific European Tel. 4% Guar. Debs. "Red" 1942	101 104	101 104	3 16 11	.	101½	..
11,839	8	4/0	Reuter's	5 6	5 6		April and October	..	..
3,381	£100 Cert.	25/0	Submarine Cables Trust 6 per Cent.*	109 114	108 113	5 6 2	,, ,,	110½	..
15,609	10	5/0	West African Telegraph	3 5	3 5	..	January and July	..	..
£249,900	100	5%	Do. 5 per Cent. Debentures	102 105	102 105	4 15 3	March & September	103	..
30,000	10	2/0	West Coast of America	2½ 3	2½ 3		January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	96 101	96 101	7 18 5	June and December	..	..
88,321	10	9d.	West India and Panama	1 1¼	1 1¼			..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10 10½	10 10½	5 14 3	May and November	10½	..
4,669	10	6%	Do. 6 per Cent. 2nd Preference	9 10	9 10	6 0 0	,, ,,	..	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	107 110	107 110	4 5 7	June and December		
64,242	15	7/6	Western and Brazilian	6½ 7	6¾ 7¼	..	May and November	7½	6⅝
33,129	7½	7/6	Do. 5 per Cent. Cumulative Preferred	5¾ 6¼	5¾ 6¼	..	..	5 11/16	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	1¾ 2¼	1¾ 2¼			..	..
£171,900	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	107 1.0	107 110	5 8 9	February & August	..	.
£214,800	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	107 1'0	107 11)	5 8 9	,, ,,	..	..
$1,211,000	$1,000	7%	Western Union 7% 1st Mort. (Building) Bonds	115 120	1'5 20	5 16 8	May and November	.	..
£166,900	£100	6%	Do. 6 per Cent. Sterling Bonds	100 104	100 104	5 15 5	March & September	..	..
			TELEPHONES.						
44,000	5	10/0	Chili Telephone (fully paid)	1 2	1 2	..	..	..	..
224,850	10/0	2⅔d.	Consolidated Telephone Const. & Maintenance	1/16 3/16	⅛ ¼	..	May and November	..	..
171,504	£1	6d.	Oriental Telephone and Electric (fully paid)	½ ⅝	¼ ⅝	..	Yearly	..	..
484,597	5	2/6	National	4⅝ 4⅞	4¾ 5	5 0 0	June and December	5	4⅞
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	14½ 15½	14½ 15½	3 17 5	,, ,,	14⅜	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	14 15	14 15	4 0 0	,, ,,	..	..
119,234	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	5½ 5¾	5½ 5¾	4 6 11		5 11/16	5 [illegible]
1,000,000	Stock	4½%	Do. Debenture Stock, 4½%	109 112	109 112	4 10 0	January and July	..	..
58,000	5	1/0	United River Plate	1 2	1 2		,, ,,	..	..
£146,733	Stock	5%	Do. 5 per Cent. Debenture Stock	90 100	90 100	5 0 0	,, ,,	..	—
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	..	City of London Electric Lighting (fully paid)	12½ 13	12½ 13	..	..	12⅞	[illegible]
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid) xd	14 14½	14 14½	4 2 9	..	14½	..
19,900	£5	..	Electricity Supply Co. for Spain	.	.	.	..	..	..
£30,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	4½ 5½	4½ 5½	.	..	..	..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	.	..	..	..	..	..
8,322	£5	..	House-to-House Electric	..	..	.	.	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	..	..	—		..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..	.	.	January and July	..	..
45,000	£5	2/6	Liverpool Electric Supply (fully paid)	6¼ 6⅝	6¼ 6⅝	—	.	..	..
111,000	5	..	London Electric Supply	..	¼ ⅝		..	..	..
49,900	£10	5/0	Metropolitan Electric Supply (fully paid)	8½ 9	8½ 8¾	2 17 2		8 11/16	[illegible]
£100,000	Stock	5%	Do. 5% Debs. (Bonds of £10, £20, and £40)	109 112	106 109	4 11 9	June and December	107½	10[illegible]
6,452	£10	..	Notting Hill Electric	4½ 5½	4½ 5½			—	..
19,980	£5	4 6	St. James and Pall Mall	7 7½	7 7½		..	..	..
20,000	£5	7%	Do. 7 per Cent. Preference	8½ 9	8½ 9	3 17 9	..	..	..
59,900	5	2/6	Westminster Electric Supply (fully paid)	6¼ 6¾	6¼ 6¾	2 19 3	..	6 7/16	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
90,000		1/6	Brush Electrical Engineering	2¾ 3	2¾ 3	6 0 0	..	2¾	2[illegible]
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	2¼ 2⅝	2¼ 2½	4 16 0		2 7/16	..
£125,000	Stock	4½%	Do. 4½ per Cent Debentures	109 112	110 113	3 19 8	March & September	..	..
20,000	5	2/6	Crompton and Co., 7 per Cent. Cumulative Pref.	2½ 3	2½ 3	.	January and July	..	..
12,139	5	..	Edison and Swan United	—			.	—	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	..	..	..	..	—	—
120,000	2	..	Electric Construction	½ ¾	½ ¾	..	..	—	—
12,845	2	..	Do. 7 per Cent Cumulative Pref.	1½ 1¾	1½ 1¾	..	.	..	..
91,195	2	10/0	Elmore's Patent Copper Depositing	1⅛ 1⅜	1⅛ 1⅜	..		1½	..
20,000	5		Fowler-Waring Cables (fully paid)	½ 1½	½ 1½	.			[illegible]
50,000	10	10/0	India Rubber, Gutta Percha, &c., Works xd	23½ 24½	23 24	5 4 2	February & August	23½	..
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103 105	103 105	4 5 9	March & September	..	..
15,995	£10	6/4	International Okonite Ordinary	..	..	.		.	—
16,000	£10	..	Do. 8 per Cent. Preference	.	.	.	December and June	—	..
20,000	9		Manchester Edison-Swan "A" (£1 5s. paid)	— ¼	— ¼	.	..	.	..
78,949	5	3/6	Swan United (£3 10s. paid)	..	..	..	May and November	..	40[illegible]
37,350	12	36/0	Telegraph Construction and Maintenance	40 42	40 42	5 14 3	March and July	41¼	..
£150,000	100	5%	Do. 5 per Cent. Bonds	102 105	102 105	4 13 6	January and July	..	..
37,514	£5	--	Woodhouse and Rawson Ordinary (£3 15s. paid)	..	..	..	.		..
41,098	£5	—	Do. Preference (fully paid)	..	..	..	.	—	
			RAILWAYS AND TRAMWAYS.						
£630,000	Stock	1%	City and South London Railway	36 38	36 38	1 16 2	May and November	37¼	37
£67,130	Stock	4%	Do. 4% Perpetual Debenture	119 121	119 121	3 6 2	May and November	120½	[illegible]
7,000	10	5%	Do. 5% Perpetual Preference	12½ 13	12¾ 13¼	3 15 6	..	13⅜	13
37,500	£10	1%	Liverpool Overhead Railway	8¼ 8½	8¼ 8½	..	..	..	..
6,295	10	5%	Do. 5% Preference	12¾ 13½	12¾ 13¼	3 16 2	..	..	.-
£125,000	Stock	4%	Do. 4% Debenture	110 112	111 113	3 10 10	January and July ..	..	.-

* Ex. 25/0 Balance of Coupon due April 15, 1894.

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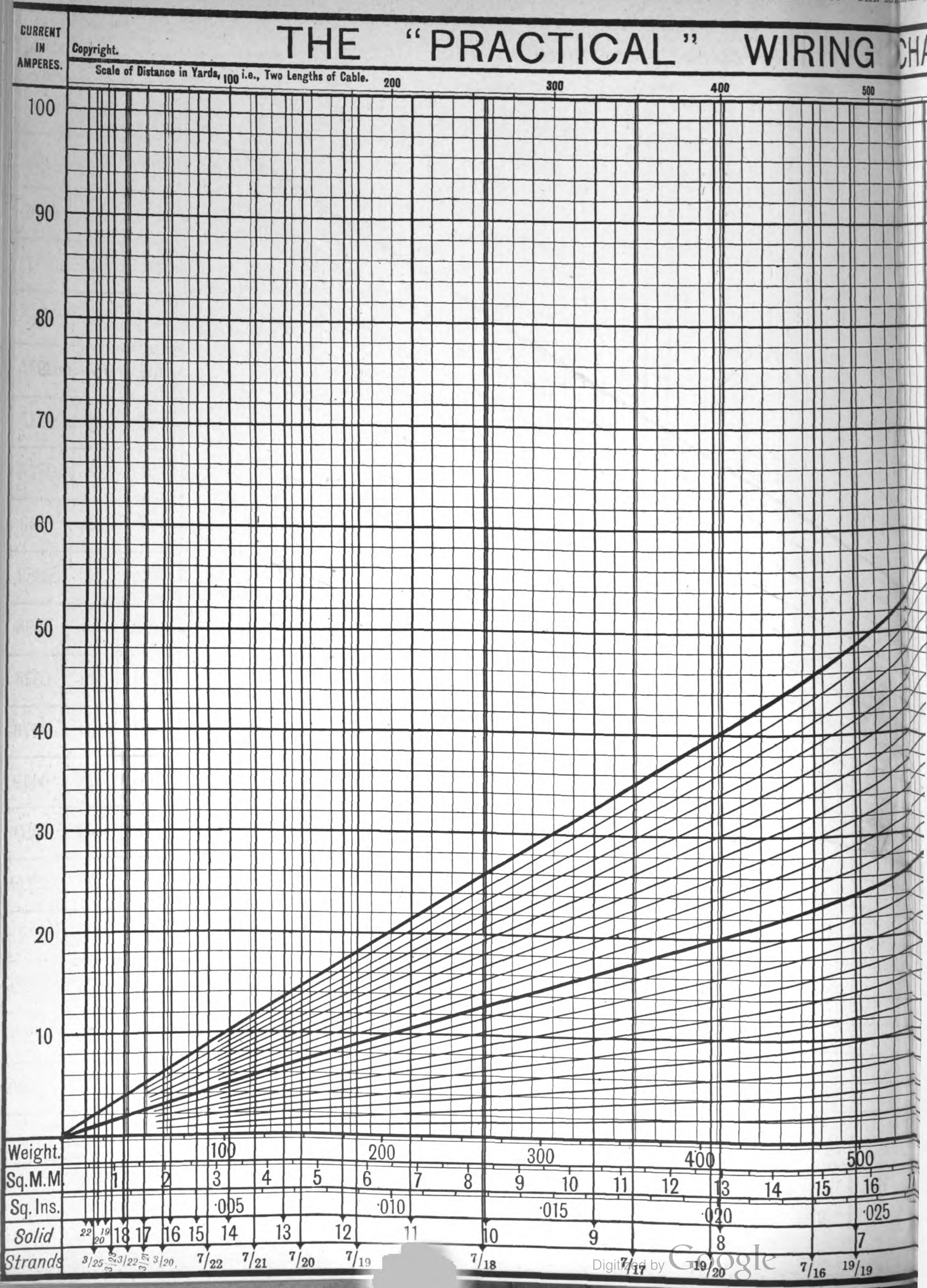
THE "PRACTICAL" WIRING CHA
CURRENT IN AMPERES.
Copyright.
Scale of Distance in Yards, i.e., Two Lengths of Cable.
100 200 300 400 500
100 90 80 70 60 50 40 30 20 10
Weight.
Sq.M.M.
Sq. Ins.
Solid
Strands
·005 ·010 ·015 ·020 ·025
22 20 19 18 17 16 15 14 13 12 11 10 9 8 7
3/25 3/22 3/20 7/22 7/21 7/20 7/19 7/18 7/17 19/20 7/16 19/19

CHART.—*Compiled by A. G. SANDERS, A.I.E.E.*

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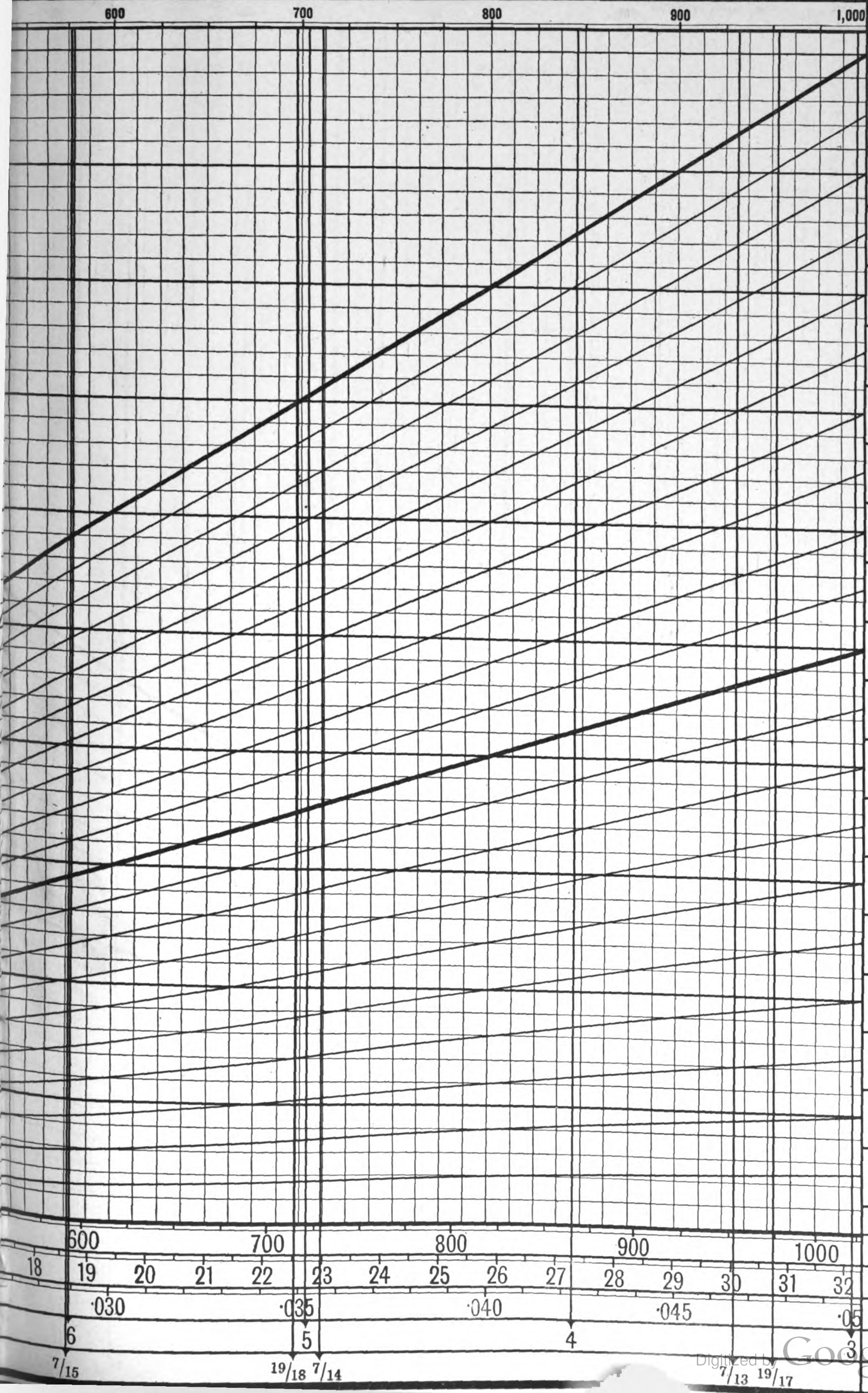

Current Density. Amperes per sq. in.	Volts lost per 1,000yds. i.e., 2,000 yds. of cable	K × C gives H.P. lost per Mile of Cable.
2000	100	·1196
1900	95	·1136
1800	90	·1076
1700	85	·1017
1600	80	·0957
1500	75	·0897
1400	70	·0837
1300	65	·0777
1200	60	·0718
1100	55	·0658
1000	50	·0598
900	45	·0538
800	40	·0478
700	35	·0419
600	30	·0359
500	25	·0299
400	20	·0239
300	15	·0179
200	10	·0120
100	5	·0060

Drawn by A. C. Sanders.

Weight of Conductor in lbs. per mile (approximately).

Area in Sq. M.M.

Area in Sq. Ins.

S.W.G. *Solid Wires.*

S.W.G. *Stranded.*

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

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NOTES.

The only noteworthy feature of the report of the Directors of the City and South London Railway Company is the announcement that the Company's engineer has been instructed "to make experiments with the view of substituting motors on the train itself in place of the present separate locomotive." We have often expressed the opinion that to use electric locomotives is to throw away one of the main engineering advantages of electric traction, and it is to be hoped that the saving in running expenses, and the increased accommodation the adoption of motor-cars will bring about will suffice to enable the concern to yield a more encouraging return to the ordinary shareholders than 1 per cent. Running expenses on the present system have now become stationary at 6·2d. per train mile, so that until the northern extension yields its anticipated profitable traffic a cautious substitution of motor cars for locomotives would appear to be the best available engineering means of improving the net income of the Company.

The Post Office authorities are now introducing telephones for telegraph purposes all over the country. These instruments have the great advantage that at small post offices every member of a household can use it; whereas with an A B C, or a single-needle instrument, skilled assistance is necessary. An attempt has been made to introduce them into the mountains of Wales, but a real Welsh grievance has at last been created. A whole district in Carnarvonshire has risen in revolt. The Rural Sanitary Authority of the place had agreed to a guarantee for a *telegraph*, not for a *telephone*. They were not going to have such a low, vulgar thing as a telephone! A telegraph they wanted, a telegraph they paid for, and a telegraph they would have, or the guarantee would be withdrawn. Welshmen, at any rate, evidently do not agree with the dictum of the late Mr. Justice Stephen that a telephone is a telegraph.

The letter from Dr. Koepsel, a translation of which we print with pleasure in our correspondence columns, clears up a point which his Paper had left doubtful in regard to his pretty and compact apparatus for determining the magnetic qualities of iron. It is clear that the demagnetising effect of the suspended coil is so small that the variations in its value due to differences of position are not sufficient to affect the reading. We think, however, that Dr. Koepsel is the only person who will suspect us of having confused the actual purpose of his compensating coil with that suggested by us as possibly necessary; for in the very next sentence to the one he quotes we state that the author *does not mention* this (*i.e.*, compensation for the swinging coil), and that it is quite possibly so small that it may be safely neglected. It is therefore unnecessary to reply to this portion of his letter; but as regards his conclusion, we cordially agree that a direct reading instrument is, *cæteris paribus*, preferable to the torsional form. We could wish that Dr. Koepsel had read our note more carefully, for another reason, for he would have been able to include in his letter the actual observations from a test bar by the ballistic method and those obtained with his instrument by shearing the curve. The curves in his Paper are on too small a scale to enable us to judge of the accuracy attained, and there still exists considerable doubt in our mind as to the possibility of determining the value of the magnetising force actually used on the test piece, the proportion of which to the total varies for every different value of the permeability. But Dr. Koepsel's Paper did not at all clearly indicate in what manner the value of H was arrived at, and his letter throws no further light on the subject.

At a meeting of an American engineering society the author of a Paper on "Municipal Electric Light Installation" recommended "the localisation of the power-house near a plentiful supply of water, in order that compound condensing engines might be used, and yet far enough from the business centre to escape excessive cost of real estate, while near enough to profit by transportation facilities." He might have added that the station should be near enough to the centre to supply the shops, and yet not so near as to make it difficult to supply the suburbs; and yet far enough away from everywhere to avoid risk of prosecution for smoke and vibration nuisances. The *desiderata* to be fulfilled by the ideal electric supply station are now-a-days at once so obvious and so unlikely to be realised to a greater extent than, say, 50 per cent., that consulting electrical engineers in particular and electrical engineers in general would do well to refrain from enumerating them—at least until they are called in by the municipality of Utopia.

According to a Paper recently read before the American Society of Civil Engineers by Mr. A. V. Abbott, Jun., telephone managers in the States have betaken themselves, like their exchange central-station *confrères* in this country, to plotting load diagrams. There have been several brilliant suggestions of

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late of how best to increase the load-factor of our electric lighting stations by combining the business of lighting with this, that and the other trade; and if only a telephone exchange required a few thousand amperes at a few hundred volts, the most obvious combination would be to run telephones by day and glow lamps by night, since the load curves of the two businesses are to a large extent complementary. According to Mr. ABBOTT, a typical Chicago week-day telephone curve is a decidedly early riser, beginning to run up at 3 a.m., though it is not until 7 o'clock that the real business of the day commences, a first maximum being attained at about 10 a.m. The curve then falls till between 12 and 1, when it rises again to attain a second peak about 2 o'clock, after which the curve falls with varying rapidity until the early hours of the morning. Rather more business, we are told, is done on Monday than on any of the succeeding days, with the exception of Saturday. During Tuesday, Wednesday and Thursday the business decreases, reaching a minimum on Thursday. On Friday a slight increase occurs. The improvement in the Chicago service which has resulted from investigations of this description has been so marked that a regular system of counting now forms one of the features of the service, counts being made on the tenth of each month. The usual method of arriving at the rate of doing business is to supply the operator with a wooden peg, which at the commencement of the count she inserts in jack 0. As fast as calls are received she moves the wooden peg from hole to hole, counting calls something after the fashion of a cribbage board. At the end of each hour the superintendents note the position of the peg.

Errata.—In "Practical Wiring Chart" description, example (3) should read "·0897 × 40 = 3·588 H.P."; and example 5 (A) should read "horse-power lost per mile as 2·691," instead of the figures given last week.

Electric Lighthouses in France.—The lighthouse on the Island of Zen, in the Bay of Biscay, is to be fitted with an electric light flashing every five seconds and capable of being seen, in clear weather, within a radius of 52 miles.

Cable Interruptions and Repairs:—

	Date of Interruption.	Date of Repair.
Sierra Leone-Accra	July 2, 1894	July 25, 1894.
Para-Maranham	July 23, 1894.	—

Electric Lighting in Austria and Hungary.—The little village of Buccari, near Fiume, is now lighted by electricity, a "central station," driven by water power, having just been completed by the International Electrical Company of Vienna.

Institution of Mechanical Engineers.—The Summer Meeting of this Institution will be held in Manchester, and will commence on Tuesday next July 31st. The following are some of the papers that will be read: "Description of the new Electric Lighting Works, Manchester," by Dr. John Hopkinson, F.R.S.; "Electric Welding," by Mr. Benjamin Alfred Dobson.

Vacant Appointment.—The Council of the University College of North Wales, Bangor, invite applications for the post of assistant lecturer and demonstrator in physics at a salary of £120. The post is now vacant, and applications must be sent in by Monday, August 20th, to Mr. J. E. Lloyd, M.A., secretary and registrar, who will furnish all necessary particulars.

A Telephonic Test of Ability.—It is stated that a London merchant requires all applicants for clerkship to hold conversations over the telephone, and forms his opinion of their ability from their answers. His theory is that the day is rapidly approaching when three-fourths of the business will be transacted by telephone, and that a clerk who is careless or indifferent in replying to inquiries will drive customers away.

Epping Forest Electric Railway.—The London, Walthamstow, and Epping Forest Railway Bill came yesterday morning before a select committee of the House of Lords. The only opposition now comes from a landowner at Upper Clapton, through whose estate of forty acres it was intended to construct the line to connect the main line with the Midland Railway system at Tottenham.

The Latest "Most Powerful Light in the World."—The Lighthouse Board, says the New York correspondent of *The Times*, are arranging to place the most powerful light in the world on the Fire Island approach to Sandy Hook, being a Lepante lens with a light of *250 million candle-power* placed at an elevation of 168ft., revolving and flashing every 10 seconds, and visible to a vessel 140 miles from New York. The new light is to be established during the autumn.

The Kapp Dinner.—About 50 well-known electricians and professors met at dinner at the Whitehall Club last Monday to bid good-bye to Mr. Gisbert Kapp, and to present him with a *souvenir* marking the high estimation in which he stands in the eyes of the profession. The chair was taken by Mr. W. H. Preece, who made his usual felicitous speech in presenting Mr. Kapp with a silver salver, a non-magnetic watch, and an album of portraits of those present.

Electric Motors in the Chilian Navy.—Electricity has been used throughout the Chilian warship "Captain Prat" for manœuvring the heavy guns and ammunition hoists. The "Captain Prat," which is of 6,828 tons displacement, and carries 9.45in. and 4.72in. guns, has been built by the Forges et Chantiers de la Méditerranée. The motors used are of the Manchester type, and have been provided by MM. Savatier et Lagabbe, who have worked out all the details of the plant.

City and Guilds of London Institute.—The prospectus is issued for the session 1894-95, setting out particulars of the examination of the Central Technical College at South Kensington and of the Technical College at Finsbury. These particulars will be found set out in our advertisement columns, and all further particulars may be obtained at Exhibition-road, S.W., Leonard-street, City-road, E.C., or at the head offices of the City and Guilds of London Institute, Gresham College, Basinghall-street, E.C.

Telephone Rates in Switzerland.—The Swiss Government is at present engaged in deliberating upon a new Bill, the object of which is to considerably modify the law respecting the telephone service, especially as regards the annual subscription rates to urban exchanges. It is proposed to fix the annual subscription at 100 francs (£4) per annum for the first year, 80 francs (£3. 4s.) for the second year, and for the third and each succeeding year, 40 francs (about £1. 12s.) per annum. An additional charge of ½d. per conversation is, however, to be charged.

Mechanical Equivalent of Heat.—A correspondent of the *Engineer* states that the mechanical equivalent of the heat unit is habitually—but erroneously—taken at 772 foot-pounds, as given by Joule, and that the correct value is 789·2385 foot-pounds. As a matter of fact, Joule gave 772·55+, and the latest determinations give a value in the neighbourhood of 778, which is a convenient figure for general calculations. It is interesting to note that some writers, *e.g.*, Mr. Willans in his Papers read before the Institution of Civil Engineers, have used the approximate value, 770 foot-pounds, for J.

Painting Arc Lamp Globes.—The *Electrical Engineer* of New York says that the Louisville Board of Public Works has made an order requiring the Electric Light Company to refrain from painting or in any way obscuring electric light lamps paid for by the city. In some localities, at the request of property owners, the Electric Light Company has prevented the light from penetrating into private dwellings by painting spots on the globes. Hereafter this will not be permitted, and all of the globes will be permitted to give out a full light, no matter how much it may inconvenience individual property-owners.

Thunderstorms.—During a violent thunderstorm, last Thursday week, the upper parts of the north and west pinnacle of Whitwell Church were struck by lightning and "some old

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rags" in the steeple were fired. A farmhouse near Chatham had a hole rent in the roof by lightning, one of the rooms being wrecked. A horse was killed and a man severely injured while standing underneath a tree which was struck by lightning at Bedale. During a thunderstorm at Hernhill the lightning struck a flock of poultry in an orchard, the fowls being found scattered all over the ground.

Patent Agents Bills.—The Select Committee on the Patent Agents Bills, of which body Mr. T. H. Bolton is Chairman, concluded their labours on Tuesday. The measure agreed to be reported to the House enables patent agents to constitute themselves a profession; provides for registration, discipline, and general control; and establishes a Statutory Committee to exercise supervision until the Chartered Institute of Patent Agents shall become sufficiently representative to take its place. The Committee have also embodied in the Bill some suggestions which have been made with a view to reforming the system of election to, and membership in, the Chartered Institute.

Electrical Engineering in Switzerland.—The electrical industry of Switzerland is becoming one of great importance, owing, in a large measure, to the enterprise of such firms as the Oerlikon Maschinenfabrik and Messrs. Brown, Boveri and Co. The following table, which shows the Swiss imports and exports of electric plant during the past two years, brings out the fact that not only are the imports decreasing but that the exports are rapidly increasing :—

	1893.	1892.
	Tons.	Tons.
Imports	44·6	86·4
Exports	1,045·9	750·6

Douglas and Laxey Electric Tramway.—The Isle of Man Tramways and Electric Power Company have completed their electric tramway along the coast between Douglas and Laxey, a distance of eight miles, and have opened out some of the finest cliff and marine scenery in the Isle of Man. On Saturday last the first trial car was run through. Dr. Hopkinson, who is a Director of the Company, was in charge of the trial, which was a complete success, the car running the whole distance without the slightest hitch. The line and system were found to be in working order. The Board of Trade inspection takes place to-day, the inspectors being Col. Rich and Major Cardew.

Junior Engineering Society.—The members of this society recently visited the electric and hydraulic installations of the Great Eastern Railway at and in the neighbourhood of Liverpool-street, by permission of the engineer, Mr. John Wilson, on whose behalf the district engineer, Mr. H. Wilmer, received the party and superintended the arrangements for their guidance over the extensive area included in the visit. The electric lighting station, situated in Norton Folgate, contains three 100-H.P. and four 200-H.P. compound vertical steam engines, each driving a dynamo. Steam is supplied by five Lancashire boilers, working at 140lb. pressure. The lights will consist of 212 arc lamps, and 4,773 16-c.p., 272 32-c.p., and 55 50-c.p. incandescents.

An Electric Police Launch.—According to the *Electrical Engineer* of New York an electric launch service is to be established as an auxiliary to the Philadelphia police service on the Delaware river. The General Electric Launch Company has filed a bid for the first boat, and other bids have been filed for the engine, charging dynamos, &c. The new boat will be what is called a "sneak boat," doing away with the rowboat of the Harbour Police, which is managed with much difficulty when the water is at all rough. This boat will enable the officers to approach river thieves and petty pirates silently, and is regarded by the police as a valuable recruit. It will also be availed of in connection with the river fire service.

A Submarine Cable Laid in a Water Pipe.—A submarine cable has recently been laid across the Narrows at Vancouver, British Columbia. The harbour about the Narrows is 3·16 miles long by 3 miles wide, whilst the Narrows is but 1,200 ft. wide by 60 ft. deep at its deepest portion. There is the same phenomenon of double tides for which Southampton Water is famous. The current runs through these Narrows at a speed which as a maximum reaches about 7 miles per hour, and the cables originally laid were quickly destroyed. There is, however, a water-pipe laid across this channel which has been successfully maintained, and it was finally decided to draw the cable through this pipe, which was accordingly done, and no further trouble has been experienced.

The North Sea and Baltic Canal.—The lighting scheme of the North Sea and Baltic Canal is a very comprehensive one, says *Engineering*, and the contract has been placed with the Helios Lighting Company of Cologne. At every 800ft. there will be placed incandescent lamps on both sides of the canal, on poles 12ft. high, the power of the lamps being 25 c.p., and of these lamps there will be altogether 884. In addition to this there will be 68 lamps for the lighting of the 13 ferries and the four bridges. The locks will each be lighted by 12 arc lamps, of which those at the entrance will have a special colour. Where the canal passes through lakes, which happens at two places for distances of, respectively, 4,000ft. and 19,000ft., there will be buoys with gas-oil lights. The electric machines will be located at Holtenau and Brunsbüttel, and the whole is to be ready by the spring of next year.

Condenser Discharge from a Man-of-War.—A curious fatality which occurred at the Norfolk (U.S.) Navy Yard on June 20th forcibly illustrates the necessity of guarding against atmospheric electricity in working about the great masses of steel that go to make up the modern warship. It appears that the steel cruiser "Raleigh" was in the wooden dry dock at the time, and a number of men were working on her hull, when a thunderstorm came up. The workmen sought shelter beneath the vessel, which rested on blocks in the centre of the dock. Suddenly, without warning, two of the men fell dead, and most of the others were knocked senseless, by an electrical discharge. The officers of the vessel, who were sitting about on deck, did not feel the shock; but it is alleged that all the compasses and similar instruments were affected, and the vessel has been permanently magnetised. The great ship had, in fact if the above account is correct, behaved like a huge condenser, and had discharged itself electrically through the men beneath it, who acted like discharging tongs.

The Physiological Aspect of Electric Shocks.—According to Prof. J. Kratter, of Graz, who has for some time been performing experiments on the effect of electrical shocks on animal life, death is most usually caused by sudden cessation of respiration and consequent suffocation; during the suffocation the heart continues in action. If the asphyxia lasts more than a certain time, about two minutes, the heart stops, this being a secondary phenomenon. Generally speaking, the animals used, cats, dogs, rabbits, and mice, were not easily killed by 1,600—2,000 volts alternating. The danger appears to lie in the nervous system, and to increase with the amount of brain development. Frequently death occurs by momentary stoppage of the movement of the heart; but a slow cessation of the heart's action, such as has been observed in cases of human death, was never observed. In no case was any anatomical alteration observable to which death might be attributed, but there are sometimes lesions, breaking of blood vessels; and the diagnosis is rendered certain by the peculiar burning at the position of contact, and by the escape of blood from the capillaries, which indicates the path taken by the current.

Self-Moving Road Vehicles in France.—The competition which has just taken place between some 46 mechanically-propelled road vehicles, on the roads between Paris and Nantes, Corbeil, and other places, will not prove of much direct interest to the electrical profession, as only one entry has been made for an electrically-driven vehicle. One half of the number of entries was taken up with petroleum motors which, in other respects than mere numbers, seem to hold the field, or rather the road, against every other type. The Daimler pattern of petroleum motor appeared to be the favourite. These vehicles are said to have a great sale to country doctors, who are enabled to do a round of from 40 to 50 miles a day by the aid of this novel means of locomotion. It is claimed that there is absolutely no smell of petroleum nor any objectionable odour whatever attending the use of the oil motor; but past experience of oil-driven vehicles, for which a similar claim has been advanced, leads us to regard this statement with considerable

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incredulity. However, a small quantity of half-burnt petroleum oil gas discharged into a rural atmosphere would probably do little harm, and cause next to no annoyance.

The Telautograph.—By permission of the postal authorities the wires between St. Margaret's Bay and the General Post Office were last Sunday afternoon and evening used for the purpose of some experiments with the telautograph. Special instruments were fixed up at both ends, and as this was the first time that long-distance experiments in telautography have taken place in this country, they were watched with interest. The results were successful. Mr. Armytage Bakewell writes to *The Times* from Hampstead: "It has been stated that the recent experiments in the transmission of autographic messages by electricity between St. Margaret's Bay and London were the first which have been made in this country in long-distance telautography. Will you allow me to point out that this is a mistake, as more than forty years ago the copying electric telegraph, invented by the late Frederick Collier Bakewell, successfully transmitted autographic messages between Brighton and London. Invisible messages, which could be rendered legible by the recipient, were also transmitted by that system. Great interest was taken by the late Prince Consort in my father's invention, and the inventor had the honour of exhibiting the instruments and of explaining their mechanical and electrical details to his Royal Highness at Buckingham Palace. The copying electric telegraph was subsequently exhibited at the great Exhibition of 1851, and received the highest award, viz., the Council Medal."

Electric Radiation Experiments for Large Audiences—In a recent number of *Wiedemann's Annalen*, Dr. L. Zehnder, who has already published some interesting work on this subject, gives a few useful hints for making demonstration of Hertz's experiments more easily than heretofore. His first suggestion is that to avoid the evaporation and spray of the acid in accumulators, they should be covered with a layer 1 to 2mm. thick of liquid paraffin. Hertz's large parabolic reflectors, made of sheet metal, can be advantageously replaced by a wire reflector of about one-third of the size. For their manufacture the author has made three parabolic wooden formers, with a focal length of 12·5cm. These were placed parallel to one another and joined by distance pieces of 32cm. long; and at right angles to these formers were stretched wires about 1mm. thick and 1cm. apart. The secondary conductor lies along the focal line of the mirror so built up, which can, of course, be seen through. If the discharge tube be placed in this circuit, then if the primary sparks be shielded from sight the secondary sparks may be seen 25ft. away in a darkened room, if the distance between the focal lines of the primary and secondary mirrors is 2·75m. In order to make the reflectors just visible the author paints them with luminous paint. The small height of the mirror, about 4ft., enables the phenomena of refraction to be easily studied, an asphalt prism of three portions, each 22cm. high, suffices. The Deprez interruptor is found to be the best for the induction coil. The author proposes to replace his wire ribs by strips of metal about 5cm. wide.

Polyphase Mining Motors.—Messrs. Johnson and Phillips invited, last Friday, a few mining men and electrical engineers interested in mining, to inspect a polyphase plant about to be forwarded to the Sheba gold mine in South Africa. The plant is specially interesting from the construction of the dynamos, which are of the two-phase type, and have been designed by Mr. Kapp for the firm. Each practically forms two machines, and, hence, if one half is broken down from any cause, the other part can be used until arrangements have been made for carrying out the repairs. The construction is, in general appearance, similar to that of the Brown machines, the field magnets being of the same design. The armature coils, which of course are arranged around the outer and stationary part of the machine, are not symmetrically placed with reference to each other, but the top half of the poles are set with an angular lead of 90 deg. with respect to the remaining poles. The result is that there are two distinct currents, the one in the upper coils being in quadrature to that in the lower. The motors were built by Messrs. C. E. L. Brown and Boveri. The stationary part is supplied with the two-phase current; and the revolving part, which forms the field magnet, is wound with three coils connected to three rings and a variable resistance. The torque can thus be controlled within wide limits. At starting the torque is comparable to that of a continuous current machine of the same output. This was roughly demonstrated by Mr. Albion T. Snell, who has given special attention to this class of motor. We shall refer to these machines at an early date. At the present we wish to point out that the doubt about the starting torque of polyphase motors no longer exists.

Magnetic Action of Hertzian Waves.—A recent number of the *Comptes Rendus* contains a note, by M. Birkeland, on some recent work done in the late Prof. Hertz's laboratory. It is well known that Hertzian waves when they travel along an iron wire magnetise it transversely, although they only penetrate a very short distance below the surface of the wire. This being so, it was an interesting problem to investigate whether it would be possible to observe in such a wire nodes and loops in the magnetisation. Experimenting in this direction, M. Birkeland was led to a negative result, which he attributed to the electrical conductivity of the wire, and hence he was led to experiment, not on cylinders of iron, but on mixtures of finely divided iron and paraffin. He uses a square resonator, having each side 60cm. long, the opposite side to the spark micrometer being formed into a coil of twelve turns, well insulated from each other. If a cylinder of soft iron is introduced into this coil, the spark length is not changed; a fact which previous experimenters have shown to be due to the screening effect of the induced currents in the superficial layer of the mass of metal. When, however, a cylinder of the mixture of iron and paraffin is introduced into the coil, the spark length may be reduced from 9mm. to 0·05mm., or to $\frac{1}{180}$th of its original value. The effects observed increase as the electrical conductivity of the cylinders diminish, so that the magnetic action of the iron becomes less masked by the conductivity effects. This is well shown by surrounding the cylinder with tin-foil, when the spark regains its original length. When a hollow cylinder of the mixture of iron and paraffin is introduced into the coil, the spark length is much shortened; but the effect is much enhanced when the hollow cylinder is filled by a solid rod. Thus the author finds that the magnetic action is felt through a thickness of 5mm. when the mixture contains 25 per cent. of iron, and through 7mm. when it contains 10 per cent. of iron.

Loss of Fuel with Banked Fires.—One of the things generally overlooked in the management of a factory steam plant is the treatment which the plant receives at night when the fires are banked. In some places, says an engineering contemporary, the dampers are left wide open, and a current of air is allowed to draw in over the fires through the tubes of the boilers, and thence to the chimney. In other cases the dampers are closed, but they leak to such an extent that a considerable quantity of air finds its way through the boiler. It is needless to say that the effect is to cool the boilers, but the extent to which this operates even where the leakage of air is comparatively slight, is seldom appreciated. An instance may be noted which shows that the matter is of considerable importance to those who are seeking the highest fuel economy. The case was one where the fires were banked at 6 p.m. and no steam was used from the plant at night save that which was condensed in the main steam pipes, and this was returned to the boiler by means of an automatic pump. The boilers were of the water-tube type, and they were fitted with hand dampers in addition to a main damper in the flue. The common practice was to shut the main damper and leave the firedoors open with a pressure of 100lb. at the time of banking. The main damper was not perfectly tight, and there was sufficient air drawn in to cool the boilers, so that when the fires were opened at six the next morning the steam pressure had fallen to 10lb. Subsequently the practice was changed by closing the hand dampers as well as the main damper, and closing also the fire and ash doors, no other condition in the operation of the plant being changed. The result was that instead of having a pressure of 10lb. at the time of pulling down the fires there was a pressure of 40lb., and the bank of coal which was previously more or less consumed was in apparently the same condition as when the banked fire was first covered.

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MOTIVE POWER AND GEARING.*

BY E. TREMLETT CARTER.

(Continued from page 295.)

Furnaces and Boilers.

"Galloway" Boiler.—There are three essential particulars in which the "Galloway" boiler, manufactured by Messrs. Galloways, of Manchester, departs from the pure type of Lancashire boiler. These are: The use of a breeches flue for the internal flue, the adherence to the old mode of external setting by carrying the furnace gases through the side flues previously to through the bottom flue, and the introduction of "Galloway" cross water tubes. The breeches flue is shown at the bottom of Fig. 19, with the back end in the foreground. It consists of two furnace flues, of circular form, each containing a separate grate and set of fireplace fittings, uniting into one common kidney-shaped flue behind the bridge. This common flue is traversed by a number of cross water tubes, and is provided along both sides with deflecting pockets or indentations. It is claimed that the union of the two lots of furnace gases behind the bridge leads to higher economy, for, by alternately firing the two grates, the excess of air in the thin fire will help to burn up the incompletely burned gases carried over from the thick fire.

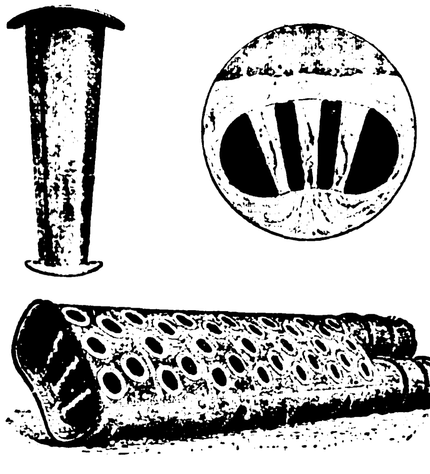

Fig. 19.

"Galloway" Tube.—The "Galloway" cross tube serves a number of useful purposes in this boiler. The shape of the kidney-shaped flue and its extreme width cause it to be subjected to great collapsing force when it is under steam pressure, and render some form of stiffening necessary. The cross tubes, primarily designed to provide this necessary stiffness, also fulfil the following useful ends:—(1) They promote rapid circulation of the water. (2) They increase the effective heating surface, and that in a part of the boiler where the gases are almost at their highest temperature. (3) They act as bafflers to the furnace gases, producing admixture of the hotter and colder portions of these gases. A single tube is shown in Fig. 19, which also illustrates the circulation given by these tubes to the water. It consists of a truncated cone, provided with two flanges for riveting the flue. The smaller of these flanges is riveted on the furnace side, and the larger on the water side of the internal flue. The introduction of the "Galloway" tube into Lancashire and other boilers is a very useful departure from the pure types. The economy of fuel caused by the introduction of these tubes is estimated at from 10 to 25 per cent. A "Galloway" boiler having a shell 28ft. in length and 7ft. in diameter will give a normal evaporation of 6,000lb. of water per hour, when supplied with good coal. The usual allowance in large boilers of this type is 3 sq. ft. of heating surface per indicated horse-power, and 46 to 48 sq. ft. of heating surface per square foot of grate.

Locomotive Boiler.—It can scarcely be said that there is such a thing as standard practice in locomotive boilers, since the proportions of the various parts must depend on the class of work which the boiler has to perform, and on the class of fuel to be used. This type of boiler is used for an immense variety of purposes, from railway engine and torpedo boat driving to agricultural machinery working; and it may be designed to burn all classes of fuel. Take, as an example, a locomotive boiler manufactured by Messrs. Robey and Co. The grate, which is almost square, has a total area of 13.2 sq. feet. With high draughts a considerable thickness of fuel may be burned on the grate, but under ordinary conditions the combustion would not exceed from 25lb. to 30lb. of coal per square foot per hour. From the upper part of the inner fire-box the hot gases pass along the fire tubes to the smoke-box, which is situated just below the uptake or funnel. There are 62 of these tubes, each of 2¾in. diameter. The area of heating surface supplied by these tubes is 424 sq. feet; and this, together with 69 sq. ft. supplied by the inside fire-box, makes a total effective heating surface of 493 sq. ft. A negligible heating surface is afforded by the smoke-box tube-plate. The ratio of the heating surface to the grate area is therefore about 37·4. The shell and other parts of this boiler are designed to stand a working pressure of 140lb. per square inch. Supplied with hot feed, and burning good coal, this boiler should be capable of evaporating about 2,000lb. of feed water per hour. It may therefore be rated at about 100 actual H.P., for ordinary rates of working, though on occasion the boiler might be forced to develop steam at a higher rate, and thus to drive a higher horse-power of engine.

"Economic" Boiler.—Messrs. Davey, Paxman and Co. manufacture, under their patents, a type of boiler called the "Economic" boiler, which has found a prominent place among electric power station steam generators. Strictly speaking, the "Economic" boiler is not a distinct type, but a combination of the Lancashire and marine patterns. It consists of a horizontal, cylindrical shell, terminating at each end in a flat end-plate, and traversed by two cylindrical furnace flues, each with a separate fireplace, as in the Lancashire boiler. The upper portions of the end-plates form tube-plates for a large number of longitudinal fire tubes, and at the front end these tubes terminate in a smoke chamber. The boiler is set in brickwork in the following manner: The back end terminates in a deflecting chamber, lined with firebricks, by which the furnace gases are passed from the under flues to the upper fire tubes. This combustion chamber, as it may be called, becomes almost white hot when the furnaces are in an active state; and the regenerative effect of its heat on the gases ensures the perfect combustion of any unburnt gases which may pass through the chamber. Passing from this chamber forward along the fire tubes, the gases reach the smoke boxes at the front end, and here they pass in two portions to a couple of external flues, which are built around the lower sides and bottom of the shell, with a dividing partition and foundation for the shell directly below the centre of the shell. The course of the gases is now backward towards the economiser, if one be used, and the chimney. By this arrangement of flues the hot gases are made to traverse the inside of the shell twice and the outside of the shell once; thus giving a much greater proportion of internal heating surface, and less surface of external brickwork for the absorption and loss of heat. Instead of having external flues, it is possible to arrange that the hot gases after leaving the smoke-box shall pass to a down-take and away to the chimney; but this arrangement reduces either the efficiency or the steaming performance of the boiler, owing to the reduction of heating surface. The arrangement is convenient, however, where it is desired to mount the boiler on iron saddles instead of in brickwork. This boiler gives the best results, assuming ordinary steam coal to be used, if worked with a draught not less than ⅝in., and it is found that with this draught about 5lb. of water can be evaporated per square foot of heating surface per hour.

The following comparison between the proportions of an

* From a forthcoming work to be published by *The Electrician* Printing and Publishing Company. All rights are reserved.

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"Economic" boiler and a standard Lancashire boiler is instructive:—

——	Lancashire.	"Economic."
Length of shell	30ft.	13ft.
Diameter of shell	7ft. 6in.	7ft. 6in.
Diameter of furnace flues	3ft.	2ft. 6in.
Number of furnace flues	2	2
Galloway tubes in each flue	6	6
Number of fire tubes	0	74
Ext. Diam. of fire tubes	0	3in.
Internal heating surface	585 sq. ft.	860 sq. ft.
External heating surface	398 sq. ft.	188 sq. ft.
Total heating surface	983 sq. ft.	1,048 sq. ft.
Surface of brickwork exposed to hot gases	917 sq. ft.	349 sq. ft.
Water room (normal)	531 c. ft.	270·4 c. ft.
Floor space	432 sq. ft.	195 sq. ft.

"Babcock-Wilcox" Boiler.—The water-tube boilers manufactured by Messrs. Babcock and Wilcox have hitherto led the way as steam generators for electric power stations, both in Europe and America. It is important, therefore, to consider the principal features and merits of this type of boiler. The particular pattern of Babcock-Wilcox boiler which is so well known in European electric power stations differs in some respects from the two or three varieties which are common in America. The boiler is composed of a large number of water tubes, placed in an inclined position, and connected at each end by means of vertical passages with a steam and water drum, placed horizontally over the range of tubes. The upper or front end of the tubes is placed immediately over the grate and forms the crown of the combustion chamber; while the rear end of the tubes is connected to a cylindrical mud-drum, placed transversely to the length of the boiler. The water-tubes are set on a zig-zag pitch—*i.e.*, they are "staggered"—so that the tubes in each row lie just above the spaces between the tubes in the row immediately below. As the furnace gases pass between the tubes this arrangement provides for efficient circulation and contact with the heating surfaces. The whole of the tubes and half the steam drum are filled with water, and the direction of the water circulation is down the vertical connections at the back, forward along the tubes, upward at the front along the vertical connections, and backward along the steam drum. A mixture of steam and water rises through the front end connections, or "headers," and the steam is separated from the water in the drum. Steam is usually collected at the rear end of the drum, to facilitate this separation of steam from the water. The boiler is set in brickwork, built into a steel or wrought iron girder framing; and the setting is so arranged that the entire load of the boiler is imposed on the girders alone, and not on the brickwork. By this arrangement any stress due to unequal expansions of the boiler parts and the brick setting is avoided, and the boiler runs less risk of injury from rapidly getting up steam than would otherwise occur. The brick setting is lined on the inner faces with firebricks. The bridge, immediately behind the grate, and the hanging leaf, which is placed between the middle and rear sections of the tubes, are also of firebrick. These serve to deflect the hot gases across the tubes, the gases traversing the tube stack three times in this pattern of boiler.

The majority of the Babcock-Wilcox boilers which now exist at electric power stations in this country are built of lap-welded wrought-iron tubes, with steam drums of the same material or of wrought steel, cast or wrought-iron mud-drums, and forged or cast-steel headers. In the latest improved construction, however, the entire boiler is built of wrought steel. The tubes are weldless, being drawn by the Mannesmann process.

The Babcock-Wilcox boiler has proved itself a very suitable steam generator for electric power purposes, where smokeless steam coal or anthracite can be obtained; and, in one instance at any rate, it has given good results with inferior bituminous coal, when stoked mechanically. We have already referred to the modification of the furnace by which it may be made to use hand-fired small bituminous coal. The chief merits of this boiler are: That it may rapidly be got under steam, varied in its steaming rate or shut down, without risk of injury and without much loss of heat; that it is compact, easily accessible for cleaning or repairs, and is built up in sections, so that any part may be removed and replaced without much loss of time; and that, owing to the absence of a large cylindrical shell, the risk of dangerous explosion is reduced to very nearly zero. The chief defects of the boiler, in the author's opinion, are: That it requires in general an expensive class of fuel; that it is liable to make wet steam if not carefully managed; that it has little water room, and must therefore be fed with water continually even while making steam at an abnormally rapid rate, and it cannot regulate its pressure so well as more bulky boilers; that it is liable to become choked internally if fed with very hard feed-water; and that, through the whole of the heating surface being external to the boiler, a great deal of loss from radiation and conduction through the setting and foundations is liable to take place. Notwithstanding these liabilities to fault, the Babcock-Wilcox boiler has given excellent results in an immense number of electric power stations.

(To be continued.)

ON THE DISELECTRIFICATION OF METALS AND OTHER BODIES BY LIGHT.

BY DR. OLIVER LODGE.

Referring to a footnote to my Royal Institution lecture, reported on page 186, June 15th, Messrs. Elster and Geitel have been good enough to call my attention to a great deal of work done by them in the same direction. To make amends for my ignorance of this work at the time of my Royal Institution lecture, and to make it better known in this country, I make abstract of their Papers as follows:—

Wiedemann's Annalen, 38, p. 40.—"On the Dissipation of Negative Electricity by Sun and Daylight."

With a view to Arrhenius' theory concerning atmospheric electricity, we arranged experiments on the photo-electric power of sunlight and diffuse daylight at Wolfenbüttel from the middle of May to the middle of June, 1889. Hoor alone had observed the effect of sunlight; other experimenters had failed to find it, but we find a discharging effect even in diffuse daylight.

We take an insulated zinc dish, 20 cm. diameter, connect it to a quadrant electrometer or an Exner's electroscope, and expose it in the open so that it can be darkened or illuminated at pleasure. Sunlight makes it lose a negative charge of 300 volts in about 60 seconds. A positive charge of 300 volts is retained. The dissipation of negative electricity ceases in the dark, and is much weakened by the interposition of glass. But light from the blue sky has a distinct effect. Fill the dish with water, or stretch a damp cloth over it, and the action stops. A freshly-scrubbed plate acquires a positive charge of $2\frac{1}{2}$ volts, which can be increased by blowing.

With freshly-cleaned wires of zinc aluminium or magnesium attached to the knob of the electroscope, a permanent negative charge is impossible in open sunlight. Indeed, magnesium shows a dissipating action in diffuse evening light. Such wires act like glowing bodies. Exposing an electroscope so provided in an open space it acquires a positive charge from the atmosphere. No abnormal dissipation of positive electricity has been observed.

Wied. Ann., 38, p. 497.—Continuation of Same Subject.

Our success last time was largely due to the great clearness of the sky in June, and we wished to see if we could get the same effect at the beginning of winter.

The following is our summary of results:—

Bright fresh surfaces of the metals zinc, aluminium, magnesium were discharged by both sun and daylight when they were negatively charged; and they spontaneously acquired a positive charge, whose amount could be increased by blowing.* A still more notable sensitiveness to light is shown by the

* A fact noticed by Bichat and Blondlot.

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amalgams of certain metals; viz., in the order of their sensitiveness, K, Na, Zn, Sn. Since pure mercury shows no effect, the hypothesis is permissible that the active agent is the metal dissolved in the mercury. If so, the following are the most active metals :—

K, Na, (Mg, Al), Zn, Sn.

All other metals tried, such as Sn, Cd, Pb, Cu, Fe, Hg, Pt, and gas carbon, show no action. The same is true of nearly all non-metallic bodies; but one of them—namely, the powder of *Balmain's luminous paint*—acted remarkably well in sunlight. Of liquids, hot and cold water, and hot and cold salt solution were completely inactive; consequently, wetting the surfaces of metals destroys their sensibility to light.

The illumination experiments can be arranged in either of two ways. For experiments in free space we use zinc, aluminium, or magnesium wires, or small amalgamated spheres of zinc provided with an iron rod. With these it can be easily shown that the illuminated surface of certain metals acts in the same way as a flame-collector.

For demonstration experiments the apparatus described* is better, and with this we show the following :—

Amalgamated zinc, negatively charged, discharges almost instantly in sunlight; and if near a positively-electrified body charges itself positively.

The same thing happens, though more slowly, in diffuse daylight. Red glass stops the action, but the following let some through :—Selenite, mica, window glass, blue (cobalt) glass.

Wied. Ann., *39*, *p. 332*.—*On a Checking Action of Illumination on Electric Spark and Brush Discharge.*

If sparks are just able to occur between a brass knob and a clean amalgamated zinc cathode, illumination of the latter by ultra-violet light tends to check them. [This is a curious inversion of Hertz's fundamental experiment on the subject.

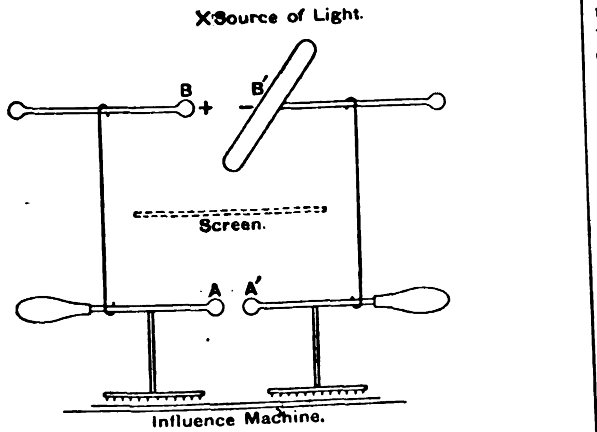

FIG. A.

Explanation of Fig. A.—B' is a brightly polished amalgamated zinc plate attached to the negative pole of a Holtz machine, with the positive knob from 6 to 10 centimetres distant. The source of light is a strip of burning magnesium ribbon 30 to 50 centimetres away. Whenever the spark is able just to choose the path B B', light shining on the zinc plate checks it and transfers the spark to A A'.

It is an effect I have not yet observed; but Elster and Geitel's arrangement differs from mine† in that the surfaces are at a steady high potential before the spark, so that light can exert its discharging influence, whereas in mine the surfaces were at zero potential until the spark rush occurred. Hertz's arrangement was more like mine, inasmuch as he illuminated the knobs of an induction coil on the verge of sparking. It appears, then, that whereas the action of light in discharging negative electricity from clean oxidisable metallic surfaces is definite enough, its influence on a spark discharge differs according to the conditions of that discharge—in cases of "steady strain" it tends to hinder the spark; in cases of "sudden rush" it tends to assist it.—O. J. L.]

Wied. Ann., *41*, *p. 161*.—*On the Use of Sodium-Amalgam in Photo-electric Experiments.*

Elster and Geitel have repeated some of Righi's experiments on the discharge of negative electricity from metals in rarefied air, and find, in agreement with him, that a reduction of pressure to about one millimetre increases the discharge velocity about six or seven times. They proceed to try sodium-amalgam exposed to daylight in exhausted tubes, and describe apparatus

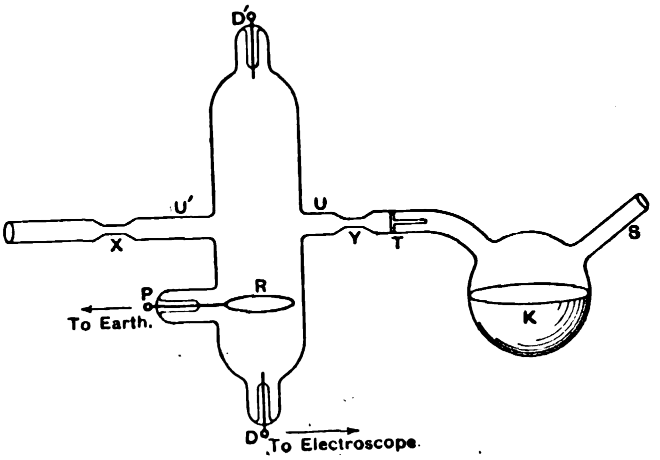

FIG. B.

Explanation of Fig. B.—The sodium and mercury are introduced through the tube S into the globe K. The tube S is then closed, a pump applied to X, and exhaustion carried on for some days. T is an open funnel sealed into the tube (as is done in some vacuum tubes made by Holtz to show a curious unilateral conductivity of rarefied gas. The object of this funnel is to permit metal from the interior, free from scum, to be introduced from K to D when the whole is tilted. Thus a bright surface is exposed to the earth ring R. It can be charged negatively, and its leak under illumination be measured, through the terminal D. Sometimes the tube is inverted, so that the active surface may be at D', further from the earth wire.

for the purpose. Such an arrangement simply cannot hold a negative charge in bright daylight, even although it be unprovided with quartz windows. Even paraffin lamps and sodium flames exert some action.

They observe that under the action of light the boundary surface of the metal and glass changes, and the metal begins to cling to the glass. They suppose that Warburg's vacuum tubes of pure sodium may behave similarly, and show photo electric sensibility.

The Same, p. 166—*On a Checking Action of Magnetism on Photo-electric Discharge in Rarefied Gases.*

The authors point out analogies between the above effects and those they had observed in the action of glowing bodies in air, and they mention Lenard and Wolf's experiments (*Wied. Ann.*, 37, p. 443), tending to show that the effect is due to a disintegrating or evaporative effect of light on surfaces. Elster and Geitel had observed that the discharging power of glowing bodies was diminished by application of a magnetic field, the effect being the same as if the temperature was lowered; and they proceed to try if the discharge of negative electricity from illuminated surfaces in highly-rarefied gas could also be checked or hindered by a magnetic field. They find that it can.

Using the light from sparks admitted through a quartz window into the vacuum tube when a negatively-charged amalgamated zinc surface was exposed near an earth-connected platinum ring, and between the poles of a small electro-magnet, they found that when the tube was full of air at 10mm. pressure the magnet had but little effect, but that at 0·15 mm., whereas without the magnet the charge of − 270 volts disappeared completely in five seconds, when the magnet was excited it only fell about half that amount in the same time. With hydrogen at 0·24mm. the result was much the same, and at either greater or less pressure in both cases the magnet had less effect. In oxygen the loss of charge was not quite so rapid; and, again, at a pressure of 0·1mm. the magnet more

* In this apparatus the mercury amalgams of K and Na are run through a fine funnel, so that the freshly-formed surface of the drops may be illuminated. Under these circumstances, while pure mercury fell from − 185 to − 175 volts in 30sec., amalgam of zinc fell from − 195 to − 116 in 15sec., amalgam of sodium fell from − 195 to 0 in 10sec., and an amalgam of potassium fell from − 195 to 0 in 5 seconds.

† *See* Fig. 22, July 6th, p. 271 or p. 155.

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than halved the rate. But in CO_2 the rapidity of loss was extreme.* Either at 1·1mm. or at 0·005mm. the charge of – 270 volts leaked away completely in two seconds when the magnet was not excited; but in the latter case (low pressure) exciting the magnet reduced the speed by about one-half. At the pressure of 1·1mm. the magnet did not seem to produce an effect. With daylight the results are similar.

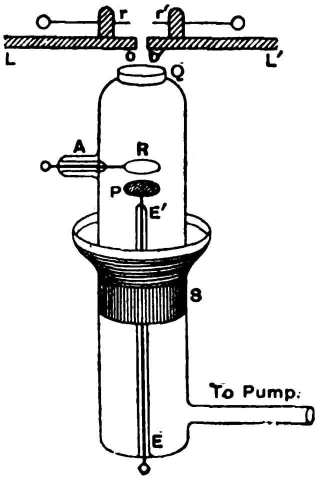

FIG. C.

Explanation of Fig. C.—P is the plate of amalgamated zinc, and R is the earth ring, as before. Ultra-violet light is introduced through a quartz window Q from a spark gap *r*. The vessel has a joint at the middle, so that the sensitive plate can be got at and changed. Magnet poles are applied outside this vessel in various positions.

The authors then discuss the meaning of this result, and its bearing on the opposition hypotheses of Lenard and Wolf and of Righi. Lenard and Wolf's view is that the loss of negative electricity is due to dust disintegrated from the surface by the action of light, dust whose existence they consider is established by an observed effect on steam jets. Righi, on the other hand, believes that gas molecules themselves act the part of electric carriers. Elster and Geitel consider that the magnetic effect observed by them supports this latter view, it being known that a magnet acts on currents through gases; and they surmise that the impact of light vibrations may directly assist electric interchange between a gas molecule and the surface, by setting up in them syntonic stationary vibrations, something like resonant Leyden jars. It is to be remembered that phosphorescent substances, such as Balmain's paint powder, exhibit marked photo-electric effect in daylight.

The unilateral character of the electric motion, and the charging of neutral surfaces by light, require special hypotheses, concerning an E.M.F. at the boundary of gases and conductors, such as Schuster and Lehmann have made.

Wied. Ann., 42, p. 564.—Note on a New Form of Apparatus for Demonstrating the Photo-electric Discharging Action of Daylight.

A vacuum tube suitable for experiments with sodium amalgam or pure sodium, or the liquid sodium-potassium alloy, is described, with the aid of which a current (shown by the

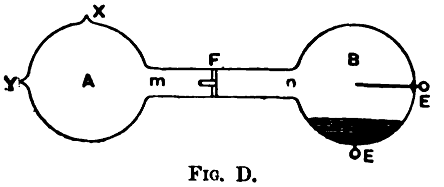

FIG. D.

Explanation of Fig. D.—A simpler arrangement, like the one above (Fig. C), whereby clean liquid alkali metals can be introduced into the experimental chamber B, from the preliminary chamber A, through a cleansing funnel F which dips its beak into the interior.

charge of an electroscope) can be maintained by a dry pile through the rarefied gas above the metal when it is illuminated from ordinary windows.

* Corresponding to the activity of this gas as found by Wiedemann and Ebert (*Wied. Ann.*, 33, p. 258), in their researches on the influence of light on ease of sparking.

Wied. Ann., 43, p. 225.—On the Dependence of the Discharging Action of Light on the Nature of the Illuminated Surface.

Experiments also on differently-coloured lights. Summary of results. The photo-electrically active metals arrange themselves in the following order—Pure K, alloys of K and Na, pure Na. Amalgams of Rb, K, Na, Li, Mg, (Tl, Zn); the same as their voltaic order. With the most sensitive term of the series a candle six metres off can be detected, and the region of the spectral red is not inactive. The later terms of the series demand smaller waves, and even for potassium blue light gives a much greater effect than red. No discharge of positive electricity is observable with these substances.

Wied. Ann., 44, p. 722.—On the Dissipation of Electric Charge from Mineral Surfaces by Sunlight.

Hitherto only Balmain's paint powder has been observed to be active among non-metallic substances. Now they try other phosphorescent bodies, and arrive at the following results:—

Fluor-spar is conspicuously photo-electric, both in sunlight and daylight, especially the variety of fluorite called *stinkfluss.*

Freshly-broken surfaces discharge much more rapidly than old surfaces.

Blue waves, and not alone the ultra-violet, have a perceptible effect on fluor-spar.

In a vacuum the mineral loses its photo-electric sensibility and its conductivity too. Contact with damp air restores its sensibility. Moistening with water weakens, but does not destroy, the sensitiveness. On the other hand, igniting the mineral destroys both its photo-electric power and its exceptional phosphorescent property.

Distinct traces of photo-electric power are shown by the following minerals also: Cryolite, heavy spar, celestine, arragonite, strontianite, calcspar, felspar, and granite.

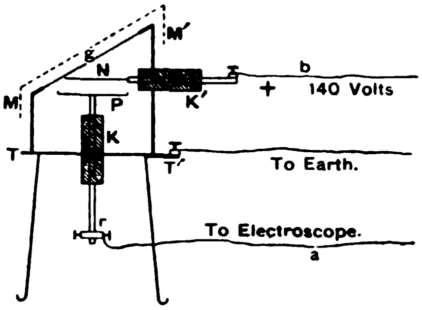

FIG. E.

Explanation of Fig. E.—Arrangement used by Elster and Geitel for exposing various phosphorescent minerals to daylight, while under inductive charge. They were put in powder in the tray P, and the transparent wire-gauze N above them was charged positively from a battery. The metal cover MM' could be removed and replaced at pleasure, and the effect on a delicate quadrant electrometer connected to P observed. By this method considerable tension can be got up on the mineral surface, notwithstanding that it is close upon zero potential. The light effect depends on tension, not potential.

The hypothesis that the power of phosphorescing when illuminated is approximately a measure of the discharging power of light has been verified in many cases; the exceptions can probably be explained by the influence which the electrical conductivity of the illuminated substance exerts on the rate of discharge of electricity from its surface. This agreement confirms the view expressed by us on the occasion of experiments with Balmain's paint, that, during electrical discharge by light, actions take place which are analogous to those of resonance. Messrs. Wiedemann and Ebert had previously been led by other considerations to the same conclusion.

We are compelled by the results of the present experiments to conclude that a more rapid discharge of electricity into the atmosphere takes place in sunlight than in darkness from the surfaces of the earth, which is composed of mineral particles charged, as the positive sign of the slope of atmospheric potential indicates, with negative electricity.

It seems to us evident that there exists a direct electric action of sunlight upon the earth, and that we have given experimental evidence in favour of the theory put forward by von Bezold and Arrhenius, according to which the sun acts on

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the earth, not by electrostatic or electro-dynamic action-at-a-distance, which would involve difficulties of a theoretical character), but through the medium of the electrical forces of light waves. We hope soon to establish the consequences of this theory in meteorology in another Paper, giving the results of two years' observations on the intensity of the most refrangible rays of sunlight and of the slope of atmospheric potential.

Wied. Ann., 48, p. 338.—Experiments on the Gradient of Atmospheric Potential and on Ultra-Violet Solar Radiation.

Elster and Geitel describe the observations they have made for two years on solar radiation, at observing stations of low and high altitude, as tested by its electrical discharging power; and they plot curves of such effective radiation for days and months, along with the curves of atmospheric potential observed at the same places. These curves are of much interest, and need study. Incidentally they find that, of thewhole effective solar radiation, 60 per cent. was absorbed at altitudes above 3,100 metres; 23 per cent. of the remainder was absorbed in the layer between this and a station at 1,600 metres; and 47 per cent. was absorbed between this and 80 metres above sea level. Or, in other words, of 236 parts which enter the atmosphere 94 reach the highest observing station (Sonnblick-gipfel), 72 the middle one (Kolm-Saigurn), and 38 the lowest (Wolfenbüttel). They discuss the question as to how far the daily variation of terrestrial magnetism is due to electrical currents in the atmosphere excited by sunshine, and other meteorological matters.

[The Paper and plates are worthy of reproduction in full in the *Philosophical Magazine.*]

Wied. Ann., 46, p. 281.—On the Behaviour of Alkali Metal Cathodes in Geissler Tubes; On Photo-electric Discharge in a Magnetic Field; and On the Measure of Photo-electric Currents in Potassium Cells by means of a Galvanometer.

Results:—The resistance of a Geissler tube provided with a cathode surface of pure alkali metal is diminished by the light

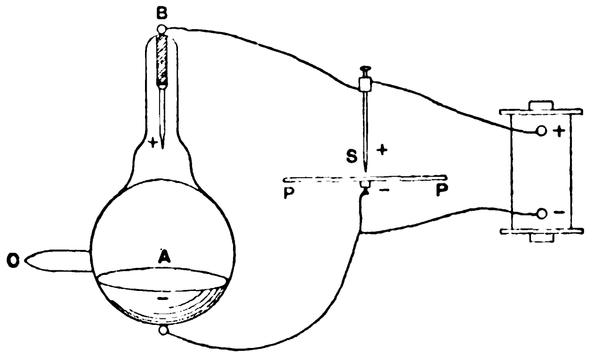

FIG. F.

Explanation of Fig. F.—A vacuum tube of rarefied hydrogen containing alkali metal as cathode, say the liquid K – Na alloy, or solid K or Na. A spark gap at S serves as alternative path, and a stream of sparks can occur to the plate P in the dark. But when light falls on the surface A, this stream of sparks can cease, showing that the resistance of the vacuum tube is diminished.

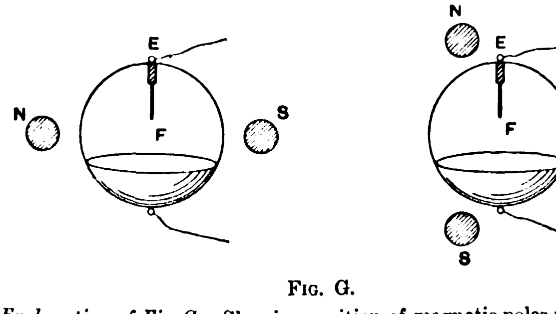

FIG. G.

Explanation of Fig. G.—Showing position of magnetic poles with respect to the vacuum tube discharge. With the poles *across* the line of discharge, as in Fig. on left, excitation of the magnet opposes the leak from the surface. With the poles as in Fig. on right, the discharge is not much affected—it is even sometimes slightly increased.

from the sparks of an induction coil; especially when the pressure is ·1 to ·01mm. of mercury. The resistance which rarefied gas opposes to an electric current in a magnetic field is greatest in the direction normal to the magnetic lines. The changes of resistance effected by any kind of light in a vacuum tube with alkali metal cathode can be measured galvanometrically. (A Daniell cell gives 100 divisions on a Rosenthal

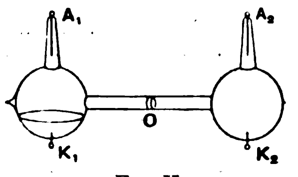

FIG. H.

Explanation of Fig. H.—Potassium vacuum bulbs containing ½ millimetre of hydrogen mounted and connected to battery and galvanometer, and arranged as a photo-electric photometer.

galvanometer when coupled up through such an illuminated tube, each division meaning about 10^{-10} ampere).

Wied. Ann., 48, p. 625.—On the Photo-electric Comparison of Sources of Light.

Attempts to make such a potassium cell into a photometer.

Wied. Ann, 52, p. 433.—Further Photo-electric Experiments.

Plates of platinum, silver, copper need exceedingly ultra-violet light before they show any photo-electric power; zinc, aluminium, magnesium show it for visible violet and blue light; the alkali metals, in an atmosphere of rarefied hydrogen, advance their range of sensibility into the spectral red; while under the most favourable conditions they show a sensibility only inferior to that of the eye itself. The Authors now use galvanometric methods of measuring the effect, instead of only electrometers, and they arrive at the following results:—

(1) The three alkali metals Na, K, Rb, have different sensibility for differently-coloured lights. For long waves their order of sensibility is Rb, Na, K; though Rhubidium is far exceeded by the other two metals in white light.

(2) Illumination of a plane alkali-metal cathode surface with polarised light causes greatest discharge if the plane of polarisation is normal to plane of incidence; and least, if the two coincide.

[This is a most remarkable observation. Its probable meaning is that the electric oscillations of light are photo-electrically effective in so far as they are normal to the susface on which they act; while electric oscillations tangential to the surface are scarcely operative. Different angles of incidence must be tried before the proof is complete. O. J. L.]

(3) Electric oscillations of very short period, such as are given by a Hertz oscillator, are commutated by illumination in the presence of alkali metals in rarefied gas, so as to be able to set up a constant electric tension in the gas.

[A Zehnder tube* was used, and the momentary phases of the oscillation during which the metal is negatively charged are apparently taken advantage of by the illumination.]

(4) The photo-electric dissipation shown by powdered fluor-spar is dependent on the colour of the mineral, in such a way that the deepest blue violet or green specimens are the most sensitive.

COST OF ELECTRICAL ENERGY.

In order that those of our readers who do not happen to be in receipt of copies of the *Journal* of the Institution of Electrical Engineers may have an opportunity of perusing the communicated remarks on Mr. Crompton's recent Paper, as well as the author's written reply, we publish these below in full:—

Mr. A. BROMLEY HOLMES: Mr. Crompton's useful and interesting Paper will be studied with advantage by all engineers connected with electrical supply. In his prophetic estimate of the future selling price of electrical energy, which he fixes at 3d. per unit, Mr. Crompton omits to make any allowance for depreciation. The experience of those who have been engaged in manufacturing businesses shows that it is not sufficient merely to provide for the annual cost of repairs necessary to maintain the plant in first-class working order, but that mere lapse of time entails a depreciation in value, and the consequent necessity of setting aside a depreciation or renewal fund to provide for the expenditure from time to time necessary to keep the plant up to date.

* See *The Electrician*, June 15th, p. 188, Fig. 13.

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In a Paper read before the Liverpool Engineering Society a few months since, the writer estimated the cost of electricity to the consumer in the near future on a business selling two million units per annum at the following figures:—

	Pence per unit.
1. Works cost, including maintenance	1·5
2. Management	0·5
3. Profit	1·5
Total	3·5

To which was added an allowance of 1½d. per unit for depreciation reserve.

Mr. Crompton's figures for the corresponding items are as follows:—

	Pence per unit.
1. Works cost and maintenance	0·9
2. Management	0·42
3. Profit	1·68
Total	3·0

As the writer's figures were based on sales of two million, and Mr. Crompton's on five million units per annum, there is a very close correspondence between them.

In Table III. Mr. Crompton gives, under item N, the evaporation obtained by Lancashire boilers in Liverpool at 5lb. of water for each pound of coal. Mr. Crompton adds a note of interrogation to the 5lb.; and to make his table accurate this note of interrogation should be replaced by 0·48, as the evaporation, averaged over a long period, has been 5·48lb. of water per pound of high-class Lancashire slack. Mr. Crompton is in error in supposing that in the northern counties little or nothing is said if smoke is produced. In Liverpool (and no doubt also in Manchester and other towns) the Corporation inspectors keep a most vigilant watch on the chimneys; but a Lancashire boiler, if properly worked, produces very little smoke and causes no nuisance. The writer cannot help thinking that Mr. Crompton's experience with Lancashire boilers at Chelmsford (item J in Table III.) has been unfortunate, and that further experiment may enable him to secure better results. The results given in last column of Table VI. are comparatively valueless unless accompanied by some information as to the average loads at which the engines are worked. In the early days of a supply station the unit size of plant selected is usually too large for the working conditions of the station, but as the demand increases this disadvantage gradually disappears. A direct-acting high-speed engine which at full load will produce one unit per hour at the dynamo terminals with 30lb. of steam, will require approximately double this amount of steam, and consequently of fuel, when working at one-third load. From this point of view Table VI., though of great interest historically, requires further details (which have unfortunately been impossible to obtain) to make it of great practical value. Mr. Crompton does valuable work in calling attention to the great waste of fuel arising from the use of small independent engines for pumps and similar purposes. In the Liverpool supply stations considerable economy has been effected by replacing the stoker engines by electromotors, and it is under consideration to deal with the pumps in a similar way. Mr. Crompton is to be congratulated on the extremely favourable rates of maintenance which he has attained, as set forth in Table VIII. Unless the capital value of the accumulators is taken at an unduly high figure, the annual maintenance rate of 3½ per cent. is one of which he may be justly proud; it will be a matter of great interest to supply station engineers to learn in the future if this remarkably low rate of maintenance can be continued during the succeeding equal period of four years. Mr. Crompton must have expended a great deal of time and trouble in collecting and arranging the valuable information contained in his Paper, and deserves the gratitude of all interested in electrical supply for his generosity in publishing the results of his experience so fully and freely for their benefit.

Mr. W. D. HUNTER: In a Paper dealing with the cost of electrical energy to consumers, it appears to me that the method adopted by Mr. Crompton, in leaving out of consideration Directors' fees, salaries, and expenses, does not show the true cost of production. I do not think the cost of management is outside the province of engineers, but is just as much an item to be considered as the choice of the system used, and the skill of the designer, and the interest to be paid on the capital expended. To my mind, the right thing to do is take the TOTAL cost of production, plus a reasonable rate of interest on the capital employed to produce the energy sold to consumers; and the argument in favour of this is that one company may produce energy at a very low cost, but such a result may only be obtained by a large capital expenditure.

With regard to Table VI., in which the comparison of fuel used by different companies is given, the figure opposite my Company (viz., the Newcastle and District Electric Lighting Company, Limited) of 310 British thermal units used per watt-hour, is *wrong*; it ought to be 204, and this I pointed out to Mr. Crompton before the reading of his Paper. As the result of careful experiment at our works, I estimated the average production of steam over the year to be 5lb. per pound of coal used—*i.e.*, the calorific value of the fuel used by us in conjunction with our ordinary method of stoking was only half that of Welsh coal evolving 14,500 British thermal units. I may further say that in the case of my Company, after the experience of the past year, it has been found false economy to use a common quality of coal, in spite of its low cost. The fact, however, remains that such coal was used, with the result shown by the figures following:—

Total coal used during the year was 4,698 tons.
Calorific value, 7,250 British thermal units.
Total units sold, 372,922.

$$\frac{4{,}698 \times 2{,}240 \times 7{,}250}{372{,}922{,}000} = 204.$$

Mr. T. P. WILMSHURST: Mr. Crompton's interesting Paper, as might be expected, resolves itself into a vindication of the supposed advantages of low tension over high tension, water-tube over Lancashire boilers, and direct over rope driving. It is open to doubt, however, whether any comparison can fairly be drawn between the working results of a station serving only a compact area, and one serving a scattered and perhaps thinly-populated area. If any such comparison can be made, surely the distance from the works to the farthest lamps, or the relative areas supplied, should be taken into account; but this consideration has been omitted from the Paper—and perhaps wisely. Examination of *The Electrician* supplement of January 5th shows that at the stations mentioned in Table VI. the distance from the works to the farthest lamps is, with the high-tension works, on the average *more than three times* as great as that from the low tension stations. Had the low-tension stations had to serve similar areas to those of their rivals, would not the relative efficiencies have been widely different?

Apropos of Lancashire boilers, Mr. Crompton remarks, "At any rate, the electric works using Lancashire boilers have not hitherto shown at all well in comparison with other types." Published records, however, appear to prove the *exact opposite*. The works using Lancashire boilers appear in the front rank for economy—notably Birmingham, Bradford, Liverpool, Brighton, Leeds, Newcastle, &c.; and the lowest works costs on record of 2·10d. are obtained in a station using these boilers!

Rope driving also comes in for its share, and perhaps more than its share, of condemnation. Examination of the before-mentioned supplement shows that the majority of stations now at work use ropes or belts; indeed, excluding the London stations, where ground space is the all-important consideration, the preponderance in favour of ropes becomes still more marked. It is a curious commentary on Mr. Crompton's criticisms that in the stations now under construction, designed presumably on the accumulated experience of past years, rope driving, Lancashire boilers, and alternating currents are being used in overwhelming proportion.

Mr. WILLIAM E. GRAY: Although I made no attempt to join in the verbal discussion of Mr. Crompton's Paper, in view of the time allowed for this being necessarily limited, I wish to join with other members in thanking the author for the very valuable paper he has laid before us on a subject which is of great interest, and which, owing to the difficulties surrounding it, has hitherto been dealt with incompletely. The data given are of exceptional value; but I cannot agree with many of the deductions drawn from these by the author, and to such points of difference I shall confine my remarks.

In referring to fuel, the author appears to consider that Welsh coal is the best under all conditions. Although this may be so with regard to London, where smokeless combustion is an essential; in other towns, with proper boiler arrangements, other classes of coal can be used with advantage. With a view to obtaining the maximum of fuel economy in the Silvertown Telegraph Works, where over 40 boilers are in use, we have been engaged for a number of years in the systematic test of coal; and, although the results cannot be considered as comparative with results obtained under other conditions, still in themselves they are of value. The type of boiler used for these tests is the Lancashire, with Galloway tubes, and fitted with mechanical automatic stokers; and the tests were uniformly carried out, admitting to the boilers feed water at 60° F., and evaporating steam at 60lb. pressure, the length of test extending over at least 12 hours. The boilers were worked at their normal rate in all cases, and the tests of the various kinds of coal were carried out in the same boilers, to ascertain which coal was most suitable and economical for use with these boilers. No test was made on the percentage of water carried over by the steam, and the following results were obtained:—

CLASS OF FUEL.	Lbs. of water evaporated per lb. of coal.	Cost of fuel, in pence, per 100 gals. evaporated.
Midland coal, average quality	5½	7¾
Durham coal, average quality	7⅓	7
Welsh coal, small nuts	6¼	10

The cost of fuel does not include delivery in London, but is probably a fair average for most towns favourably situated for fuel transport, and naturally on the cost of transport would greatly depend the class of coal to be used. But the above goes to show that, even in London, an economy can be effected by using Durham coal, if such steps are taken as are necessary to prevent any inconvenience arising from its use.

In considering the type of boiler to be used, the author appears to have somewhat lightly treated the claims for consideration of the Lancashire boiler. Where rent is high, water good, and rapid steaming an important factor, the water-tube and locomotive type boiler present great advantages; but in many towns rent is not high, water is not good, and rapid steaming—due to disposition of plant—is not an absolute necessity; in such cases the Lancashire boiler can be used with advantage. It may be objected that the question whether the water is good or not should be considered apart from the boilers. Unfortunately, this cannot always be done, even if the size of the plant and volume of water to be treated justifies the erection of a purifier, as we cannot always be certain that the water passing through will be purified completely. The use of a purifier will, we know, allow us to use water which would otherwise be useless, and no doubt aids us in making indifferent water serviceable; still, we cannot ask for perfection in the purifier, and must seek for a boiler which will deal economically with the water at our disposal, whether purified or not, according to circumstances. The amount of moisture in the steam, and cost of upkeep of the boilers, must also be taken into consideration where economy is sought.

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The author refers to superheaters. The economical advantages of these, properly applied, is undoubted; but before deciding to adopt this system on the score of economy of steam consumption alone, would it not be well to consider the cost of upkeep? Even under the favourable conditions mentioned by Prof. Unwin as obtaining in Alsace, I am assured that the cost of maintenance is an important factor, and that many of the engineers who have closely followed the experiments carried out there have decided to await further improvements before adopting this system.

Dealing with engines, Mr. Crompton is apparently prepared to pin his faith to the high-speed type, directly coupled to the dynamo. Although there is no doubt that, owing to the great abilities of the late Mr. Willans, much has been done to improve this type, slow-speed engine makers have not been idle; and, as mentioned by Mr. Crompton, Carels, Treves, Sulzer, and other makers can produce engines which will be difficult to improve upon from the point of view of economy of steam consumption. The objection to the large space demanded for these engines as compared with that required for the high-speed type is, after all, a question of rent plus cost of maintenance; and it remains to be proved, for the high-speed engine, whether it can compete favourably on these grounds. In referring to the cost of oil for engines, it is to be regretted that the author draws no distinction between vertical and horizontal slow-speed engines.

Attention is drawn to the classification of Table VI., and it is inferred that the difference in cost per unit is due to the difference in mode of drive. If this were really so, it would go far to support the author's contention that direct drive is to be preferred to rope drive; but the Table shows that the rope-driven plant is nearly invariably alternating current, while the direct is continuous current. I must leave to others to decide whether the comparison is a fair one between these two systems, and confine myself to saying that it certainly is not a fair comparison between the relative values of the two drives. This the author admits when he shows that the initial efficiency of the high-speed plant described is little greater than that obtained with a horizontal slow-speed engine with rope drive. What the comparative efficiency would be after, say, six years, he does not tell us. Whatever the disadvantages of a rope drive may be, it certainly has the advantage of being a flexible, instead of a rigid, connection between engine and dynamo.

Although the author gives us no comparative costs of maintenance for the engine and boiler he prefers, he at least gives us the cost of maintenance of his underground system in use by the Kensington and Knightsbridge Company, his results being based on the last four years' working; but, as he gives no cost for maintenance of continuously-insulated cables underground, I am at a loss to understand how he arrives at the conclusion that his system is less cos ly. To fill his omission, I give the figures published in the report of the Metropolitan Electric Supply Company.

Mains, including cost of laying mains, £141,639. 0s. 8d. Repairs, maintenance, and renewals of mains of all classes, including materials and laying the same, £26. 15s. 8d. The system here employed is high-tension where the strains that the dielectric is subjected to are greater than those borne by the mains of the Kensington and Knightsbridge Company. As part of the cables were laid over four years ago, the comparison is a fair one. The result--*i.e.*, a cost of maintenance of less than 1-50th per cent.—does not bear out Mr. Crompton's contention.

In conclusion, if the reading of Mr. Crompton's Paper tends to convince electrical engineers that no standard type of plant is possible; but that the plant must vary according to the conditions of work, which must be carefully considered before the machinery is selected; then, in addition to the value of the tables he gives, the author's Paper will have done much to prevent the industry following in a groove from which it will be difficult to stir, and which may lead to utter failure in many cases.

Mr. ARCHIBALD SHARP (*communicated*): No reference has been made in the discussion to the cost of energy for electric traction, possibly on account of its relatively much smaller importance on this side of the Atlantic, as compared with the cost of energy for electric lighting. At the generating station of an electric railway or tramway the peaks of the load curve have bases of about one-quarter to one-half a minute, instead of two or three hours as in an electric light station. These peaks occur at small intervals, corresponding to the time of starting of the trains or cars. The maximum ordinate of the load curve may be twice the mean ordinate, in which case the engines—which must be of power equal to that denoted by the maximum ordinate—will be running most of the time at half-load, with a corresponding low efficiency. If engines of power just equal to that denoted by the mean ordinate of the load curve could be used, in conjunction with storage of energy for the peaks of the load curve, the efficiency of the engines would be increased, and the cost of the energy diminished. A fly-wheel of quite reasonable dimensions can be designed to give the necessary store of mechanical energy. Let W be the weight of the rim in tons, V the linear velocity of the rim in feet per second, then the energy stored in the rim will be

$$\frac{W V^2}{2g} \text{ foot-tons, } = \frac{W V^2}{948 \cdot 8} \text{ H.P.-minutes.}$$

If a variation of speed of 2½ per cent. above and below the mean speed be allowed, the energy available will be $\frac{W V^2}{94 \cdot 8}$ H.P.-minutes. The greatest safe speed of rim of large cast-iron fly-wheels of the usual type seems to be about 75ft. per second, though there are cases in which a speed of 100ft. per second is reached. Taking a mean speed of 75ft. per second, and a variation of 2½ per cent. above and below the mean, to get 100-H.P. minutes available, 168 tons would be required in the rim, which is prohibitive. I have designed a high-speed fly-wheel which can be safely run up to a speed of 300ft. per second. The distinctive features of its construction are illustrated in Figs. 1 and 2. The nave of the wheel is suspended from the rim by a series of steel loops; one loop forming a pair of spokes is shown thickened. The ends of the pair of spokes are fastened to the rim by nuts. The portion of the spokes in contact with the nave lie in helical grooves cast on the latter. There is absolutely no fastening of the spokes to the nave beyond that due to friction. The rim, being supported at small intervals by the numerous spokes, is nowhere subjected to large bending stresses due to centrifugal force, as is the case in large wheels with a small number of arms. It may, therefore, be run at a much higher velocity with safety. A wheel with mild steel rim and steel spokes may be safely run at 300ft. per second linear speed of rim. At this speed, and with 2½ per cent. variation above and below the mean, 10½ tons weight of rim would be required to get an *available* storage of 100-H.P. minutes. Assuming that the form of the largest peak above the mean line is triangular, with a base half a minute long, the top of the peak would be 400 H.P. above the mean power required,

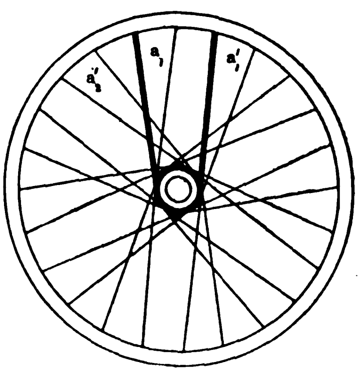

FIG. 1.

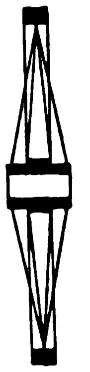

FIG. 2.

and the fly-wheel would therefore be equivalent to an engine of 400 H.P. To get the above necessary high speed the fly-wheel would, in most cases, be fixed on the same shaft as the armature of the dynamo, a simple friction coupling affording a provision against damage by short-circuiting. The dynamo would still have to be of capacity equal to the *maximum* ordinate of the load curve, though the engine need only be of power equal to the *mean* ordinate. The smaller the number of trains driven from the central station the greater is the ratio of the maximum to the mean ordinate, and therefore the greater will be the saving effected by the use of such a fly-wheel accumulator. The saving is not only effected in first cost of engines, but also in working expenses; the steam consumption per I.H.P. being, as is well known, much less in an engine working full power than in the same engine working at half load.

(*To be continued.*)

THE MECHANICAL EFFECTS OF ELECTRIC WAVES.

That electro-magnetic waves are capable of producing mechanical effects upon suitably suspended resonators has been proved by Peter Lebedew, who gives an account of his results in No. 8 of *Wiedemann's Annalen*. The primary conductor used was a Lecher wire system 28m. long. This system, which cannot well be used as a source of waves owing to its excessive damping, was used to excite a *vibrator* of suitable wave-length. A very light resonator was suspended by a torsion thread near the vibrator, in such a manner as to be excited by the vibrator, and also turned by the mechanical forces brought into play, the amount of force being measured by the torsion. To correct for the varying excitation of the vibrator, the latter was controlled in each case by an *indicator* constructed after the fashion of an induction dynamometer or an electrometer, accordingly as it was the magnetic or the electric component of the oscillation that was brought into play. The magnetic vibrator consisted of a piece of zinc 20cm. broad and 65cm. long, bent double, so that the ends formed two condenser plates opposite each other, the capacity of this condenser being adjusted by varying the distance between the plates. The magnetic resonator consisted of a coil of four turns of fine silver wire, whose terminals were connected with a couple of electrometer needles, whose relative positions determined the capacity of the condenser formed by them, and hence also the pitch of the resonator. The whole was mounted on a glass rod, with the plane of the coils vertical and suspended by a quartz fibre. The magnetic indicator was a closed ring of fine silver wire suspended inside the vibrator with the same orientation as the resonator. For the electric component modified forms of vibrator, resonator, and indicator were employed, only permitting the action of electrical forces. As a result of the experiments performed with these instruments, it was found that both types of resonators behaved in the same manner. The effect increased as the "pitch" of the resonator approached true resonance, and suddenly changed sign when that point was reached. When they were "tuned" higher than the vibrators they were *attracted* by the incident wave system, as shown, for instance, in the magnetic resonator by its tending to turn its plane into a position parallel to that of the vibrator. When the resonator was tuned lower repulsion took place, both attraction and repulsion being strongest in the neighbourhood of unison.

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SPECIAL NOTICE.

With this week's issue of "THE ELECTRICIAN" is published a Supplement containing a Full Report of the Proceedings at the Celebration of the Twenty-Fifth Anniversary of the Establishment of Submarine Telegraphic Communication with the Far East. This Supplement is issued gratis, and complaints of non-receipt should be sent immediately to the Publisher.

With the number for July 20th, was issued (Gratis to Subscribers) a Supplement Large Sheet "Practical" Wiring Chart.

OCEAN TELEGRAPHY AND THE IMPERIAL INSTITUTE.

The brilliant gathering which assembled last Friday evening to celebrate the twenty-fifth anniversary of submarine telegraphy to the far East would, in any case, be a memorable incident in the career of the companies to whom we owe that great enterprise. But the occasion rises to one of truly national import when we consider the distinguished and illustrious personages who honoured it with their presence, and the building in which they met. The Imperial Institute is, indeed, the most fitting place that could have been chosen for a commemoration festival of this kind; but that its vast resources were placed at the disposal of the entertainers is a gratifying proof that they had not over-rated their title to be honoured as pioneers in the imperial work which that Institute was founded to consummate. Proud as they may be of their achievements in the past the promoters of ocean telegraphy have, if possible, still greater reason for pride in the fact that time and patience have brought the reward which for long was grudgingly withheld. One has only to cast an eye over the list of guests who sat down to the banquet or were present at the reception following, and to read the congratulatory speeches and telegrams, to be convinced that the great undertakings which were launched a quarter of a century ago amidst mistrust and forebodings, and persevered in with but lukewarm encouragement for a

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number of years, are now receiving the full recognition and applause which they so justly deserve.

After this lapse of time the commercial risks, the electrical difficulties, the engineering obstacles which had to be overcome in the laying of this vast system of submarine cables, are apt to be forgotten, or treated as of little account. But it is impossible to speak too highly of the courage and determination of those who had to face these difficulties for the first time, and who manfully stood to their task until its triumph was assured. The commercial insight which inspired the undertaking, without any known data to guide it, is something to strike us with wonderment even now. Not less so are the social and political consequences, perhaps not altogether unforeseen, which have resulted from a successful adventure dictated primarily in the interests of trade. The whole world is, one might say, now on speaking terms; a fact which needs only to be named to indicate its profound and far-reaching consequences. What those consequences may be are beginning to be realised; and nowhere so keenly as at the National Institute, which gave Sir JOHN PENDER and his colleagues so hearty a welcome last week. That the cable companies which connect the mother country with her children and dependencies in the far East should receive special distinction, reflects the highest credit not only on the hosts but on the guests. Whatever may be the mission of the Imperial Institute in the future, its present work could not have been begun, it would not have been so much as dreamed of, and it certainly could never be fulfilled, but for the cheerful and efficient help which submarine telegraphy is able to render. We heartily join in the good wishes which were showered upon the representatives of the cable companies from every quarter of the globe.

CENTRAL STATION PRACTICE.

The publication of No. 113, Vol. XXIII., of the *Journal* of the Institution of Electrical Engineers affords additional interest to the discussion of Mr. CROMPTON'S Paper on the "Cost of Electrical Energy" by giving the full text of Mr. CROMPTON'S written reply, together with communications from several members who did not speak at the meetings. There is little or nothing in the nature of a departure from the beaten track of the spoken discussion, in the communicated comments, with the exception, perhaps, of Mr. GRAY'S remarks on the relative merits of continuously-insulated and bare mains, and the observations by Mr. SHARP on the mechanical difficulties met with in engines for electric traction. Everything else runs in well-worn grooves: opinions on the relative values of Lancashire and water-tube boilers, on the utility of rope drives, and on the merits of large slow-speed engines, and other matters which had been discussed very fully by the speakers. These opinions, however, come from very good men, and are valuable additions to the discussion. It is worthy of notice, for instance, that almost all those who have sent written communications, including Messrs. BROMLEY HOLMES, WILMSHURST, and GRAY, have sided with the speakers who advocated Lancashire boilers. May we not fairly say that all attempts to pronounce a stereotyped judgment, either favourable or otherwise, on any particular type of boiler, are hasty and ill-judged? In a question of this sort local conditions are of supreme importance, and mere generalisations count for very little. But electrical men have from the beginning shown a strong tendency to let their practice run in grooves; and, like a flock of sheep, they follow whomsoever has sufficient initiative ability to strike out along any new line, or to condemn any old one. One season they shout the praises of compact, quick-steaming boilers; the next they are all agog with thermal storage, hot water and bulky steam generators; and anon they follow the beck of some leader who points them back to the rapidly-steaming type of boiler from which they went astray. But, among the vacillating multitude, there are some few who have the sense to think and experiment for themselves, and the courage to stick to their own conclusions. Among these latter Mr. CROMPTON takes a foremost place; and he expresses his conversion back to water-tube boilers with a conviction and sincerity as genuine as when, three years ago, he gave expression to directly opposite views. In the interval Mr. CROMPTON has made careful and extensive trials of the two types of boilers concerned; and, even if unable to accept his conclusions, no one can fail to give them the highest respect and consideration.

Two of the new contributors to the discussion, Mr. GRAY and Mr. WILMSHURST, side with Prof. UNWIN in favourably regarding the use of slow-speed engines. They even go further and praise the rope drive! Against this latter view we may set the conversion of Mr. RAWORTH, of the Brush Company, from rope-driving to direct driving. While, against the advocates of the slow-speed engine for electric lighting stations, we have the statement by Mr. CROMPTON that even among the makers of these engines "a feeling in favour of high-speed engines for electric supply works has already set in;" and we may further remark that the Americans, who have up till recently been strongly in favour of geared slow engines, are now telling us of the highly original discovery they have made and propose to put in practice, viz., that direct quick-running engines are a better thing. We cannot agree with Mr. CROMPTON in his assertion that the economic advantages of high speed, superheating, and steam jacketting, can be superadded to one another. Of course, it is possible to effect a given economy by any one of them, or partially by all three; but the full benefit of any one cannot be tacked on to the full benefits of another. Mr. WILLANS has shown, for instance, that when his engine is run at a certain high speed, the whole of the initially-condensed steam is re-evaporated during expansion. Not quite as favourable a result can be obtained by jacketting a slow engine. But if the two conditions are combined, the result will be a positive injury to the efficiency.

We do not know, in the whole range of engineering materials, of anything we could recommend as being safe to use for the flywheel proposed by Mr. SHARP. It is not merely that the conditions during the time the wheel would be running steadily at 300ft. per minute are, to say the least of it, a trifle risky; but there is the additional consideration that one cannot suddenly impose the excessive load caused by the starting current in a large electro-motor without enormously adding to the already heavy stresses in the parts of the flywheel; besides which, what may be expected to happen if the engine runs a little too fast? The usual factor of safety would be insufficient to meet the special case of a flywheel designed for such heavy work; and the outlook for the discovery of a material which would render Mr. SHARP'S design reasonably safe is, at the present moment, a rather unfavourable one. Mr. SHARP suggests the use of mild steel; but our estimate of the stress in such a flywheel would seem to indicate that even with an excessively low allowance for a factor of safety this material would be inadequate. Indeed, we are inclined to think that mild steel would reach its ultimate stress long before the conditions proposed by Mr. SHARP could be attained.

Mr. CROMPTON disposes of the question of the antiquation of plant in a somewhat off-hand manner. He argues that the

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creation of an antiquation fund practically amounts to raising capital at the present time for use at some future time. Better not do it, he says, in effect; it is far better to let the men of the future raise capital for themselves as they want it. Of course, if the antiquation idea be carried logically to the bitter end, which its originator probably never dreamt of, we ought to set aside a sum not only sufficient to purchase new electrical plant when the existing plant becomes antiquated but also sufficient to obviate any necessity arising, at any time in the remote future, for the purchase of any form of apparatus, electrical or otherwise, which might be required to do what the present electrical plant is now doing. What a pity the gas companies did not think of doing this for us, and actually do it, in the early days of gas lighting!

ON IMPULSIVE CURRENT-RUSHES IN INDUCTIVE CIRCUITS.

BY ALFRED HAY, B.SC. (EDIN.).

(Continued from page 297.)

§ 16. The curves shown in Fig. 6 require a few words of explanation. The switch was closed at the instant when the E.M.F. was passing through its zero value, and opened at the end of a positive half-wave of current. Referring to Fig. 5, we find 2,000 C.G.S. lines per square centimetre as the initial magnetic induction at the instant of switching on. This gives us the starting point of the abnormal magnetic induction curve shown in Fig. 6. We may now plot the abnormal hysteresis loop by taking corresponding values of the current and magnetic induction; as before, the current scale may be converted into a scale of magnetic force by multiplication by the factor 2·32 (§14). This abnormal hysteresis loop is shown in Fig. 7. The loop starts from the point corresponding to an induction of about 2,000, and reaches a maximum induction of about 6,700, or 3·35 times the normal maximum. The lowest point on the descending branch of the loop corresponds to an induction of about 1,150. Here the descending branch of the loop terminates. The loop then begins to ascend, crosses itself, and reaches a much lower maximum of magnetic induction (about 6,100) than in the first case. The same process is then repeated over and over again until the normal hysteresis loop (shown dotted in Fig. 7) is eventually reached. Roughly, we may describe the action as a gradual creeping down of the abnormal loop along the axis of magnetic induction, combined with a sort of shearing parallel to the axis of current.

Strictly speaking, in choosing 2,000 as the starting point of the abnormal magnetic induction curve, we have committed a slight inaccuracy, for a reason to be explained presently. In obtaining the curves shown in Fig. 6, the current, after having been switched on, was kept on for a little over 5½ periods, and then switched off. Now, during this time, the current has not had time to settle down completely into its normal state, so that the initial magnetic induction of the iron is, probably, somewhat higher than 2,000. In order to find whether there was any appreciable difference between the magnetic state of the iron at the end of 5½ periods, and its state after 6½ periods, the experiment was varied by keeping on the current for 6½ periods instead of 5½. It was found that this reduced the maximum value of the current during the first half-wave from 7·35 to 7·03, or by about 4 per cent.

§ 17. A comparison of the curves given in Fig. 6 with those given in Fig. 3 is instructive; it shows us that the general nature of the phenomenon is the same in both cases, but that the distortion of the waves is incomparably greater in the circuit containing iron. The question thus arises, what is this greater distortion due to? Dr. Fleming, in the Paper alluded to in § 1*, was the first to point the way towards an explanation by suggesting that the "rush" depends entirely on the relation between the initial magnetic state of the iron and the phase of the E.M.F. at the instant of switching on. A number of interesting experiments in support of this view are described by Mr. Mordey in the discussion on Dr. Fleming's Paper. With the arrangement of apparatus used in the present experiments it becomes possible to determine with fair accuracy the connection between the current-rush and the phase of the current at the

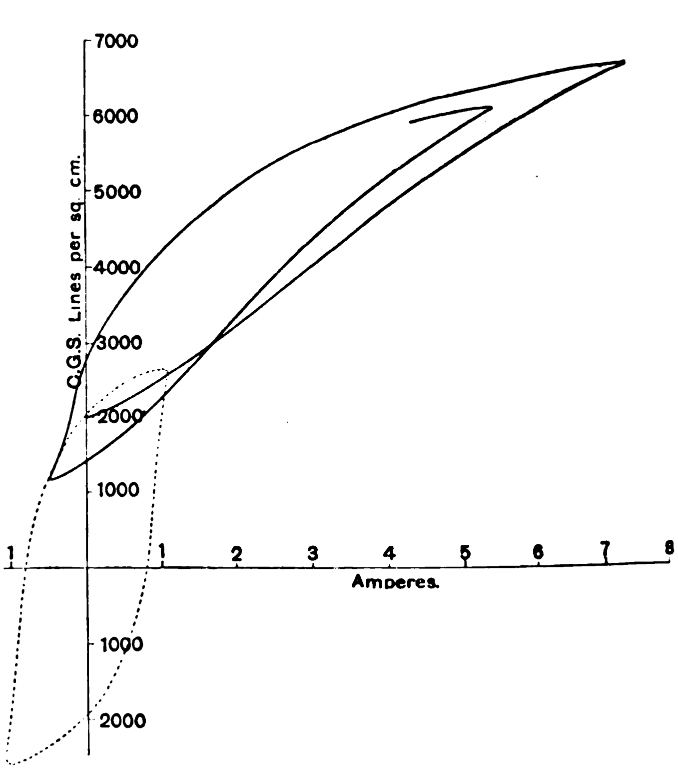

FIG. 7.

instant of switching off. This relation is shown in Fig. 8, where the abscissæ denote the values of the current at the instant of switching off (on the supposition that the current has settled down into its normal state), and the ordinates the greatest values of the current during the first half-wave. The switch is supposed to be closed at the instant of zero value of the E.M.F. This diagram brings out very clearly the following points:—(1) If the switch is opened when the current is diminishing *numerically*,

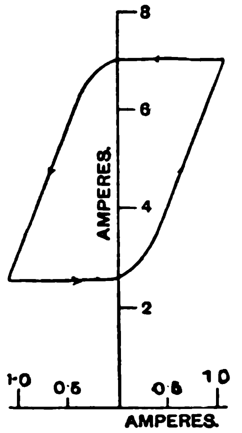

FIG. 8.

then the exact point on the current-wave at which the circuit is broken is immaterial, since the iron always returns to the same state. (2) If the switch is opened when the current is *increasing* numerically, then a very slight difference in the instant of switching off may produce a considerable variation in the "rush." (3) If the switch is closed at the instant when the E.M.F. has a small value, there will always be an abnormal current-rush, *quite independently of the magnetic state of the*

* "Experimental Researches on Alternate Current Transformers," *Journal* of the Institution of Electrical Engineers, Vols. XXI. and XXII.

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iron. Thus we see, from Fig. 8, that there will be a current rush $= \frac{2\cdot56}{1\cdot09} = 2\cdot35$ (§ 3) even when the magnetic state of the iron is least favourable to the production of a "rush."

§ 18. Between the enormously distorted waves of Fig. 6 and the normal waves of current we may have all intermediate stages. One of these is shown in Fig. 9. It is here given on account of two points of interest which it presents, the peculiar *shape* of the current waves, and the exceedingly small amount of damping. It is obvious that these waves will persist throughout a very large number of periods.

We may now consider generally the action which takes place during a current-rush. In all the experiments so far described no distortion of the primary E.M.F. wave was noticed. We may therefore suppose that the primary E.M.F. is not appreciably affected by the rush. When the switch is closed the induction begins to increase comparatively slowly with the current, so that the latter reaches a value greatly in excess of its normal value. This means that during the first half-wave the

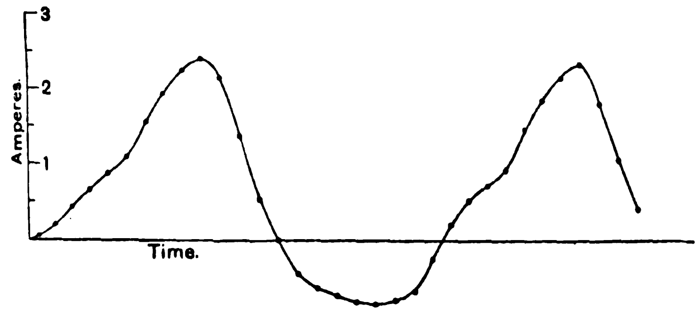

Fig. 9.

drop due to resistance is considerable, and the counter E.M.F. small. We thus get an abnormally small half-wave of counter E.M.F. (or secondary E.M.F., the magnetic leakage in the transformer used being quite negligible). The initial magnetic induction wave is raised considerably above the time-axis; ultimately it settles down into its normal state. Now since the magnetic induction is the integral of the counter E.M.F. it is obvious that the gradual lowering of the magnetic induction wave can only take place in virtue of the half-waves of counter E.M.F. being large and small alternately. We should therefore expect the secondary E.M.F. wave to be distorted by the rush in such a manner that an abnormally *large* half-wave of current corresponds to an abnormally *small* half-wave of secondary E.M.F., and *vice versa.* These conclusions are fully borne out by the curves given in Fig. 6.

(*To be continued.*)

THE DECORATIVE USE OF GLOW LAMPS.*

The immense advantage which electric incandescent lighting possesses is, that it lends itself so readily to decorative purposes. In order that it may be employed in this sense to the best advantage, certain general guiding principles have to be held in view and followed. Unfortunately, this is not always the case, and the result is, that the effectiveness of the light, from the artistic point of view, is greatly diminished. The first principle which should be allowed to guide us in the production of an artistic effect by electric lighting is, that while a proper and sufficient illumination is thrown upon the surfaces to be illuminated, the source of light must be itself, as far as possible, concealed. The illuminating power of a light for the purpose of vision does not depend merely upon the candle-power of the lamp, but it depends upon the amount of light which is received by the eye from the surfaces from which it is reflected. The pupil of the eye is capable of being varied over wide limits, probably from about four square millimetres, or the 150th part of a square inch, to 70 square millimetres or the tenth part of a square inch. This expansion or contraction of the pupil of the eye is effected by muscles over which the will has no control, and it is termed in physiology a "reflex action." If the eye has been kept in darkness for some time, then the pupil becomes expanded to its greatest extent. Under these conditions, if the eye is opened, and especially if exposed to a bright light, this light falling on the retina causes an immediate muscular contraction of the pupil to be effected. It is very easy to see this adjusting process going on in the eye by shutting the eyes for a few minutes and then opening them in a bright light whilst a hand mirror is held before the face so as to examine the pupils of the eyes, the pupils will be seen to be rapidly contracting in area immediately the eyes are opened. Hence, if the eye is turned upon a brilliant line of light, the contraction of the pupil which immediately sets in imposes a limitation upon the amount of light which can enter the eye; and if the eye is turned immediately towards a dull badly illuminated surface, the pupil is not at once suddenly expanded again. One part, at any rate, of the injurious effect produced by trying to read or write in the twilight is due to the strain produced in the eyes by the muscular effort thus demanded in the eye. When, therefore, we enter a room in which there are a number of bright lights, such for instance as a room in which incandescent lamps are being employed, the filaments of which can be seen, the moment that the eye is turned upon these bright lines of light, muscular contraction of the pupil sets in, and on turning the eye away again to other less illuminated surfaces, the retina of the eye does not receive sufficient light to observe details. In common language, the eye is dazzled. There is a certain fascination about brilliant points or lines of light which captivates and attracts the eye even against the will. It will thus be seen that the presence of brilliant lines or points of light in a room has a tendency to keep the pupil of the eye in a state of partial contraction, which unfits it for obtaining the best visual effect when turned upon surfaces less illuminated. Some eyes are especially sensitive in this respect. If, however, the lamp globes are made of frosted glass, or in other ways protected so that the image of the incandescent filament cannot be directly thrown upon the retina, the actual visual effect may be increased in spite of the fact that such frosted globes or screens may cut off from 30 to 50 per cent. of the light. This is a common experience with everybody who tries to read or write in the neighbourhood of a brilliant incandescent lamp. By covering the globe with tissue paper or a ground glass or a porcelain shade, although a diminution to a very large extent is produced in the total light actually distributed from the lamp, yet, nevertheless, we are able to see better and more comfortab'y by it. The process, however, which is commonly adopted of cutting off a large proportion of the light by a semi-opaque globe is a wasteful one, because there can be no object in making light merely to absorb it.

The proper method is to so place the incandescent lamp that no light from the filament can directly enter the eye; but that all the light sent out from the filament shall be reflected to the eye from the objects to be seen, such as the walls of the room and the various objects in the room, and that the light shall reach the eye only after reflection from their surfaces. Bare or uncovered lamps, and especially if suspended half way down a room or on a level with, or a little above the eye, are a crude and exceedingly disagreeable method of illumination. In all cases where incandescent lighting is carried out by those who understand the proper methods of using it, so as to produce the best artistic effects, the guiding principle is followed of so placing the lamps that the whole of the light emitted from them only reaches the eye after reflection from surrounding objects. This result can be attained in a variety of ways. The lamps may be placed in shades so as to throw the light upwards upon the ceiling of the room or upon the walls, from which surfaces it is ultimately reflected down on to the objects in the room. Wherever highly decorated and light ceilings exist in a room to be lit, this is a very effective method of distributing the light. It is always possible to arrange glow lamps, protecting them by metallic or other ornamental shields, so as to obtain this desired effect. A natural shell, properly supported, forms a

* From a forthcoming work on "Electric Lamps and Electric Lighting," by Dr. J. A. Fleming, to be published by *The Electrician* Printing and Publishing Company. All rights are reserved.

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very effective screen and reflecting surface. The white pearly interior of the shell acts as a reflecting surface, and if the shell is very slightly translucent, then a pleasing effect is produced by the small and diffused light which passes through.

The second important principle of decorative electric lighting is to distribute the light properly and to prevent the concentration of light in large masses, thereby avoiding the production of harsh shadows. Everyone is familiar with the exceedingly disagreeable effect which is produced by sharp and strong shadows. A soft gradation of light and shade is essential to the production of an artistic effect in a room. The inartistic productions of many amateur photographers, especially in the region of portraiture, are much more due to the fact that they have not the means at their disposal for producing the right effects of light and shade on their subjects, than to any defects in their photographic manipulation. Any concentration of the light in large masses, in public or private rooms, and especially when thrown downwards, invariably produces disagreeable shadows upon the face; and, therefore, in places like ball-rooms or drawing-rooms no such process of employing downwardly-suspended incandescent lamps should ever be permitted if it is desired to obtain the best results. All artists know the immense importance of obtaining proper lighting by diffused light, and the northern aspect which they invariably select for their studios is determined by this consideration. It is essential that the light should be so distributed in small units, in order that there shall be no sharp shadows cast upon any object. A simple test for the effectiveness of the distribution of light in any room may be obtained as follows: Take a white card or a sheet of white writing paper and hold it horizontally about the level of the eyes, then hold a pencil or other small rod vertically on the card, and note if any marked shadow of the pencil is thrown in any direction: if it is, then the light is insufficiently diffused, and the lamps ought to be re-arranged. The best effects as to distribution of light are generally obtained by the employment of 5 candle-power lamps. These glow lamps are constructed with bulbs of semi-opaque glass having the shape of a candle flame. These candle lamps are carried on the extremity of an artificial porcelain candle, so as to resemble in some degree an ordinary wax candle alight. These lamps are then arranged in groups on chandeliers or brackets, being protected in many cases from direct visibility by plain or ornamental shades. A third great guiding principle of artistic lighting is to proportion the light to the nature of the surfaces from which it is reflected. We require light in our living rooms to see the pictures, decorations, objects, and, above all, to see one another; and we can only see these objects by the light which they reflect back to the eye. The aim should therefore be to have sufficient but not excessive incident light. It should be borne in mind that the different surfaces with which the walls of rooms are covered have very different reflective powers. Dull walls absorb eighty per cent. of the light falling on them, and reflect only about twenty per cent. of the light; this is the case, for instance, with walls covered with dark oak panelling or dull-coloured paint or paper. Ordinary light tints of paper or paint may reflect from forty to sixty per cent.; clean white surfaces, such as white painted and varnished wood or plaster, may reflect as much as eighty per cent., and mirrors from eighty to ninety per cent.

The following figures have been given by Dr. Sumpner for the reflecting power of various surfaces:—

Table *of Reflecting Powers of Various Surfaces.*

White blotting paper	82 per cent.	Plane deal (clean)	40–50 per cent.
Ordinary foolscap ...	70 „ „	Plane deal (dirty) ...	20 „ „
Newspapers.........	50–70 „ „	Yellow painted wall (dirty)	20 „ „
Yellow wall paper ...	40 „ „	Yellow painted wall (clean)	40 „ „
Blue paper	25 „ „	Black cloth	1·2 „ „
Dark brown paper ...	13 „ „	Black velvet	·4 „ „
Deep chocolate paper	4 „ „		

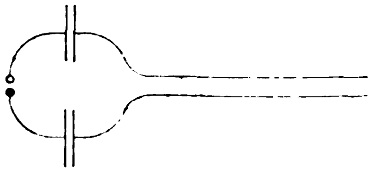
Everyone is familiar with the way in which the laying of a white table-cloth brightens up a dark dining room, or in which the substitution of white for dark curtains lightens up a room. The reason for this is obvious from the above table. Hence, rooms with dark oil paintings, dark woodwork, hangings, curtains, or portières require relatively much more illumination per square foot than rooms with very light decorations, water-colour paintings, mirrors, &c. Experience has shown that in a room of the latter description an illumination is required which is equal to an expenditure in the lamp of about ¾ or 1 watt per square foot of floor surface, on the assumption that the lamps are placed, on an average, about 8 or 9 feet above the floor. A room of the former description, such as a picture gallery with dark oak walls, may require from 2 to 3 watts per square foot of floor surface. These figures, however, cannot be taken too absolutely. Experience is the only guide as to the amount of light to be placed in a room. As a broad general rule, 100 square feet of floor surface will be barely illuminated by one 16-c.p. lamp placed about 8 feet above the floor. It will be well illuminated by two such lamps placed 8 feet above the floor, and brilliantly illuminated by four such lamps. In other words, one 16-c.p. lamp per 100 square feet of floor surface is hardly sufficient, one 16-c.p. lamp per 50 square feet of floor surface is fairly good, and one for every 25 square feet of floor surface is brilliant. These figures are given on the assumption that the lamp is placed about 8 feet above the floor, and that the floor surface is fairly reflective. The lighting of pictures is a very special study, and can only be properly undertaken by those who have given considerable attention to the method of placing and using incandescent lamps. The mere illumination of a room by a number of lamps hung head downwards by cord pendants from the ceiling, a method which is not unusually adopted, is the most crude and imperfect method of applying the electric light, and ought never to be permitted in any cases where the smallest decorative effect is really desired.

FURTHER NOTES TO THE LECTURE ON THE WORK OF HERTZ.

BY DR. OLIVER LODGE.

It may be well to explain that in my Royal Institution lecture I made no reference to the transmission of waves along *wires*. I regard the transmission of waves in *free space* as the special discovery of Hertz. Their transmission along wires is a much older thing, Von Bezold saw them in 1870, and I myself got quantitative evidence of nodes and loops in wires when working with Mr. Chattock in the session 1887-8 (*see*, for instance, reports of the Bath meeting of the British Association, 1888), and I exhibited them some time afterwards to the Physical Society.

It may be worth mentioning that the arrangement frequently referred to in Germany by the name of Lecher (viz., that shown in the figure), and on which a great number of experiments



have been made, is nothing but a pair of Leyden jars with long wires leading from their outer coats. The use of air dielectric instead of glass permits the capacity to be adjusted, and also readily enables the capacity to be small, and the frequency, therefore, high; but otherwise the arrangement is the same in principle as had frequently been used by myself in the series of experiments called "the recoil kick." For these and other reasons no reference has been made in my lecture to the excellent work done on wires by Sarasin and De la Rive; nor to work done by Lecher, Rubens, Arons, Paalzow, Ritter, Blondlot, Curie, D. E. Jones, Yule, Barton, and other experimenters.

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CORRESPONDENCE.

DIRECT-READING MAGNETIC APPARATUS.

[*Translation.*]

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the remarks on my apparatus for the determination of the magnetic qualities of iron which you make in the issue for July 6, 1894, of your valuable paper, and which I have read with much interest, the concluding sentence is as follows: "Would it not simplify matters to make it a torsional zero-reading instrument, and thus do away with the compensation which would be necessary for the magnetising effect of the swinging coil itself?" &c.

I may remark in this connection, that unfortunately a mistake occurs here on the part of your esteemed correspondent, in that he assumes that the compensating windings are used to neutralise the effect of the moveable coil. This is not the case; the magnetic effect of the movable coil is practically nothing. The compensating winding is intended to neutralise the magnetic effect of the fixed magnetising coil on the yoke, for otherwise one would measure B + H with the instrument. Even if for wrought iron there is no great difference between B + H and B, yet for less permeable kinds of iron this difference would become very large; and even for better kinds of iron it must be taken into consideration, since the measurement does not take place at the test piece but at the yoke, and one would therefore be compelled to subtract the readings taken with no test piece in the instrument from those obtained with the test piece in place. The compensating winding enables the instrument to do this automatically when the measurement is made, so that all kinds of iron give directly comparable results in the instrument.

Thus a torsional apparatus would also require a compensating coil, and would lack the universally-acknowledged advantages of a direct-reading instrument.—Yours, &c.,

Berlin, July 17, 1894. (Signed) DR. ADOLF KOEPSEL.

VACUUM TUBE EXPERIMENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have been continuing the series of experiments on vacuum tubes which I have undertaken.

A remarkable result has been obtained which may interest your readers, and I do not think that it has been found already.

A tube was fitted with two "Hertz grids" midway in its length, then exhausted. The grids were "crossed." Under these conditions the current should not traverse the tube end to end. But since residual matter enters into the phenomenon of the bands formed in vacuum tubes, any prediction might be falsified. It might be thought that partial bands would appear in the tube on each side of the grids (which were close to one another) since the current employed was an alternate one. The actual result was that under no conditions could the tube be made to show the *faintest* sign of light. During the next few months I shall be making several further experiments with "grids" at various angles, and other experiments connected with the subject, which will be published in due course.—Yours, &c., DAVID SALOMONS.

July 19, 1894.

Proposals for the Paris Exhibition, 1900.—Thirty-six projects for what is called the Clou, or main attraction, of the Paris Exhibition for 1900 have been sent in to the special subcommittee. The well-known engineer, M. Armengaud Jeune, proposes the offering of handsome prizes for solutions of the three following elementary problems, transmission of sight to a distance, chromo-photography on paper, electric lighting without focus by cold light with the aid of electric undulations of great frequency. M. Trouvé has not quite such lofty ideas, nevertheless even he advocates nothing less than a luminous cascade falling from the upper platform of the Eiffel Tower and also a luminous fountain rising to the same height.

LEGAL INTELLIGENCE.

Re Woodhouse and Rawson United (Limited).

FRIDAY, JULY 20TH.

Sir Rawson Rawson again went into the box, and his examination was continued by the Official Receiver. Sir RAWSON said he wished to assure the Court that he had every disposition to assist it and the Official Receiver, but at four-score and two the memory was liable to fail. Statements made by himself in a speech to shareholders to the effect that the profits of the preceding year were not accidental or casual, but would be repeated; being put to the witness, he said in 1891 they had the prospect of a very valuable concession, and of considerable profits arising therefrom. He did not suggest that the Okonite Company, the Kensington Stores, and the other concerns would again yield large sums, but he did anticipate that there would be other business of a similar character. He first became aware of the connection of his son, the Managing Director, with the Phœnix Trust Company just before the meeting, at which the latter explained the circumstances of his joining the Company, and at which he undertook to draw up a report upon the subject. Witness did not know until some time later that Baron Grant was connected with the Phœnix Trust. A letter came some time in 1891 signed by Baron Grant, and this it was which led to their hearing of his connection with the Company. Witness knew nothing whatever of the National Financial Corporation, and was not aware that his son had any connection with the concern. He was not aware that Baron Grant was consulted in any way about the formation of the United Company, but knew that there was a private telephone wire between the offices of the Company and Baron Grant's offices. Baron Grant was intimately concerned in the Elmore Companies, and he knew his son was using his utmost endeavours to make those companies prosperous. He could not say whether the other Directors were aware of this telephone connection.

Mr. JENKINS wanted to know whether it had ever been proved to be a fraud to speak to Baron Grant.

The REGISTRAR said certain names which were notorious were being introduced, and he supposed the suggestion was that there was a certain amount of suspicion in the connection; he did not think, however, there was any need to bring in those names.

The OFFICIAL RECEIVER said his only reason for referring to Baron Grant was that Mr. Pope had referred to him as a man to be associated with whom was not likely to add to the prestige of the Company.

Mr. JENKINS said it was not quite fair to put this upon Mr. Pope. All that gentleman had done was to point to the fact that a resolution was passed.

Mr. H. G. RAWSON said the way in which the matter of the telephone wire had been put by the Official Receiver was misleading. As a matter of fact, the connection was with the Phœnix Trust Company's offices.

Mr. F. L. RAWSON: And the Phœnix Trust Company paid for that telephone. We did not.

The WITNESS was then examined by Mr. F. L. Rawson, and said he did not recollect being informed when the Phœnix Trust Company was first formed that Baron Grant, amongst others, was to be connected with it. With regard to the anticipated profits of the last six months of 1890, the French Elmore Company was brought out in that period with considerable profit to the United Company. The Austrian Company was brought out about October, 1890, and the profits from that came into the succeeding year. They also received a commission on the sale of the German patents. Mr. North, the business manager, told him that they should make a profit of from £6,000 to £8,000 in that year at the Kidsgrove works. In 1891 they had a call upon about 2,500 Ward Car shares. But for the legal restrictions upon the running of the Ward electrical cars, shares would have been very valuable; as it was they had to have a man with a red flag in front of the cars. The police authorities were satisfied with the cars, but an Act of Parliament was necessary to enable them to run them. Witness did not remember the exact figures mentioned, but he understood there would have been a considerable economy in the cost of running these cars as compared with horse-drawn vehicles. With regard to the value of the Epstein shares, the opinion of the best patent agents was taken as to the value of the patents, and also the opinion of three or four leading counsel as to their validity, and upon this they based their valuation of their shares. When the time came for fixing the valuation of the Phœnix Trust shares, they obtained from the managing director a statement of the items forming the valuation. Some question arose about one or two points, and they were referred back, and there was a reduction in the valuation. They took a great deal of pains to satisfy themselves in 1891 of the value of the Elmore shares, as well as of the shares of all the other concerns in which they were interested. All the Directors felt that Mr. Rawson (the Managing Director) had made great personal sacrifices to support the Company, sacrifices of a very unusual character; and, he might say, they reproached themselves for allowing him to do so. As to the reason why the arrangement was made for the repayment of his debt in debenture stock, witness's recollection was that at first it was supposed that his (Mr. Rawson's) interest in Woodhouse and Rawson (Limited) would be liquidated in cash; but as the guarantee fund was largely repaid to the Limited Company in debentures, it was thought only fair that Mr. Rawson should be permitted to repay his debt to the United Company in the same substance.

By Mr. Pilling: WITNESS never heard of or saw a balance-sheet of the Epstein Company which showed a loss of £5,000 for the first year of working. He was not aware, as a matter of recollection, that the founders' shares of the Phœnix Trust Company, which they had acquired for £25, were valued in the books at £15,000; but if the figures were in the books he would accept them. Witness could not say how many shares the United Company held in the Phœnix Trust, and did not know whether Mr.

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Pilling's suggestion of four was accurate or not. Mr. Pilling suggested that the original arrangement with regard to the loan made to Mr. Rawson was that he was handed a cheque with which to buy shares, and that when those shares were sold the proceeds should be handed to the Company. Witness would not altogether agree to the proposition; but the purchase was made in the interests of the Company, and not in Mr. Rawson's own interests. If the shares had been sold no doubt the money would have been repaid in cash. There were but two members of witness's family besides himself concerned in the administration—Mr. Stepney Rawson, the electrician of the Company, and Mr. Frederick Rawson, the managing Director. These had both been connected with the Limited Company, with which witness had nothing to do, and when the United Company took over the business of the Limited it took over his sons as well. Mr. Henry Rawson, who was a barrister, had attended meetings of the Board, partly because Mr. Pope found himself unable to attend regularly, and partly because witness himself needed assistance. For these attendances the fees paid to him were settled by Mr. Pope. Mr. Henry Rawson upon many occasions sacrificed his professional business in order to attend to the affairs of the Company.

By Mr. H. G. Rawson: When asked to join the Board of the United Company he looked into the documents connected with its formation, and satisfied himself that the prospectus was supported by those documents. Upon the last day that Sir Albert Cappell attended at Queen Victoria-street witness followed him into the corridor when he was leaving, and put to him the question as to whether there was in his mind any reason beyond insufficiency of the capital subscribed which would entitle him (witness) to refuse to become a Director if asked, and Sir Albert Cappell said, "No, the Company has an excellent business." The amount of capital which the Directors who retired thought should have been subscribed was reached the following week. Witness knew Sir John Coode well, and during a conversation subsequent to his retirement, Sir John said the Company had a very good business if well managed. Mr. North was specially engaged to take charge of the industrial business. He was sent to Kidsgrove to report on the works there, and his report was to the effect that the works, with a moderate expenditure in obtaining improved plant and buildings, would yield to the Company a profit of £6,000 or £8,000 a year. Witness's idea regarding those works was that they were in bad condition, but might be made most suitable for their purposes; therefore they paid a moderate sum for them. The explanation of the loss on the first year's working at Kidsgrove was that contracts had been accepted by the vendors which they were unable to carry out, and which the United Company were unable to carry out when they acquired the business. They had some difficulty in getting a suitable manager, but they had every confidence in Mr. Owen, the present manager, and anticipated successful working at Kidsgrove after his appointment. It certainly was not the fact that the Directors gave but little attention to the industrial business; on the contrary, they did their utmost to develop the industrial business. The document put in was a balance-sheet prepared by the Company's accountant at witness's request in 1891, and it showed a profit of £11,000 on the industrial business; this was the analysis of the accounts which witness sent to Lord Aberdare. The Directors did not desire to divulge the sources of their income to the public; but there was no attempt whatever to keep the information from the shareholders. The Board gave careful consideration to Mr. Pixley's suggestions, and had no reason to suppose that he was not ultimately satisfied with the course taken, or with the explanations offered on all the points he raised.

Mr. F. L. RAWSON, Managing Director of the Company, was next called; and, examined by the Official Receiver, said he was never a considerable holder of shares in the Limited Company. The Directors had always desired that the vendors (him-elf and Mr. Woodhouse) should not acquire a preponderating influence, and he did not think that their joint interest amounted to more than from £10,000 to £16,000. He could not say now whether he had any interest in shares in the Manufacturing Company which were in Mr. Woodhouse's name. He was the holder of 261 shares in the Supply Company, and 108 shares in the Contract Company, but he believed he held the latter for the Limited Company. The partnership between Mr. Woodhouse and himself started in 1881, and the Manufacturing and Supply Companies were formed about 1886 or 1887. At this latter period the partnership was certainly solvent. Mr. Woodhouse died about a month after the formation of Woodhouse and Rawson (Limited) in 1887. He knew Mr. Harper, who was an accountant in his employ, but was not the chief accountant of the firm. Mr. Harper's statements that the partnership and the subsidiary companies were insolvent, that there were large mortgages on the Cadby Hall works, that the mortgagees were pressing, and that the Manufacturing Company was started to a great extent to relieve the mortgage, were all absolutely untrue. These statements were made in the course of the examination of a man who had brought an action against him (witness), and without any cross-examination. As a matter of fact they never had the Cadby Hall property at that time, and there were no mortgages upon it. There was a sum of money lent to them by Mr. Philip Rawson when they started business. They borrowed money on the business, and on securities; and where money was so borrowed, it usually happened that the lender would from time to time ask for his money back. The best test as to their being in difficulties for money, he thought, was the interest they had to pay, and he did not think they had ever paid more than 6 per cent. in their lives. The private books of the partnership were kept by Mr. Ward, and not by Harper, and the latter, witness was perfectly certain, could not have seen them at that date. Witness could not produce any accounts relating to the partnership. He was quite sure the partnership was solvent, because Messrs. Spain, the accountants, went through the books specially, and their report was so thoroughly satisfactory that, upon the strength of it they were able to borrow £2,000 at 5 per cent. This was just before the formation of Woodhouse and Rawson (Limited), in 1887. The shares held by the partnership in the Manufacturing and Supply Companies were taken account of by Messrs. Spain and included, witness thought, at cost price. Just about that date they had lost a considerable amount of money through an action with the Edison-Swan Company, and it was the shortness of capital in consequence that led to the formation of the Limited Company. Witness could suggest no grounds for Harper's statements beyond the fact that he had brought an action against him and, he supposed, was not particularly well-disposed towards him. About 1884 or 1885, when the electric lighting companies were being brought out, they could have sold their business at a very large profit indeed; they had an offer made to them of many tens of thousands of pounds, and they refused it.

The OFFICIAL RECEIVER: Are you aware that a balance-sheet of the Manufacturing Company, got out by Mr. Champneys, for the year ended June 30, 1889, and that, taking the goodwill of the business as being worth £37,265, there was a deficiency of £44,000?—I am aware of it, because you have stated it. But that does not take in the value of the patents.

You are aware that at the time there was an accumulated debit on the profit and loss account of £34,936?—Mr. Champney's figures make it so. Of course, that did not include anything for the arrangement made with the British Company for the manufacture of the lamps, and did not include anything for the patents.

Woodhouse and Rawson (Limited) in 1889 were creditors for about £35,000?—Possibly.

And they held some 26,000 shares?—Yes. WITNESS did not think the figures showing a deficiency of £70,000 at the time when the United Company purchased the business were correct; but there was a large deficiency, and he had always stated that Woodhouse and Rawson (Limited) squeezed the Manufacturing Company, and that the proper price was not paid for that business.

The OFFICIAL RECEIVER read the special report of Messrs. Chandler and Pixley, the auditors, on the accounts of the Supply Company to September 30, 1887, in which it was stated that there was a loss on the whole business of £2,923, and asked witness if he thought that was a satisfactory report.

WITNESS: I think it is satisfactory because it shows how carefully Messrs. Chandler and Pixley went into the affairs of the Company.

The OFFICIAL RECEIVER: I am not asking you about that. Is that not a very unsatisfactory report?—It was rather better than we expected. The previous year we had made a good profit. Then we had our lamp business stopped, and I have no doubt that that large loss is caused by our having to write down a large amount of stock to a merely nominal value.

At this stage the proceedings were adjourned until Tuesday.

TUESDAY, JULY 24TH.

The OFFICIAL RECEIVER said he had not understood his Honour's remarks at the previous hearing with regard to the mention of well-known names to mean that he was not to go into the question of the promotion of the Company. He had reason to suppose, from the correspondence, that Baron Grant at all events was consulted with reference to the Company.

The REGISTRAR said he had not the slightest wish to check the Official Receiver in any way in regard to anything he thought it particularly necessary to bring out.

Mr. F. L. RAWSON was again sworn, and replying to the Official Receiver, stated that his explanation of the report of Messrs. Chandler and Pixley in 1888 as to the payment of a dividend by the Supply Company amounting to £501, notwithstanding that heavy losses had been sustained, was that an interim dividend was paid in consequence of their having made a special profit in connection with the Welsbach Company. The result of the operations of the Company was that there was a loss during the year in consequence of their being beaten in the Edison-Swan action. It turned out that they were unable to sell their lamps, and therefore they had to write down the value of the lamps, which brought out a loss instead of a profit. The position of the Company improved in the next year, for, although they were unable to do much with lamps, they worked up a business in other goods. He considered that the position of the Supply Company in 1889 was very good. The Woodhouse and Rawson partnership guaranteed the whole of the book debts to the Limited Company; it was not true that £17,000 was still unpaid under that guarantee. The minute of a meeting of the Liquidators of the Limited Company, held in July, 189', was incorrect when it stated that that amount was still due. The debt of the Manufacturing Company was not paid quite in full.

The OFFICIAL RECEIVER: May I take it that the debt was not discharged?—No; the debt was discharged, because more than the amount we guaranteed was paid by the Manufacturing Company to Woodhouse and Rawson (Limited), and it was later advances made by Woodhouse and Rawson (Limited) to the Manufacturing Company, after the date of the formation of the United, that were unpaid. I did not guarantee those. The Liquidators made absolutely certain that they got everything from the firm of Woodhouse and Rawson that they possibly could. They raised all the points they could.

Did you complain of the incorrectness of this minute?—Not at that date. I probably mentioned the matter at the following meeting.

What do you suggest the Limited received of the large amount due from the Manufacturing Company?—I suggest they received the whole of that, chiefly in shares; but partly in cash.

Mr. Hoster admits that the debt was not paid in full, and I thought you had admitted it.—I admitted that the money was due at that date, but part of that was liquidated after the formation of the United, chiefly by the fact that the United did not take over the Manufacturing Company's business for some considerable time.

You say that on the formation of the United Company the guarantee of the Woodhouse and Rawson partnership ceased?—So the solicitors stated. My recollection is that Mr. Hoster took one view, and the rest

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of the Directors took the same view as myself. Mr. Hoster insisted upon going to the solicitors to see if they could get anything more out of me, and the solicitors advised that they could not.

As regards the Contract and Maintenance Company, are you aware that the accounts made up to December 31, 1888, in which the goodwill is taken at £5,000 as an asset, showed a loss of £3,144 ?—I am not aware of the precise figures ; I should have estimated the loss at about £1,500 or £2,000.

In June, 1889, the loss appears in the accounts of the auditors, a copy of which has been furnished to me, as being £3,450 ?—That shows an improvement. That is a loss of about £300 in seven months. The loss steadily decreased until in the second year of the United it was turned into a profit. All businesses of that nature must commence with a loss.

The Company began in 1887. Up to June 30th of that year the loss was £1,977 ; in the half-year ending December 31st that is increased to £2,482 ; in the next six months it is increased to £3,024 ; then to £3,144 in the next six months ; and on June 30, 1889, it stood at £3,435. That is a steady loss right throughout ?—A steadily diminishing loss right throughout.

Is that not a steady loss throughout ?—No, it is not.

Is there a single half-year's account which does not show a loss ?—No. The reason of that is that all the expenses of developing go into profit and loss. We were entitled to put those sums to a special fund. The business was steadily improving all the time.

You take your goodwill throughout here as a credit asset of £5,000 ?—Yes. That goodwill was steadily improving all through that period.

Can you seriously suggest that a business steadily losing throughout can have a goodwill ?—Certainly. Anyone who knows anything about these matters knows that losses, when they are steadily diminishing, are likely to turn to profits afterwards. The goodwill was the goodwill of Woodhouse and Rawson for contract business in the North of England and in connection with the Crossley Telephone Company, which was one of the most successful companies of the time. The principal man in that company was Louis John Crossley, a well-known electrical engineer, who was also a Director of the London and North-Western Railway, and his goodwill in a business of that sort was very valuable in itself. We had a contract for lighting the offices of the London and North-Western Railway, for lighting trains, and so on, which we should not have got but for his connection.

As regards the formation of the United Company, who was your financial adviser ? Who assisted you throughout ?—Eventually Mr. Budd, of Messrs. Budd and Johnson, solicitors ; in the early days Baron Grant advised me.

Can you give me the date when Baron Grant advised you ?—In the beginning or middle of 1888. I heard Baron Grant was forming a Company for taking over the Hammersmith Electric Lighting Act and combining certain businesses with it, and I went to see if I could get the contract for the works. That was my first acquaintance with him. We had negotiations, which resulted in my getting the contract. At that time I was negotiating the combination of the Manufacturing Company with the other businesses, and after some little time Baron Grant asked whether we would combine with the businesses he had in hand.

Then did not Baron Grant's assistance continue right up to the formation of the Company ?—I cannot say. I do not think he had very much to do at the end when Sir John Coode and Sir Albert Cappell resigned. But I took his advice during that year, at one time very often. But before I went to Baron Grant I went to our solicitor's, a man I consider one of the ablest solicitors in the City, and to our bankers, and explained fully to them the circumstances, and asked if they saw any objection to my consulting Baron Grant on financial points. They said there was not the slightest objection, and that he was a very able man.

All throughout that you were acting in the interests of the vendor ?—Yes, at that time. Baron Grant, I may say, was just as particular as the new Directors with regard to being satisfied on all points.

I do not wish to make the least suggestion that Baron Grant was not the best adviser possible, or that he did not give you the best advice. All I wish to know is, who were your financial advisers ?—He was most particular, and wanted everything explained to him about points he might have heard of elsewhere. I gave him full information about everything he asked me.

I see you were consulting him in September, 1889, and you ask him, "Do you think it worth taking any notice of ?" Evidently something about the Limited ?—Yes ; what I consulted him about was articles appearing in the Press. Baron Grant's advice in every case, so far as I recollect, was to take absolutely no notice of the Press, not to write letters contradicting, or explaining any statement. No letter, therefore, was ever written to the papers by the Company except upon purely technical matters.

Who drafted the prospectus ?—I did.

The REGISTRAR asked if Mr. Rawson wished to state anything further about Baron Grant.

WITNESS : Originally, when the amalgamation was proposed between the companies he had in hand and the companies that I was going to amalgamate, he made terms for handing over the Hammersmith Electric Lighting Act My recollection is that he was to receive £15,000. As time went on the new Directors went very carefully into the businesses, and ultimately they would have nothing to do with the Hammersmith Electric Lighting Act nor with the businesses that he had proposed to amalgamate. Baron Grant then claimed from us, Woodhouse and Rawson (Limited), that he ought to have some compensation, because he had lost his chance of bringing out those companies in the way he was going to do. Prospectuses had been prepared, and he had several directors for the companies he proposed to bring out. Then what I arranged with him was this, that we should pay him a fee for simply consulting him, and the fee ultimately was paid. I remember he objected to the amount of the fee, and said he had been very badly treated by Woodhouse and Rawson (Limited), and I paid him something myself. The amount he received from the Limited was somewhere round about £5,000.

The REGISTRAR : Have you any objection to saying how much you paid him ? I do not press the question.—I gave him a certain percentage upon certain profits I was going to have. Ultimately he got nothing. The maximum he could have had was £5,000, or possibly £7,000. I may state that that is approximately about the fee which is usually paid for work of this description.

The OFFICIAL RECEIVER : Mr. Rawson is not a specialist.

WITNESS : I am a specialist. I was myself offered £5,000 to act in a consultative capacity for an industrial concern recently brought out.

The REGISTRAR : Then Baron Grant only got £5,000 and this promise ?—£5,000 and the promise, from which he got nothing.

He had no interest in Woodhouse and Rawson ?—No ; not in any of the Companies. Witness added that he was afraid he had given a wrong impression in mentioning Baron Grant's name in connection with the arrangement. The arrangement was made with the National Financial Corporation.

The OFFICIAL RECEIVER : The National Financial Corporation was practically Baron Grant, was it not ?—I did not know that until you told me about nine months ago. He was the working man in it.

As regards the Phœnix Trust, I think Baron Grant and the National Financial Corporation and yourself practically constituted the Company, except for any interest the United Company had in it ?—And some small shareholders.

They are very small shareholders. Were the arrangements with the Phœnix Trust entered into in any way in consideration of Baron Grant's services in connection with the formation of the Limited Company ?—No, certainly not.

Baron Grant did not undertake any risk ? He was merely a friendly adviser ?—No risk at all.

So that any sums he did receive were simply in consideration of his friendly advice ?—Not friendly advice. Advising in that way was his business.

Now, as regards the prospectus of the United, did you consult him as regards that ?—Yes.

As regards this paragraph as to the profits of the Limited for the year ending June 30, 1888, stating that they were, as shown by the audited balance-sheet, £21,440, did you first desire that Mr. Pixley should allow his name to appear as certifying the accounts ?—Yes, we wanted him to give a certificate, but he objected.

On what grounds ?—On the ground that it was not his place to value the shares that were held by Woodhouse and Rawson (Limited). That lay with the Directors, and, therefore, he could not give a certificate with regard to the £75,000 for the following year ; his objection was that it was an estimate, and he could have nothing to with an estimate.

Mr. Pixley's view was that no one would be in a position to judge of the value of the certificate without reading the report ?—Unquestionably he says that. I do not think he really considered his answer. My reason for saying that is that I discussed that matter with him. I asked him if that was a fair statement to put in the prospectus, and he said it was, and signed the prospectus.

The REGISTRAR : What do you mean by signing the prospectus ?—I took over the draft of the prospectus the Directors were considering, and got him to put his own signature to it. I then took it back to the Directors. They also went into the question of whether it was a proper thing to put in.

Which of them ?—All of them on the Board at that time. It is very difficult to say who they were now.

Did Lord Aberdare consider that ?—It is difficult to say. I am certain that Mr. Whateley considered that most carefully.

Did Mr. Whateley have this report of 1889 on the £21,440 profits before him ?—Mr. Whateley was very very careful about all the details. I am not certain one way or the other about Lord Aberdare. I am certain about Sir John Coode, Sir Albert Cappell, and Colonel Howard Vincent.

Do you say they studied this report of Mr. Pixley ?—Over and over again. They not only did it, but they cross-examined Mr. Pixley himself upon it. They also had Sir John Stokes, and I think Mr. Hoster, before them, and went fully into those reports. I cannot say as to Mr. Philip Rawson.

You know the paragraph at the end of this report ?—"The accounts are in accordance with the books of the Company, but it is obviously impossible for us to be responsible for the net profits, having regard to the nature of the assets and the Company's interest in many trading concerns not yet fully developed and without Stock Exchange quotations of their shares."—It was absolutely impossible for anyone to be responsible.

Quite so ; but was not that a material paragraph to be brought before anyone investing in the United Company ?—No. Auditors are commonly in the habit of giving their certificate qualifying it with a report as Mr. Pixley did. Mr. Pixley has the reputation of being one of the most particular auditors there are, and he always qualifies his certificate if he can.

My recollection of his evidence is that it was a very unusual course for him to adopt ?—It is an unusual course, and it might ruin a company with a business of this nature.

Then as regards the statements in the prospectus as to the various businesses taken over. Except the paragraph saying that owing to the reputation acquired by the Company and its experienced electrical staff, they were often consulted by patentees as to the best means of turning their inventions to account, can you point to any information to the investor that the Company was to go into a considerable promotion business ?—Not a considerable promotion business, but it says the business was not confined to any particular branch, but was especially engaged in many directions unknown to the public. The endeavour was to show that we were

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going in for the business of dealing in patents, and patentees reading that would know what it meant.

The REGISTRAR: That is not the point, what a patentee would understand. An uninstructed person would assume that the Company had a large business in giving advice, and not in promotion.—That was not my view after constructing it.

Mr. JENKINS: It goes on to say: "And from this source considerable profit has been derived." Considerable profit could not be derived from advising.

The REGISTRAR was of opinion that members of the Bar derived profits from their practice of giving advice.

Mr. JENKINS dissented from the suggestion that "considerable profits" were so derived.

WITNESS: What I meant was the financial business of buying patents and selling them to companies brought out. Anyone knowing anything about patents knows that you have to form a company to work a patent. You cannot get them taken up by existing firms.

The OFFICIAL RECEIVER: I asked if there was any other paragraph you could point to beside that.—I do not suppose there is. But as showing the probable effect upon the public mind I may say that it was commented upon in the Press at the time that we were going in for this business. The papers said it was abundantly clear the Company was going to do that class of business, and they thought it was a mistake.

You contemplated this business?—Yes, because we had these patents that we expected to sell for a large sum.

There is a paragraph here saying that valuations had been made by competent experts, and the amount placed on these patents had been the guide in fixing the purchase money?—That is the case.

You have read Mr. Edmunds's valuations, addressed to the Directors of the Electrical Union. Can you tell me what you understood to be the figure at which Mr. Edmunds has valued these patents?—He valued the patents held by the Manufacturing Company at £37,265; the lamp patents at £60,000; and the other patents, including the interest in the foreign Elmore patents, the Elmore zinc patents, and a number of others, at £125,000; altogether, just over £220,000. The way we got down to £159,000 in the Directors' statement was this: In between the date of his valuation, April 12th, and the date when the United Company came out, the end of July, the interest in the foreign Elmore patents had been sold to the foreign Elmore Company. The Directors took the amount it had been sold for, and deducted it from the total valuation, and so brought out £159,000 as the value of what remained.

Did the Directors consult Mr. Edmunds at all about the value he put on the Elmore patents?—No; he was in America, or he would have been consulted.

You see by his examination that Mr. Edmunds says his idea was that he had valued the patents at something like £159,000?—Yes. Evidently he had forgotten the circumstances.

It is impossible to gather from the valuation what the value placed by Mr. Edmunds really was?—WITNESS: I had to get him to explain it to me.

I asked Mr. Edmunds what was the amount, and he had great difficulty in finding it out, and finally he acquiesced in the figure £159,000.—WITNESS: Mr. Edmunds was very very ill for months after that. He could not explain it to me when I saw him just before his examination. He had not the slightest recollection. When the valuation was made, and I first read it through, I told him I did not think he had got it clear. Then he explained it and I saw it, but I wanted him to put it clearer, and he refused, saying it was quite clear enough.

As regards the valuation of these patents, the information was supplied by you to him, was it not?—Yes, as is usual.

You employed Mr. Edmunds as representing the Limited Company?—No, I did not. I made it absolutely clear that his valuation was for the new company.

In his examination Mr. Edmunds says, "Possibly if I had been employed by the purchasers I might not have had that information from Mr. Rawson." From that I do not understand that Mr. Edmunds was clear that he was employed by anybody except the Vendors?—I think Mr. Edmunds could not recollect, and gave you a fencing answer. He could not say one way or the other. I told him distinctly it was made for the Directors, and it was addressed to them. He wanted 10 guineas if the valuation was used on the prospectus, and 50 guineas if only for the new Directors. The Limited paid him, but he was distinctly informed that the valuation was for the new Directors.

You told me early in your examination that when you consulted Baron Grant you were acting for the Limited Company. Did you depart, when you came to Mr. Edmunds, from that position?—No. I gave him the instructions as for the Directors of the United Company.

But there were no Directors in April, 1889?—Oh, yes. There were Directors in 1888—*in posse*. I cannot recollect who they were; but I sent a draft prospectus in October, 1888, to Mr. Baker, who was to have been a Director.

Seriously, do you suggest that the Directors of the United Company had anything to do with the valuation of Mr. Edmunds?—Oh, yes. There is not the slightest doubt about that at all.

But the Company was not formed until July, 1889?—There were Directors—proposed Directors—certainly in October, 1888, Directors who were looking into and investigating the affairs of the Company.

The REGISTRAR: Who were they?—I do not recollect. There were several people selling us businesses who all wanted to have a Director on the Board, and these went into the affairs of the Company. I do not want to mention names, because people do not like to have their names mentioned as having been proposed Directors of a Company when they did not actually become Directors.

The OFFICIAL RECEIVER: But I want to know. You must have had something in your mind.—WITNESS: What was in my mind was that I would have got out of that valuation if I could have avoided it, partly on account of my dread that the valuation might come out badly.

But you could not have floated your Company without a valuation?—Oh, yes; you do not usually value the patents in such a case.

I put it to you that you employed Mr. Edmunds to value the patents?—And I tell you that I certainly did not. I took every care, and made it clear that the valuation was on behalf of the new Directors.

The REGISTRAR: Did he not take your valuation and knock something off?—No. What happened was this. His headquarters were at Manchester, and he asked me if I would have the actual writing done. The heads of the report were made out in my office, and he took them away, and I recollect quite well that he came back and put in the amounts. I was quite surprised by some of those figures. It was not in my mind a satisfactory valuation. I wanted the valuation as soon as possible, and made my case as strong as possible, but he wanted documents to confirm my statements. If I had had any idea of this I would have refreshed Mr. Edmunds' memory when I saw him.

The OFFICIAL RECEIVER: As to the question of your interest in the Phœnix Trust I see there is a minute of September 3, 1890, stating that "the Managing Director again explained the circumstances in connection with the formation of the Phœnix Trust Company, and his joining the Board as a Director, and stated that he was going to make a report in writing to the Board, so that they might have a record in writing of the same." Will you tell me at which Board meeting this report was brought up?—At one of the meetings in September, 1890. I believe there is no record of the report in any of the minutes.

Mr. Philip Rawson said in his examination that he first learnt of your connection with the Phœnix Trust in January, 1892, and that he never saw the report, and did not recollect it. Can you point to any one of the Directors who were aware in September, 1890, of your connection with the Phœnix Trust?—Sir Rawson Rawson and Mr. Philip Rawson unquestionably were. In November, 1891, I stated to the Board that if they thought there was any objection to my having those shares in the Phœnix Company I would not only give them up, but also all the dividends I had received during the year. The Directors thought I was rather more entitled to them than before because they saw the amount of work that had fallen to me in forming the Phœnix Company.

On September 27, 1890, you wrote to Baron Grant that you had let your Directors know from time to time of the nature of your connection with the Phœnix Trust, and had made to them a report in writing, and had it entered in the minutes.—That proves exactly what I say.

But you say you sent in a written report and had it entered in the minutes.—There may have been a misunderstanding as to that, but there is reference to the Directors asking me to make a report in writing.

With the exception of Sir Rawson Rawson, can you point to any Director who has in his evidence admitted that he knew of your connection with the Phœnix Trust on or about that date of September, 1890?—No. Mr. Pope may not have known at that date, as he was often away from the meetings for some time.

Mr. H. G. RAWSON: If I had seen the relevancy of it I would have asked the question. At the present moment I am utterly in the dark as to its meaning.

The OFFICIAL RECEIVER: One of the Directors is making a profit unknown to the other Directors.

Mr. H. G. RAWSON and Mr. JENKINS both said this was the first suggestion of any such thing.

WITNESS said Baron Grant advised him to make the offer of which he had spoken to the Board.

After the luncheon interval,

Mr. H. G. RAWSON said he had had an opportunity of asking Sir Rawson Rawson what his recollection was as to the date when he first became aware of the Managing Director's connection with the Phœnix Trust Company. He (Mr. Rawson) would have asked him specifically if he had known the question was going to be raised. The question put by the Official Receiver was, "When did you know of the connection of Baron Grant with the Phœnix Trust Company," and as he considered the question irrelevant he did not give any attention to it. The other question, on the contrary, was excessively material; and, if his honour wished, Sir Rawson Rawson was prepared to go into the box and answer the question.

Sir RAWSON RAWSON was then sworn, and asked by Mr. H. G. RAWSON: When were you first aware of the connection of the Managing Director with the Phœnix Company and of his pecuniary interest in that Company?—Witness: Before it was actually formed, to the best of my recollection.

Can you speak as to the knowledge of the Board generally?—My recollection is that the Managing Director reported to the Board sometime in 1890 the difficulty he had in disposing of the Elmore shares in London. We were very anxious to realise the Elmore shares, and he reported to me the formation of this Company. I cannot say whether he reported to the Board before the Company was formed, but he certainly reported to me before that because he brought the Chairman of the Board to me. That was not Baron Grant. I cannot say who the Directors were who were present when the matter was discussed. My recollection is that the Managing Director explained everything fully, and that it was known what the consideration was he was to receive. There ought to have been a record of the report in the books, and he could not explain why there was not

The OFFICIAL RECEIVER: Was it explained to the Board that the Phœnix Trust Company was practically composed of Baron Grant and Mr. Rawson?—No; that was not so. To the best of my belief Baron Grant was not a Director at all. He may have been interested in it. I think I mentioned before that I think the attention of the Board was first called to his connection with the Company by a letter coming from the Phœnix Company, signed by Grant. I was surprised at it, and called the attention of the Managing Director to it.

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Were you aware that out of the 4,078 shares issued 1,000 were held by Mr. F. L. Rawson, 1,000 by Mrs. F. L. Rawson, 1,000 by the National Financial Corporation, and 1,000 by Baron Albert Grant?—I know nothing about that.

Then how could your Managing Director have explained the circumstances in connection with the formation of the Phœnix Company? Was not that very material?—No, I think not. The Company was formed to help Woodhouse and Rawson United to dispose of the Elmore shares.

You stated in your examination on the last occasion that you were not aware that Baron Grant had *assisted* in any way in the formation of the Company?—I did state that. I have learnt it to-day for the first time.

Was it explained to the Board at the meeting in September, 1890, that out of 100 Founders' shares in the Phœnix Trust Mr. F. L. Rawson held 25 or 50? I do not know whether it was defined at all; but we knew that we took a large interest in that Company for the purpose of bringing it out in order to assist Woodhouse and Rawson United.

Was it explained what the amount of capital was that was actually paid up?—No.

Was that material or not?—I cannot say.

You went into considerable negotiations, did you not, with the Phœnix Company? They bought a large portion of your shares and entered into very heavy contracts. Was it not material to know whether this Company really had any substance or not?—We were satisfied as to its being substantially able to do what it proposed.

How were you satisfied?—I cannot say what steps we took, but we were satisfied.

Supposing the shares had not floated—we know they were successfully floated by the Phœnix Trust, but supposing they were not—you would have had to fall back upon the Phœnix Trust. Now, I ask you, what had you to rely upon that the Phœnix Trust could pay the £75,000 for those shares?—My recollection may fail me, but as far as it serves me the value of those Elmore shares was assured when we made the arrangement with the Phœnix.

By Mr. H. G. Rawson: It was within his (witness's) knowledge that the Managing Director gave up half of his holding to the United Company. He had no doubt that when the matter was discussed the other members of the Board knew what the nature of the interest was which Mr. Rawson had in the Phœnix.

By Mr. F. L. Rawson: Before the formation of the Phœnix Trust offers were made by other trust companies to make practically the same arrangement as that entered into with the Phœnix. Witness could not say whether the Directors considered the nature of the constitution of the Phœnix Company and its capital, nor did he know that one of the trust companies alluded to offered Mr. Rawson the same proportion of Founders' shares as he afterwards received from the Phœnix.

By the Registrar: The Managing Director offered voluntarily to give up the shares. He said he had entered into the thing in the interests of the Company, and wished to share any profit which accrued.

The REGISTRAR: If he acted in your interest, why did he not give up all the shares?—He had individually acquired those shares, and therefore he was not bound to give them to us.

Then why did he make this present at all?—I am afraid your Honour must ask him.

The OFFICIAL RECEIVER: Can you say when the United Company took those Founders' shares?—I cannot say exactly, but about the time when the Managing Director informed us of the formation of the Phœnix Company and the objects of it.

The OFFICIAL RECEIVER: Long before the Elmore shares were purchased.

The REGISTRAR: That is so.

Mr. F. L. RAWSON returned to the witness box, and his examination was resumed by the OFFICIAL RECEIVER, who said: I want to draw your attention to a letter you wrote to Mr. Stutchbury in September, 1892, saying you would be glad to know whether he, whilst he was secretary or afterwards had known you take advantage of your position to do anything which was not in the interests of the shareholders, or that might not be considered right and proper for you to do. Mr. Stutchbury, in reply, questioned whether the Board fully understood from the commencement the nature of your connection with the Phœnix Trust Company, and that as a Director of the Phœnix Trust Company you were interested in the profits of that Company, and received from it a similar amount in dividend to the United Company itself, the profit of the Phœnix Company being principally derived from its connection with the United. Did you reply to that letter?—I do not think I did. I read it partly through to the Board, and they said: "Oh! we know all about that; we don't want to hear anything more."

Can you point to any minute?—It would not be entered in the minutes.

Did you tell Mr. Stutchbury that this letter was read, or partly read?—That I cannot say.

The OFFICIAL RECEIVER asked that Mr. Stutchbury might go into the box again.

Mr. STUTCHBURY was recalled, and said that he was present at the Board meetings at the time referred to. He did not think the letter was read, but he believed the Managing Director had it in his hand and referred to it. He would not like to swear that the matter of the Phœnix Trust was referred to; at many of the meetings he might be present for only 10 minutes, or a quarter of an hour. The reference in the letter to the telephone connection with Baron Grant's offices was mentioned. He did not think the Managing Director read the letter word for word, but summarised it.

Mr. F. L. RAWSON resumed: Mr. Philip Rawson and himself were constituted a committee with regard to the Okonite Company. He received authority, after a full discussion at the Board, to apply on behalf of the United for shares in the Okonite Company. He did not know whether it was mentioned in the minutes or not. The committee was appointed to sign all the cheques, the application forms, and everything else in connection with the Okonite matter. Mr. Philip Rawson might be unaware now that such a committee was formed, but it would be found that he signed the cheques. There ought to have been a minute on the subject, and it was a mistake if there was not. When the Okonite Company came out they applied for £15,000 worth of shares and debentures. They were obtained and sold, and it was afterwards considered that there ought to be a further purchase. In August it was settled what amount they would take up, and then the applications were made in the names of nominees in order that it should not be known outside that they were selling these shares and debentures. All the Directors were aware of this, except, perhaps, Mr. Pope, who, as a Director of the Okonite Company, would not vote or have anything to say about Okonite matters at the United Board except to give them information about the Company.

At this time you commenced buying yourself?—I lent money to the Company to do it.

At the time you were a considerable debtor to the Company, were you not? They had advanced you £28,000.—My recollection is that I had about £10,000 then.

Can you say how it was this money was repaid to you that you had advanced, as you call it, when you were already a debtor?—It was repaid according to the arrangement made.

The REGISTRAR said it was possible that a man might not be able to pay his debt, but to oblige his creditor might, by a special effort, raise a sum of money temporarily.

The OFFICIAL RECEIVER: It is rather unusual that a Director should be a considerable debtor to a Company, and I want to bring out this point, when the Directors were repaying these moneys to Mr. Rawson was it brought before them that at that time he was a debtor to them?—WITNESS: It is only fair to say that when I paid that £6,000 for the Okonite shares I said I might leave some of it with the Company, and there is a minute to the effect that I paid £600 as a part of my indebtedness, but there is no record in the books of that having been paid. Afterwards it was all paid back. I remember I said I could not afford to pay it.

Examination resumed: The circular as to the value of the Elmore shares was drafted by witness and considerably altered by Lord Aberdare. It was issued with the authority of the Board, and they had a good many letters and calls from shareholders thanking them for calling their attention to them. That might more properly have been the business of the Phœnix Trust Company. With regard to the circular announcing the retirement of Sir Albert Cappel, Sir John Coode, and Colonel Howard Vincent, there was a minute that the cause of their secession should be stated in the circular, and the fact that subscribers might claim to be repaid in full. Witness drafted that circular, and it was revised by the Directors. Witness offered to show the circular to the retiring Directors, but they refused to see it or to have anything to do with it. He was responsible for the clause as to subscribers having the right to withdraw being left out, but the circular was considerably modified after it was drafted. A copy was sent to all the Directors before it was sent out, and witness took it to the solicitors, Messrs. Budd and Johnson. Mr. Budd, who had been advising them, was away in Paris, and as there was great pressure of time witness consulted Mr. Johnson about it. He certainly acquainted Mr. Johnson with the fact of the minute requiring the statement that subscribers might withdraw. His reason for leaving it out was that he assumed all the subscribers, who were a particularly high class of applicants, would be perfectly aware of their right to withdraw. He felt certain at the time that he had done everything in regard to the matter that he ought to have done; but he felt now that he ought to have waited until a copy of the circular had been sent to Mr. Budd and approved by him. With regard to the notification to the bankers, the minute which said that was ordered to be sent was added at the succeeding meeting, when Col. Howard Vincent complained that the minutes had not been properly kept; but witness was certain that the original minutes were correct, and that no such resolution was passed.

You contested very strongly the decision not to go to allotment?—I wrote a letter to Sir Albert Cappel, thanking him for trying to induce Sir John Coode to consent to go to allotment.

Do you suggest that Sir Albert Cappel wanted to go to allotment?—Yes, and he tried to induce Sir John Coode, but Col. Howard Vincent said he did not see, in the face of the position taken by Sir John Coode, how we could do otherwise than agree with him. The difficulty with Sir Albert Cappel came when the writs were served.

The Official Receiver referred to Mr. Pixley's proposed certificate on the balance-sheet of 1891, in which he said that the figures did not disclose certain facts, that the gross profit consisted almost entirely of profits made on financial operations, and concluded by expressing the opinion that no dividends should be paid in money until the investments had been converted into cash. Was there anything incorrect in that statement?—WITNESS: As to the gross profit being made on financial operations, the Epstein profit was certainly not a profit made on financial operations, but on industrial; it was the working out of the Epstein patents. It was not a financial operation in any sense except that the patents were sold to a company, and the shares were put in at par. It was the result of hard work for something like two years by my brother and myself and Mr. Epstein. The last paragraph is a matter of opinion.

But Mr. Pixley never departed from that opinion, did he, as regards the inadvisability of paying a dividend?—Yes. He admitted it might be right to pay a 5 per cent. dividend; it was the payment of a 15 per cent. dividend that he objected to

Then you dispute his evidence?—There is no question about that. He admitted that to me.

He said he never advised the Directors to pay a dividend?—That is quite correct; but he admitted that there was no objection to a 5 per cent. dividend.

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He says he advised them not to pay a dividend?—He never advised them not to pay a dividend of 5 per cent. That report was before he had gone into the matter and knew the values. Mr. Pixley said to me, "My advice to you is, as it always is, never to pay a dividend if you can possibly avoid it." He has exaggerated notions as to that. He said we should be merely putting responsibility upon ourselves, and it would be better to have the money in our pockets. That was not the view the Directors took.

There is a letter of October 15, 1891, from Mr. North to you, in which he says, "I have perused the proof balance-sheet which you handed me, and I have no hesitation in saying that it is, as now constructed, fradulent. I am sure no Director who values his character would pass it. When you consulted me about the balance-sheet for 1889-90 there were several things to which I took exception, but the present balance-sheet goes much further, and I trust a dividend will not be declared on such figures." Did you receive that letter?—Yes. That was at the time when I found out the practices of Mr. North, and he thought he would blackmail me and keep my mouth shut by writing that letter. He withdrew that letter, and said he had written it in ignorance of facts I gave him with regard to the care the Directors had taken in relation to these matters. Witness considered that a subsequent letter, which was read, and which went into details of the accounts, was a trimming letter. The impression on his mind was that Mr. North withdrew entirely when witness referred him to the Board. When he said witness was not to be blackmailed, he said, "Oh, well, I understand the Board have gone into these things. I never knew that." Then he withdrew his letter. Witness did not know that he showed either of the letters to the Board. At that time he had only discovered that petty cash had been taken; he was trying to find if there was anything further against North, and did not wish to go to the Board about the matter until he was sure of his ground, as he had already been called to account for complaining of Mr. North without being able to prove his case.

Witness was next taken through the investments, and questioned as to the values put upon them. He remembered a letter to him from the Secretary or Manager of the Okonite Company in October, 1891, saying that Company would pay no dividend that year, and requesting him not to make any reference to that Company at the meeting of the United Company's shareholders. He probably brought that letter before the Board, but in any case they were well aware that no dividend would be paid, owing to special circumstances. The Okonite shares were taken in the accounts at the Stock Exchange quotation of their value. Messrs. Budd and Johnson wrote, and quoted counsel's opinion, that an independent valuation of the Epstein shares should be taken, and the matter was discussed by the Board, who came to the conclusion that it was not worth while incurring the additional expense. There would have been a profit apart from the Epstein shares, for there was actually £4,000 paid on account of those patents, and there was his time and that of Mr. Stepney Rawson and the experts to be added.

At this point the examination was adjourned until to-day (Friday).

Cassel Gold Extracting Company v. Cyanide Gold Recovery Company and Others.

In the High Court of Justice on Monday last, Mr. Justice Romer commenced the trial of an action in which the plaintiffs claim that they are the registered owners of certain letters patent, numbered 14,174, of 1887, granted to John Stewart MacArthur, W. Forrest, and William Forrest for improvements in obtaining gold and silver ores and other compounds, and they allege that the defendants have infringed their letters patent. The defence was a denial of infringement and an allegation that the plaintiffs' letters patent were not valid, was different from that for which the patent was applied for, and was not new at the date of the patent, having been published in a number of publications, which the defendants relied upon as anticipations.

Sir R. WEBSTER, Q.C., M.P., for the plaintiffs, said that between 600,000 oz. and 700,000 oz. of gold had been successfully extracted by the plaintiffs' process, having a value of £2,500,000, and royalties had been paid to the extent of £117,000 in connection with the process. There had been a variety of methods of extracting gold, chemical, mechanical and electrical; but prior to this patent there was no method of extracting the residuum of gold from the tailings or washings of gold ore. The defendents invited persons to have their ores tested by the Pielsticker process, Pielsticker being the person who was alleged to have invented the infringing process. The defendants had permitted his clients to inspect what was being done at the laboratory of Mr. Harland, F.I.C., at Plough-court, Lombard-street, E.C. The suggestion was that they were not working to obtain gold by the dissolving action of the cyanide of potassium, but by electrical action, which had the effect of extracting the gold from the ore electrically, and not by the process Messrs. Forrest and MacArthur had described. The plaintiffs' case would be that electricity did not add anything to the dissolving power of the cyanide of potassium; and that the gold which was extracted was in the defendents' process got out by the dissolving action of the dilute solution in exactly the same way as in the plaintiffs' patent.

Professor James Dewar describel in technical language the operation of the plaintiffs' and defendants' patents as he understood them, and the use that had been made of cyanide of potassium as a means of extracting gold. He had seen the Pielsticker process, and it was his opinion that the separation of the gold from its ore was there brought about by the solution of cyanide of potassium. Heat was used in many of the previous methods. The ore in Rae's specification, dated 1867, was placed in cyanide of potassium solution and treated electrically. There was nothing in common between Rae's method and that of the defendants. Pressed as to this, witness admitted that in each case the ore was placed in a solution of potassium, and in each case the electric current passed through the ore and through the solution. Rae's and the defendants' methods were in principle the same thing.

Sir EDWARD CLARKE, Q.C., M.P., for the defendants, suggested a method of arranging the current so as to make Rae's patent work, but WITNESS declined to go into the causes which made Rae's patent fail, and added that it was not common knowledge to him that cyanide of potassium was effective for dissolving gold from its ore. Simpson's claim was for the process of separating metals from their ores, to wit, subjecting the ore to the action of a solution of cyanide of potassium, carbonate of ammonia, and chloride of sodium, and subsequently precipitating the dissolved metals. When this specification was produced he would have attributed importance to the presence of carbonate of soda and the chloride of sodium, but would not do so in his present state of knowledge.

Prof. DEWAR re-examined: The heat used in other methods was to produce the solution which was to be used. In Rae's patent there were two electrodes, and the electrodes in the first tank had nothing to do with the solution of the gold by the cyanide of potassium. There was no indication in Rae that you could get at the solution without electricity. The claims in Rae would not guide anybody to the patents owned by the plaintiffs. As far as he knew, Rae's patent was never used; certainly never used in England. Neither was the Sanders process, nor Simpson's.

Sir RICHARD WEBSTER said that no user was set up of any one of these anticipations, and that would be of importance.

Prof. ROBERTS-AUSTEN, F.R.S., Chemist of the Royal Mint, said he was well acquainted with the various processes for the production of gold from its ores. In 1887 he had never heard of the production of gold from its ores by means of cyanide of potassium. Before 1887 the great bulk of gold was extracted by the amalgamation process, by which almost any ore might be treated.

Mr. Justice ROMER: In Rae's process, as he describes it, has the electric current any influence in the solution?—Yes.

How does the electricity act differently in Rae's from the defendants' in promoting the solution?—In the case of Rae's the particles of gold are brought in contact with the anode, while in the defendants' they are suspended. The electricity in the defendants' process has no effect in promoting solution. He knew that there was such a work as "Chemistry Applied to Arts." In that book it was stated that Faraday found that ordinary gold leaf might be reduced in thickness without destroying it by means of a solution of cyanide of potassium, and that "cyanide of potassium is employed in the reduction of rarer metals from their ores," and from Faraday onwards all the books have referred to the solubility of gold in cyanide of potassium. The solution acted on the surface of the gold, and would necessarily act in the case of gold finely divided. The system of obtaining the ore from the solution was known at the date of plaintiff's patent, as was the fact that cyanide of potassium was a solvent of gold was known. The real question was the question of cost. At the date of the plaintiffs' patent there were undoubtedly difficulties in getting the gold out of solution, and, in answer to the learned Judge, the WITNESS admitted that Rae's patent got a solution for gold, and that Rae would have completed the problem if he had found a proper method of extracting that gold from the solution. Rae, however, thought that electricity would answer. The attenuated gold spoken of by Faraday was less than $\frac{1}{3000}$th of an inch. He had never heard of Rae's process being practically worked; but it would effect the solution of gold. Rae's method did not disclose any more than was known in electro-plating.

Lord KELVIN said that he had examined the Pielsticker process. In the plan shown to him the anodes and cathodes were at a certain point, and these had an electromotive force of less than two volts. The electricity thus produced would retard the action of solution. He had not experimented on this particular bath, but would expect to find the deposit on the cathode. Shown a trough on which he had experimented, he explained that he made the experiment to ascertain the effect of electricity in precipitating. A retarding effect was the result of the experiment. He also explained another experiment with an electric wire. Taken to the plaintiffs' plan, he explained that with the cyanide of potassium used with the anode and cathode, the anode having the gold, the gold would, by the solution, be deposited on the cathode. By Rae's process the electricity retarded the action. As to the effect of the solution according to strength, he corroborated the evidence of Profs. Dewar and Roberts-Austen as to the greater effect of the weaker solution. In Faraday's disclosures with regard to gold leaf, the relation of area to mass was of great importance. Faraday's specification would not lead anybody to the practical process of dissolving gold out of ore by that solution. The gold he used in the electric bath was smelted, but not annealed. The liquid could pass from one tank to the other. He did not test whether in its passage it had deteriorated. If it had, he felt sure that the deterioration would have remained on one side. Polarisation would protect the metal from the current going through it. Agitation of the liquid in the experiment he made would not have altered that result. The gold was not in the same state as it would be in the ore. In the experiment the gold was not so small as it would be in the crushed ore. The effect of the electricity would not be to dissolve the gold. Looking at Rae's patent, there was a cathode on which there should be a deposit. Rae might think he got the deposit through the current. In Pielsticker there was an electrical deposition, and the leaf of gold was suspended between the two terminals in the jar. A considerable portion of the current would pass through the gold. If the gold was in the ore, a much smaller portion of electricity would pass through. Assuming the gold leaf to be dissolved by the current, that would be in the solution; if time enough were given it would ultimately be on the cathode.

Mr. E. J. MILLS, F.R.S., Professor of Technical Chemistry in the Glasgow and West of Scotland Technical College, said that the specifications alleged to be anticipations did not disclose the use of cyanide of

potassium for the extraction of gold from its ore. He admitted that Rae's process was efficient for dissolving the gold in the ore.

Mr. Justice ROMER said that the sole question was whether the electricity going through the defendants' apparatus did have the effect of assisting solution, and asked witness why he did not try that.

WITNESS said that their experiments were conducted in a simple and trustworthy form, and there was nothing in the apparatus used which would vitiate the results.

Mr. R. TATLOCK, F.R.S., F.I.C., Public Analyst for Glasgow, said he was the author of an article on "Cyanide of Potassium," relied on in the particulars of objection, which said that "nearly all the cyanide of potassium made is used in electro-gilding, &c. It is also applied in the reduction of some of the rarer metals from their ores." That referred to the dry process, and not in any way to the wet process. The witness then corroborated previous witnesses as to the results of the experiments.

Dr. GEORGE GORE, F.R.S., said he never knew gold dissolved directly in cyanide of potassium for the purpose of forming a solution. Electricity was used in connection with electro-plating. Rae's and the defendants' processes were alike successful in dissolving the gold in the ore.

Sir HENRY ROSCOE said that the plaintiffs' process had rendered the economical extraction of gold from tailings possible. In the alleged anticipating specifications there was no case in which the cyanide of potassium alone was used for the purposes of extraction. Cyanide of potassium had long been used in conjunction with electricity in dissolving gold for electrolytic purposes. In his opinion, Rae's specification did not point to the fact that Rae knew that gold was soluble in cyanide of potassium without the aid of electricity.

In answer to his Lordship, WITNESS said that Rae might have thought that electricity was a facilitating agent. In his opinion, in the patent of Rae the use of electricity was an essential part of the process.

Mr. LOUIS JANIN said he knew at the date of Rae's patent that the solution of cyanide of potassium was effective for the purpose of getting gold in solution; but it was a special knowledge. The solvency of gold was generally known years before, but not of gold in ore. In 1840 Elkington used cyanide of potassium.

Professor CROOKES said the discovery of MacArthur and Forrest was that what was known to scientific men (namely, that a solution of cyanide of potassium would melt gold) was enlarged to apply to gold-bearing ores practically. The merit of the plaintiffs' invention was the applicatian of a scientific fact to practical use, showing that what was known in the laboratory, and had only been done on a small scale, could be applied on a large scale, and practically, to gold-bearing ores.

Mr. JOHN STEWART MACARTHUR, F.I.C., one of the patentees said that in 1886 he began the chain of experiments which led up to this patent. Before he experimented he had no knowledge that the cyanide of potassium could be practically used to extract gold from ore. Persons would not, he believed, have been led to that by the alleged anticipations. He understood Rae's process to be a simultaneous dissolving and depositing process. It was within his knowledge that Rae's patent was unworkable, and, in his opinion, nobody would have been led to the dissolving of gold by cyanide of potassium by Rae without the use of electricity. He had experimented to see whether the electric current had any effect in dissolving the gold in the ore, and found no beneficial effect. His results showed that the dissolution of the gold out of the ore was not assisted by the electricity. The conclusion that the electricity had no effect was arrived at from the fact that there was as much gold left when electricity was not used as when it was.

In answer to Sir Richard Webster, WITNESS said that 36,000oz. of gold per month was being obtained by his process, which otherwise would have been lost.

By His LORDSHIP: The electricity was not renewed in the experiments.

Sir EDWARD CLARKE: But in the defendants' process the solution is regenerated?

WITNESS said that was the statement of the defendants, but he had reason to doubt it. When the electricity was removed from the defendants' process it became the MacArthur process. He had no special knowledge that his patent would not deal successfully with American ores.

WITNESS was being taken to his subsequent American patents when Sir Richard Webster objected.

Mr. JUSTICE ROMER thought it might help the defendants by showing the reason why Rae's process was not worked.

Sir EDWARD CLARKE said it would help them by showing that the plaintiffs' patent was not applicable to all forms of ore, though it happened to be applicable to the particular ore of Africa. Rae's method would dissolve the gold from the ore, but he thought it would not be possible to precipitate the gold from solution in Rae's process. One of the weak points in Rae's process was the precipitation. Experiments could be made again if necessary. The process of using zinc for the recovery of gold was well known at the date of the patent, and zinc shavings were an improvement of that process. Zinc was not used for the purposes of forming the solution.

Mr. GEORGE MACCULLOCH, Chairman of the African Gold Recovery Company, said there was still some gold in the tailings which could not be dealt with. He should say that about one-half of the present production would not exist but for the introduction of the cyanide process.

Sir EDWARD CLARKE, Q.C., M.P., for the defence, submitted that the plaintiffs had made out no case. The claim was for any solution containing cyanogen or cyanides, or any other substance containing or holding cyanogen. That was the largest claim that could possibly be made. It was admitted that for years it had been well known that an aqueous solution containing cyanogen had the property of dissolving gold. Under these circumstances he submitted that there was no subject matter of invention at all. What novelty and what ingenuity could it be suggested there was in the plaintiffs' patents?

Mr. JUSTICE ROMER intimated that he was with the defendants on several points; but would not determine the case without hearing the evidence.

[The evidence for the defence will be given in our next issue.]

Davies v. R. Bolton and Co. (Limited).

This was the action in which Mr. Justice Vaughan Williams had referred to the insufficiency of the existing law with reference to debentures, and was important as showing how far persons dealing with companies are affected by irregularities in the internal affairs of those Companies. The action was originally brought by Mr. G. L. Davies against the Company (in liquidation) to enforce a First Mortgage Debenture on all the Company's assets, issued to Reginald Bolton, to secure a sum of £649. 1s. 3d., with interest at 5 per cent. This debenture was directly afterwards transferred to Davies, and after the commencement of the action it was transferred to Mr. Cecil Fane, who obtained leave to continue the proceedings. The action was defended, in the name of the Company, by the Official Receiver and Liquidator.

Mr. Justice WILLIAMS said the case raised a question of some general and public importance. The practice of insolvent traders turning themselves into limited companies and then issuing debentures in favour of some, or all, the creditors of the particular trader—debentures which secured really the price that was payable by the Company to the vendor—had of late years become extremely frequent. It was quite clear that in many cases the whole operation was a mere fraud. It involved conduct which, if it was that of an individual trader, no one would hesitate to describe as a fraud on his creditors. He was glad to say the present case was not a flagrant instance of the user of the practice referred to. Mr. Bolton was not present, and his Lordship did not wish to say anything against him. He had apparently absconded. He entered into partnership with Davies, and his Lordship was not surprised that it turned out unsatisfactorily, and that Davies was glad to get out of it at a sacrifice. After such sacrifice had been made there was still a considerable sum due from Bolton to Davies. After this Bolton turned himself into a company, not with a view to benefiting Davies, but rather in a spirit of hostility to him. Thereupon Davies put the matter into the hands of his then solicitors, who pressed Bolton for payment. Bolton was unable to pay the amount due, but said the Company had to pay him for the purchase of the business, and anticipated that the sum would come in from the shareholders; but that if Davies pushed matters very far Bolton might become bankrupt, and there would be a loss to the creditors. The debenture in question in this action was given, and it was the duty of the Court to consider the various objections which had been raised to it. He was of opinion that the seal was affixed to the debenture so as to bind the Company. Bolton was a Director, and certain clerks and friends were the other Directors, but Bolton was the beginning, the middle, and the end of the Company. When the Court was satisfied that the seal of the Company had been affixed to the debenture in the course of business by those who had the management and control of the Company, non-compliance seemed to come within the terms of and to be cured by article 115 of the Articles of Association of the Company. The debenture must be held valid, and the plaintiff was entitled to have it enforced.

The question of costs was reserved. The debenture included all the assets, and his Lordship said he should not make any order which would involve payment of costs by the liquidator personally unless he was satisfied that that was the ordinary practice followed by the Judges of the Chancery Division.

Reddaway and Company Limited) v. Barnham and Company (Limited).

At Manchester, last week, Mr. Justice Collins and a special jury, this case was heard. It was an action for an injunction to restrain the defendants from continuing to infringe the plaintiffs' registered trade marks, and from continuing to use the word "Camel" in such a manner as to pass off their beltings and driving bands as the plaintiffs' goods, and for an account or damages. It was claimed by the plaintiffs that from 1879 to 1892 they had manufactured and sold at home and abroad large quantities of belting having the word "Camel" or the figure of a camel upon it, so that the word was universally understood to indicate that goods to which it was attached were of the plaintiff's manufacture. The defendants denied that there was any such universal understanding, and said that they had made and sold a belting known as "camel-hair belting," such belting being of a particular kind and the words being descriptive of the material used in its manufacture. They had used this description of their belting for some time prior to the incorporation of the plaintiff Company, and to the knowledge of, and without any objection on the part of, one of the plaintiffs.

After hearing evidence the jury returned a verdict for the plaintiffs, and an injunction was granted. An application to suspend the injunction was refused, and the plaintiffs were allowed costs on the higher scale.

In re Medical Battery Company (Limited).

In this action a scheme of arrangement has been sanctioned under the Joint Stock Companies Arrangement Act, 1870, but "only on the condition that the memorandum of association of the new Company (to be formed to purchase and carry on the business) should be so framed as to provide that electrical treatment and the sale of electrical belts should be under the control of a duly-qualified medical assistant, "who would be

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present when each belt was sold (!) The memorandum as altered must be produced to the Registrar.

Under the scheme it is proposed to raise £3,000 by First Debentures, the present debentures to take second place. There are to be six new Directors, the old Directors to have no connection with the Company.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

The 1894 Edition of "The Electrician" Electrical Trades' Directory and Handbook contains 1,000 closely-printed pages, and several new and useful features have been added. The price of the Directory and Handbook is 7s. 6d. Postage in the United Kingdom, 9d.; abroad, 1s. 4d. *The 1895 edition is in preparation.*

"Electric Lamps and Electric Lighting," being four Lectures delivered before the Royal Institution in April-May, 1894, by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is in preparation, and will shortly be published.

"Electromagnetic Theory," by Oliver Heaviside, is now ready, price 12s. 6d. (abroad 13s.). Prospectus on application.

"The Incandescent Lamp and its Manufacture."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application to the Publisher.

"Drum Armatures and Commutators."—This book, written by Mr. F. Marten Weymouth, is also ready; price 7s. 6d (abroad 8s.). Prospectus on application.

"Inventions, Researches and Writings of Nikola Tesla," by T. Commerford Martin, may be obtained from the Publisher of *The Electrician*, and a copy will be forwarded post free on receipt of 16s. 6d.

"How to Wire Buildings."—Copies of this work, by Augustus Noll, will also be sent by the Publisher post free on receipt of 6s.

"Electrical Engineering Formulæ," a pocket-book by W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. (abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application to the Publisher

Tenders Invited.—The Great Yarmouth Corporation require tenders for installing the electric light at the School of Art. Tenders have to be in before noon of the 30th inst. to Mr. T. M. Baker, town clerk.

Tenders Accepted.—The Electric Lighting Committee of the Burgh of Ayr have, we are informed, decided to place the contracts for the plant required for their new electricity works with the undermentioned firms:—

Siemens Bros. and Co. (Limited), engine-house plant	£5,940
Callenders Bitumen Co. (Limited), cables and culverts ...	1,842
Penman and Co., boiler-house plant	1,541
S. Z. de Ferranti (Limited), meters	590
John Fowler and Co. (Limited), Leeds, arc lamps & posts.	476
John Fowler and Co. (Limited), Leeds, switchboard	437
Swinburne and Co. (Limited), transformers and boxes ...	420
Carrick and Ritchie, overhead crane	192

We are also informed that the absence of the names of the Brush Electrical Engineering Company, Messrs. Crompton and Co., and of the Electric Construction Company is due to the refusal of these firms to tender to the specification. The full list of tenders received will be found in our issue of the 13th inst.

——— The Melbourne City Council have accepted the tender of Messrs. G. and C. Hoskins for the supply of 900 30ft. poles for electric lighting purposes, at £1. 3s. 4d. each. The tender of the same firm has also been accepted for erecting and painting 1,344 poles for the sum of £425. 12s.

Tenders Received.—The Belfast Corporation have handed over the tenders received for a travelling crane for the new electric lighting station to Mr. McCowen, the resident electrical engineer, to report upon.

Liquidations.—The petition for the compulsory winding-up of the Collier Audible Telephone Syndicate (Limited) was disposed of on Thursday by Justice Vaughan Williams. The Company was formed for the purpose of working a certain patent, and in March, 1892, entered into agreements by which in effect it transferred its undertaking to another company called the Collier-Marr Telephone and Electrical Manufacturing Company, subsequently going into voluntary liquidation. The present petitioners, Messrs. W. Shepherd and Sons, were creditors, and, on the ground that the voluntary liquidation had been going on for over two years without a satisfactory result, asked for a compulsory order. His Lordship made the order, as requested.

Receivership.—The Halifax and Huddersfield Union Banking Company applied last week to Mr. Justice Chitty for the appointment of a receiver and manager for the business of Andrews and Preece (Limited), electrical engineers, of Bradford, of which Company the bank were debenture-holders. Mr. James Duff, accountant, Halifax, was, by consent, appointed receiver and manager.

Dissolution of Partnership.—The partnership between Messrs. T. Somers, A. Firth, and J. Bowns, trading as the Baker Blower Engineering Company at Stanley-street, Sheffield, has been dissolved, the business being continued under the control of Mr. T. Somers.

Appointment.—Mr. A. B. Mountain has been appointed by the Huddersfield Corporation borough electrical engineer and manager, at a salary of £250. Mr. Mountain was selected in December, 1891, to superintend the laying of the mains and the erection of the electric lighting machinery. For these duties he received £200 a year, and it was pointed out, at the meeting at which his appointment was now confirmed, that the electric lighting department was making satisfactory progress.

Vacant Appointment.—The Town Council of the City of Cape Town invite applications from qualified engineers for the office of electrical engineer to manage the Electric Lighting Department of the City, at a salary of £400 per annum. Further particulars are given in our advertisement columns.

New Address.—Members of the electrical trades, and buyers generally, are informed that the Telegraph Manufacturing Company, of Helsby, near Warrington, have, in addition to their establishments in London, Liverpool, and Glasgow, now opened a branch to serve the Lancashire and Yorkshire districts at 2, Parsonage, Manchester, where stocks of the Company's manufactures will be kept. Telegrams should be addressed "Vigorous Manchester."

New Firm.—Mr. J. D. Miller, M.I.E.E., who was formerly with the National Telephone Company, has started business as a consulting electrical engineer in Dundee.

Personal.—Messrs. Gabriel and Angenault have secured the services of Mr. George Davis for the management of their London Depot at Connaught-mansions, Victoria-street, S.W., where a stock of incandescent lamps of their manufacture will be kept. Mr. Davis has been with the St. James's and Pall Mall Company as Inspector since the foundation of that Company in 1889.

Admiralty Contracts.—The United Asbestos Company (Ltd.), of Dock House, Billiter-street, E.C., have been successful, for the tenth time, in securing the contract with the Lords of the Admiralty for the supply of "Victor" metallic joints and other asbestos goods for use in Her Majesty's Navy.

Messrs. Drake and Gorham.—This firm have in hand in London the entire reconstruction, rewiring, and additions to Mr. Bruno Schroder's mansion at Kensington-court, S.W., for about 70 lights, and Mr. Harris's house in Montagu-square, for 32 lights.

Boudreaux Dynamo Brush Company.—This Company are issuing printed particulars of their latest form of foliated rolled metal dynamo brushes, and a list of many of the principal users in England, France, Belgium, and Austria. The names of many of the principal firms in those countries are included in the list. The Company are agents in this country for Labour's alternating-current generators and transformers, and Desruelles' and Chauvin's patent ammeters and voltmeters, of which particulars and prices are now ready.

The "Hercules" Belt Fastener.—Hercules was strong, and he cleansed the Augean stables. Hence his connection with leather, though it is doubtful if horse hide is any good for belts. However, the "Hercules" belt fastener is claimed to be strong and is intended as a leather connection. In itself it is undoubtedly stronger than the leather which it is designed to bind, being made of steel; but the danger with this kind of fastener is that there is a liability of the leather being torn. In the "Hercules" belt fastener this danger is obviated by the use of a kind of cover plate to distribute the stress over the leather instead of allowing it to be concentrated at the joint holes. The fastener makes a strong and neat joint, having the combined advantages of strength, flexibility, and smoothness. It is made by Messrs. Honeywood, Austin and Co.

McDougall's Steam Saving Appliances.—It is scarcely necessary to point out the vital importance of the economical use of steam in electric supply stations and other steam-driven works. The Chadderton Ironworks Company (Limited) have recently sent us a copy of their illustrated catalogue, descriptive of the McDougall steam-saving appliances manufactured by them. From a list we see that these appliances, which comprise steam separators, driers, traps, anti-priming pipes, and oil separators, as well as the McDougall system of mechanical stoking for steam boilers, have an extensive and increasing use in electric supply works.

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WELDED PIPES.—Mr. John Spencer sends us illustrated particulars of his patent welded iron and steel socket and spigot pipes and flanged pipes. The spigot-and-socket tubes, made from 2in. to 6in. diameter can, it is claimed, be fixed by the workmen accustomed to the old lead and yarn joint, and as these tubes can be made about one-half the weight of cast iron pipes, and in lengths more than double that now in common use, the cost of freight and of all jointing is considerably reduced, as is also the loss by breakage in transit. The welded flange pipes are made to take the place of brazed-on flanges and of cast-iron pipes also. As Mr. Spencer points out, there is nothing new in welding pipes into flanges; but the newly-patented method is devised to provide a flange pipe which is as strong at one part as another, or, in fact, may have an increase of strength at the welded point. The weight of these pipes is claimed to be much less than that of cast iron. Important tests have been made particulars of which are given in the printed sheets.

ABERYSTWITH.—The whole of the 17 arc lamps have been erected on the Marine and Victoria-terraces18; further arc lamps are to be put up within the borough and on the chain pier.

ADELAIDE (SOUTH AUSTRALIA).—A pamphlet has been prepared by the South Australian Gas Company entitled, "The Electric Light as Applicable to the Lighting of the Streets of Adelaide." The pamphlet is prepared with the special view of instructing the citizens of Adelaide on the advantages and disadvantages (but principally the latter) of electric lighting. The authors have used considerable ingenuity in preparing statistics of small failures with the view of proving to the citizens of Adelaide that the electric lighting scheme which the City authorities have under consideration will prove disappointing to the projectors and to the ratepayers.

ANNUAL DINNERS.—The employés of the Kensington and Knightsbridge Electric Lighting Company (Limited) held their fifth annual dinner on Saturday last at Crampton's Hotel, Ramsgate, Mr. H. W. Miller presiding.——The annual outing of the employés of the City of Bath Electric Light and Engineering Company (Limited) took place on Thursday last week, at Badminton, the seat of the Duke of Beaufort.

ARMY AND NAVY STORES.—The extensive depots of these stores, situate in Coburg-row and Francis-street, Westminster, are to be lighted by electricity from designs by Mr. Bernard R Drake. The contract has been placed with Messrs. Crompton and Co. (Limited), whose tender was the lowest received from the firms nominated by the Army and Navy Stores to submit tenders.

ARUNDEL CASTLE.—Amongst the many important improvements recently introduced by His Grace the Duke of Norfolk at Arundel, which include almost the entire rebuilding of the castle itself, may be mentioned an electric lighting installation of considerable magnitude, which will be when completed one of the most important in the country. The building intended for the generating station is situate near the entrance to the castle gardens, and is provided with an octagonal shaft 46ft. in height. This building has a total frontage of 92ft., with a depth of 48ft., and a height of 36ft. It comprises boiler house, engine room, accumulator room and fitting shops. The plant consists of three Galloway steel boilers with Atkinson's feed-water heaters attached Three 90-H.P. vertical compound engines have been put in, coupled direct to specially compounded six-pole dynamos capable of working up to 400 amperes. The accumulator room contains two battery sets of 62 cells each. The castle itself is situated about 500 yards from the generating station, and is lighted throughout by incandescent lamps of various candle-powers. Incandescent lamps are to be used for the courtyard and the drive from the lodge. The various plans sent in for lighting the castle were placed in Mr. W. H. Preece's hands for selection, Mr. G. Kapp acting as consulting electrical engineer to the Duke. Mr. A. F. Phillips, C.E., has superintended the building and general arrangement of the plant, the contractors for the buildings being Messrs. Read, Bright and Co. The Brush Company have supplied the whole of the machinery and electrical plant, and the work has been carried out under the superintendence of Mr. W. Geipel, the Brush Company's superintending engineer, Mr. A. Bard, C.E., acting as resident engineer. Mr. J. E. Sayers has been in charge of the electrical part of the work, and Mr. J. W. Donnet of the mechanical department at the station.

BALLAARAT (VICTORIA).—The Ballaarat Electricity Supply Syndicate has concluded an arrangement with the Victorian Government Railway authorities for lighting the various local stations and embankment at Ballaarat by electricity. The Government will, it is stated, save about £300 per annum by the introduction of the new light as a substitute for gas. The post and telegraph offices and other public buildings are shortly to be lighted by electricity, so will also the mechanics' institute. The leading shopkeepers of the city promise their support to the syndicate.

BELFAST.—It is expected that some of the engines for the electric light plant will be ready for testing in about a week's time. Numerous applications have been received for electric current from parties both inside and outside the electric lighting area.

BURTON-ON-TRENT.—In the abstract of borough accounts for the past year, issued by Mr. Fish, the accountant to the Corporation, it is stated that the amount raised for introducing the electric light into the borough was £25,992, of which sum £14,095 was expended up to March 25th last. The net profit from the gas department proved to be the lowest since the incorporation of the town in 1879.

CARDIFF.—The Lighting Committee of the Corporation have been requested to include the Free Library in their inspection, with the object of ascertaining the cost of lighting the building by electricity.

CHELSEA (LONDON, S.W.)—It is expected that the electric lighting work at the Town Hall will be completed in about a fortnight. Many complaints have been received from those who hire the Hall for evening meetings at the discomfort caused by the gas, and the change to electric lighting will doubtless be fully appreciated.

CHURCH LIGHTING.—St. Martin's Church, Scarborough, is being installed with the electric light. About 100 lights will be used.

COUNTRY HOUSE LIGHTING.—Yestor House, Haddington, N.B., the seat of the Marquis of Tweeddale, is now fitted throughout for the electric light. Motive power has been obtained from the Mains, situate half a mile distant from the mansion. About 300 incandescents are used, the generating plant being supplemented by a battery of accumulators. The work has been carried out by Messrs. A. A. C. Swinton and Co.——Jordanston House, Blairgowrie, which is in course of erection, is being fitted for the electric light.

EALING.—The buildings of the central electric lighting station at Ealing, erected to the design and under the superintendence of Messrs. Bramwell and Harris, are approaching completion, the directors being Messrs. Wilkinson Brothers. The lighting plant is being put in by Messrs. Siemens Brothers and Co., the boilers by Messrs. James Watt and Co., and the mains by the Callender Company. It is expected that the supply of current will commence in September, the official opening taking place on the 29th of that month. An electrical exhibition is to be held in the Victoria Hall, or other suitable place, where customers will have an opportunity of selecting fittings suitable for their particular necessities. Exhibition will be made of the various applications of electricity to lighting, domestic, and other purposes.

EAST HAM.—An application from the Local Board to the West Ham Gas Company asking for a reduction in the price charged for gas supplied to the public lamps has received the same negative reply as did that of the West Ham Corporation a short time back. At the last meeting of the Local Board the reply from the Gas Company was discussed, and it was the opinion of members that the time had come when the Board should take some steps to light the public streets by electricity. Mr. Keys, a member, pointed to the fact that the hospital was lighted by electricity, by means of power from the sewage works, and this had proved a great success. The surveyor to the Board, in the course of his remarks on the subject, said that he hoped that the time would shortly come when they would not only have the town lighted by electricity but would also have electric tramways.

EDINBURGH.—Mr. Treasurer M'Crae has presented the year's Corporation accounts, and in the course of his introductory statement said that they had not spent all the money last year that they had estimated for electric lighting purposes, and therefore the electric light did not show such a large increase on the year's expenditure as might reasonably have been anticipated. There was only an increase of £1,725.

ELECTRICAL EXHIBITON AT WORCESTER.-As previously announced, the Worcester Corporation have arranged to hold a popular exhibition of electrical appliances in October next, coincident with the opening of the supply station. The Corporation invite plant, apparatus, and fittings makers to apply for space, which, as well as electric current, will be supplied free of charge. This spirited and liberal policy should prove attractive to manufacturers and dealers, and result in a varied and extensive display. Its effect will doubtless be to increase the popularity of the electric light installation, considerable interest in which is being manifested locally, as is proved by the fact that orders have been already received for nearly 3,000 lamps. The Corporation intend using the current for lighting the streets, and driving a portion of the pumping machinery at the water-works.

ELECTRIC ORGAN.—Messrs. Hele and Co., of Wyndham-street, Plymouth, are erecting in the music saloon of Sir Gervas Glyn's house in Surrey a new organ, fitted with the Hope-Jones electric action. The organ has four keyboards, which can be played at a distance of 50ft. from the instrument.

EXETER.—It has been decided by the City Council to light the new wing of the museum building by electricity. The foundation stone is to be laid by the Mayor on August 1st.

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FAREHAM.—The burning question as to whether the Local Board should purchase the local electric lighting company's undertaking for £6,500, or whether the value of the Company's undertaking should first be ascertained by an independent valuer, was thoroughly discussed at a meeting held at the Town Hall last week. The general opinion was that the Company's business should be taken over by the Local Board. It was ultimately decided that the Local Board be instructed not to sign the contract until the independent valuation had been made. This motion was strongly opposed by the members of the Board, who insisted that a very reasonable bargain had been struck with the Company, and one which would considerably benefit the town.

FISHMONGERS' HALL.—The electric light is to be fitted throughout the whole of the premises of the Fishmongers' Company at London Bridge, S.E., under the supervision of Messrs. Massey and Allpress.

GLASGOW.—A sub-committee, recently appointed to consider the question of the liability of the Police Commissioners in the matter of telegraph wires, has received an account for £349 from the engineering branch of the Post Office for the work of diverting underground wires from the Glasgow bridge to the temporary new bridge, and it was pointed out that, although the Corporation received no payment for way-leaves granted to the Government for running telegraph wires over the bridges under the custody of the Corporation, when these wires have from any cause to be removed or diverted the work is done by the Post Office officials at the expense of the Corporation. After some discussion the solicitor pointed out that there was no remedy, and the account was passed and the subject dropped.

HALIFAX.—Sixty-three applications for electric current have already been received by the Local Board from the principal tradesmen of the town. The Masonic Hall Committee have also decided to introduce the electric light into their buildings.

HAMPSTEAD.—It is proposed (provided the Metropolitan Asylums Board agree to take from the Vestry the electric current required at the North-Western Hospital) to lay the necessary mains and transformers through Buckland-crescent, Belsize-park, and Belsize-avenue, to the hospital, of sufficient capacity to supply the private consumers in those roads and the Vestry Hall, the total estimated cost of the work being £1,734. A proposal to still further extend the mains to property in course of erection in the South End Green district, was referred to the Electric Lighting Committee for their consideration.

HARROW.—It was announced at the last meeting of the Local Board that the Electric Lighting Provisional Order had passed both Houses of Parliament. A meeting of ratepayers had been held, at which certain statements had been made which had been put into writing and submitted to the Electric Lighting Committee for consideration and report. It was suggested to call in the services of Prof. A. B. W. Kennedy at a fee of 100 guineas. After some discussion the subject was referred back to the Committee.

HEYSHAM.—The Lancaster Rural Sanitary Authority have given their consent to the local electric lighting company applying to the Board of Trade for a licence to supply the Heysham district with electric current.

HULL.—The electrical engineer, Mr. A. H. Gibbings, has presented a report to the Electric Lighting Committee of the Corporation, in which he suggests that additional engines and dynamos of 600 H.P. should be purchased and erected, to meet the demand for the coming winter, at an estimated cost of about £4,500. It was resolved to print the report, so that the matter may be fully discussed at the next meeting of the Corporation. The electrical engineer reported that the Electric Light Department had now 176 consumers on their books.

ISLINGTON (LONDON, N.)—It has been decided by the Vestry to purchase additional land and property adjacent to the site adopted for the central electric lighting station at Eden-grove and Bernard-place, Holloway, in view of extension being necessary in the near future. It has further been decided to apply to the London County Council or some other body for a loan of £51,000 for 42 years at 3½ per cent. interest, repayable on the annuity system, the money to be devoted to the purposes of completing the electric lighting works.

KINGSTOWN (IRELAND).—During the regatta festivities this week several outdoor displays have been given, much interest being taken by the spectators in the lighting of the front of the civic headquarters with about 750 8 and 16-c.p. incandescents.

LEWISHAM (LONDON, S.E.)—The District Board of Works have received a memorial signed by 10 residents, complaining of a nuisance alleged to be caused by the works of the Crystal Palace and District Electric Supply Company. It was resolved to take the usual steps to lay the complaint before a magistrate, when the memorialists will be called upon to prove the nuisance.

LONDONDERRY.—The opponents of the Corporation's electric lighting scheme have succeeded in bringing about a crisis which has led to the resignation of Mr. Magee, Chairman of the Electric Lighting Committee. It would appear that a short time back the sum of £2,130 was required for the supply and erection of additional arc lamps for public lighting, and the Local Government Board was notified of this fact. A query arose as to whether the Corporation had duly passed a resolution asking for powers to borrow this sum, and as this formality had been dispensed with, and as Mr. Magee, as Chairman of the Electric Lighting Committee, was responsible for the application being made, his opponents succeeded in passing a resolution which Mr. Magee considered as one of want of confidence, and tendered his resignation. Mr. Magee pointed out that statements were constantly made in order to injure the electric lighting scheme, which, notwithstanding, was for the benefit of the public. It was ultimately decided to notify the Local Government Board that the letter sent to them on the subject was unauthorised, and, upon this motion being carried, Mr. Magee tendered his resignation. The gas element in the Corporation were scarcely able to control their gratification at the success of their manœuvres; but it is scarcely necessary to point out that, whether Mr. Magee is again induced to accept the post of Chairman of the Electric Lighting Committee or no, the Londonderry electric lighting scheme will go on and prosper, despite its opponents. There are few districts where the electric light and its sponsors have met with more strenuous, and not always straightforward, opposition than in Londonderry. But this has not prevented the scheme making sure, if slow, headway.

MAIDSTONE.—The Electric Lighting Committee have reported to the Local Board that, owing to no satisfactory arrangement having been come to with the Company with which the Board had been in negotiation for the transfer of its Provisional Order, a new advertisement is to be issued by which the Board ask for offers to be sent in by responsible firms for taking over the Order. In discussing the Committee's report, which was subsequently adopted, several members pointed to the opposition with which from the first the electric lighting scheme had been received; in fact, the gas interest had proved too strong for those who felt sufficient pride in the town to propose the adoption of the newer and better illuminant. It was pointed out that the advantage the Board possessed over any company likely to undertake the Order was that they were in a position to borrow at 3 per cent., whereas a company would be expected by its shareholders to pay 5 per cent. on its capital.

MELBOURNE (VICTORIA).—It has been decided to re-engage Mr. A. J. Arnot as electrical engineer to the City Council for three months, dating from June 9th.

MILL LIGHTING.—The extensive flour mills occupied by Mr. A. Robinson, at Norwood Bridge (Surrey), have been lighted throughout by electricity, 100 16-c.p. and a few larger lamps being used. The residence of the proprietor in the rear of the mill is also lighted by electricity, a separate building having been provided for the generating plant. The work has been successfully carried out by Mr. Wilson Hartnell.——The mills occupied by Mr. E. Barlow at Radcliffe are being fitted with the electric light, about 300 incandescents being used. The work is being carried out by Messrs. Bennett and Druce, who have also an installation for 250 lights at the Preston Industrial Co-operative Society's premises in hand.

MORECAMBE.—The local Electric Lighting Company have succeeded in abating the nuisance complained of at the electric lighting station, to the satisfaction of the local authorities.

NEWCASTLE-ON-TYNE.—Although the number of electric lamps erected by the Newcastle Corporation is limited, the result of the experiment has given the greatest satisfaction, and it is stated that the Corporation is taking steps to acquire, if possible, the plant and undertakings of the electric lighting companies established in the town; or, as an alternative, to come to an understanding respecting an adequate provision for the electric lighting of the city. It will be remembered that the sum of £200 was voted at the last meeting of the Council for the purpose of employing an expert to advise as to the cost of an electric lighting scheme for the city. No selection was made at the meeting on Tuesday, as the Corporation's city engineer is in London making further inquiries on the subject.

PORTSMOUTH.—The Corporation electric lighting installation is, we understand, giving the greatest satisfaction, and considerable extensions will shortly have to be effected. Applications are being constantly received from localities outside the present supply area, and, as sufficient orders come in, the Electric Lighting Committee have decided to take the necessary steps to extend the mains. The authorities of various places of worship are discussing the advisability of introducing the electric light, and the South Parade Pier Company have already decided to light the pier electrically.

RUSSIAN CUSTOMS TARIFFS.—A number of alterations have been made in the Russian customs regulations recently and the classification of certain articles have undergone considerable modification.

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Parts of dynamo-electric machines under Section 167 now pay a duty of from 1 rouble 40 copecks to 4 roubles 32 copecks in gold per 36lb. weight according to the metal of which they are made. Belts pay a duty of 20 copecks in gold per Russian pound. Under Section 147, iron, steel, or copper wire, and electric cables of all kinds when coated or covered with other common metals, are to be cleared under the rules of this section. Other changes affecting the electrical and allied trades have been made, particulars of which can be obtained from the Board of Trade.

SEVENOAKS.—The Holloway Electricity Supply Company have notified the Local Board of their intention to apply for a Provisional Order to enable them to supply electric current in the Sevenoaks district. Opinion was divided as to the advisability of the giving or withholding of consent to the application.

SHOREDITCH (LONDON, E.)—At the last meeting of the Vestry it was proposed to appoint Mr. Manville, of Messrs. Kincaid, Wal'er and Manville, consulting electrical engineer in connection with the proposed supply and erection of electric lighting plant at the Pitfield-street station at a commission of 3 per cent. on the amount of the lowest tender received. The matter is to be decided at the next meeting of the Vestry.

STOKE-ON-TRENT.—The North Staffordshire Railway Company have now introduced the electric light for the whole of the extensive station buildings at Stoke, including the range of underground passages.

SYSTEMATIC DAMAGE.—Ernest Lawrence, a carriage cleaner, employed on the District Railway, was brought up at the West London Police-court on Tuesday last, charged with wilfully breaking open a reading lamp, the property of the Railway Automatic Electric Light Syndicate (Limited), with the intention to steal money therefrom. It appeared the Company had lost considerable sums from the lamps, and suspicion had fallen upon some of the railway servants. The prisoner was only charged with damaging one lamp, but a number of others in the same train were found injured. The prisoner had been watched, and the present charge was made. The prisoner was committed to gaol for two months, with hard labour.

THEATRE LIGHTING.—We recently stated under this heading that the gas-engines required in connection with the lighting of the Theatre Royal, Bradford, were supplied by Messrs. Crossley Brothers. Messrs. Tangyes (Limited) ask us to state that this is an error, the engines supplied being Tangye engines.

WINDSOR.—It has been decided to apply to the Board of Trade to revoke the Windsor Electric Lighting Order for 1890, and to apply for a Provisional Order for power to light the districts of Eton and Windsor in place of the Order it is proposed to revoke. The Electric Lighting Committee of the Town Council have been collecting informations from Local Authorities who are either using or contemplating adopting the electric light, and the whole subject will be discussed at an early meeting of the Council.

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

July 16, 1894.

13,652. CHARLES ESSON. London. Improvements in electric switches.

13,700. J. EDWARD KINGSBURY. London. Improvements in telephone switchboard mechanism. (The Western Electric Company, U.S.A.)

13,706. A. H. ENTWISTLE, H. G. STEPHENS and A. DUBBER. London. An improved shade for electric lighting and like purposes.

13,714. LUDWIG JAROLJINEK. London. Improvements in or relating to the exploding of blasting charges in mines.*

July 17, 1894.

13,728. ALFRED DICKINSON. Darlaston. A combined pole and lamp post for supporting overhead wires or cables for electric tramways or railways, telegraph, telephone, and other wires or cables.

13,744. JOHN ELDRIDGE SPRATT. London. Electro-magnetic massage roller.

13,747. WILLIAM W. STEVENSON. London. An improved electrical coupling or terminal.

13,749. CHARLES A. ALLISON. London. Improvements in electric signalling apparatus. (The Standard Electric Signal Company, U.S.A.)*

13,750. CHARLES A. ALLISON. London. Improvements in electric signalling apparatus. (The Standard Electric Signal Company, U.S.A.)*

13,751. CHARLES A. ALLISON. London. Improvements in electric signalling apparatus. (The Standard Electric Signalling Company, U.S.A.)*

13,756. CHAS. NELSON WAITE. London. Improvements in, or connected with, electrolytic cells and diaphragms therefor.*

13,762. CHAS. DANIEL JENNEY. London. Improvements in and relating to electric railways.*

13,765. E. HIBBERD JOHNSON and R. LUNDELL. London. Improvements in and relating to electric railways.*

13,771. EDWARD LACHMANN. London. Improvements in and relating to electric railways.

13,791. W. LLOYD WYNN WILLIAMS and G. H. MORGAN. Liverpool. Improvements in or appertaining to incandescent electric lamps.

13,794. G. WASHINGTON EISENHUTH, R. HERMAN and EMILE H. HERMAN. Liverpool. Improvements in electric conduits and conductors therefor.*

13,795. W. P. THOMPSON. Liverpool. Improvements in the process of electro-plating and apparatus therefor. (Clarence Morse Barber, U.S.A.)*

July 18, 1894.

13,836. CHAS. G. YARNOLD. London. Improvements in apparatus employed in the evolution and collection of hydrogen and oxygen gases by electrolysis.

13,871. G. ANDERSON KELMAN, Senior. London. Improvements in or relating to electrical transformers or converters. (James A. Kelman, jun., U.S.A.).

13,872. GUSTAVE VERMEÉRE. London. Improvements in and relating to electric railways.

July 19, 1894.

13,900. A. M. ROSEBRUGH. Canada. An improvement in multiplex telephony. (Date applied for under Patents, &c., Act, 1893, Sec. 103, January 6, 1894, being date of application in U.S.A.)

13,903. CHARLES ELLAH STALLYBRASS. Cardiff. Improvements in magnetic locks or apparatus for opening locks of safety lamps by magnets only.*

July 20, 1894.

13,983. JOSEPH WADDINGTON. London. Improvements in apparatus for driving air propelling and exhausting ventilators electrically.

13,993. AUGUSTUS H. JOHNSTON. London. New or improved electric light regulator.

13,995. WILLIAM PHILLIPS THOMSON. Liverpool. Improvements in or relating to electric railways. (James Francis McLaughlin, U.S.A.)*

July 21, 1894.

14,029. STEPHEN SIMPSON. Mansfield. Improvements in prepayment mechanism, application to gas, electricity, and like meters.

14,065. W. A. MALSON, T. MALSON, S. R. MALSON, and EMMANUEL SMITH. London. Improved electric fuse head for use in blasting.

SPECIFICATIONS PUBLISHED.

NOTE.—All Specifications can now be obtained at the uniform price of 8d. each.

1893.

6,677. GRIMES. Railway electrical signalling devices.

13,779. MÖLLER. Telephone circuits.

14,000. DE FERRANTI. Electricity meters.

14,003. GOLDSTON. Electric circuit-closing devices.

14,481. MOY. Ammeters and voltmeters.

14,997. EDWARDS (La Cour). Electric contacts for telegraphic vibrators.

15,074. COOPER and others. Electric coupling.

15,355. PYNE and THOMPSON. Electric battery.

1894.

5,253. WISE (Lewis). Producing and utilising electricity.

5,254. WISE (Lewis). Producing and utilising electricity.

6,482. MOREAU and MUNIER. Telephone systems.

8,599. MCKEOWN. Electric arc lamps.

9,968. SPERRY. Arresting motion of electrically-propelled mechanisms.

10,045. ORMSBY and BANISTER. Electric motors.

10,169. BLOT. Secondary battery plates.

10,427. MEDHURST (Chandor). Composition for lamp incandescers.

COMPANIES' MEETINGS AND REPORTS.

Direct United States Cable Company (Limited).

The thirty-fourth ordinary general meeting of this Company was held at Winchester House, Old Broad-street, on Tuesday, under the presidency of Sir John Pender, G.C.M.G., M.P.

The SECRETARY (Mr. T. Finnis) having read the notice convening the meeting and the minutes of the last ordinary general meeting, which were confirmed, the report of the Directors was taken as read.

The CHAIRMAN then said: Gentlemen, I have no doubt that you have all perused the report carefully, but before asking you to approve it I will,

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as usual, go over the heads of it, and make some reference to the conduct of the business during the last six months. The revenue for the half-year to June 30th last, after deducting outpayments, amounted, in round figures, to £34,843, and the working and other expenses, including income-tax, required £18,750, leaving a balance of £16,093 as the net profit of the half-year, making with £3,080 brought forward from the previous half-year a total of £19,173, which has been appropriated as follows: Interim dividend at 2s. per share for the quarter ended March 31st last, £6,071; final dividend of 2s. per share now proposed for the quarter to June 30th of £6,071; transferred to reserve fund account £6,000; balance proposed to be carried forward £1,031, making a total in round figures, as above, of £19,173. The revenue, as compared with that in the corresponding period of 1893, shows a falling-off of £5,993, which is attributable entirely to the prolonged commercial depression. The expenses in London, as shown by Abstract A in the accounts, remain practically unaltered as compared with the corresponding period. The expenses at stations, detailed in Abstract B in the accounts, show as follows: Increases of £70 in rent, taxes, fuel, and light, £112 in agencies, and £24 in assurance. On the other hand, however, there are the following reductions, namely, a small amount of £5 in salaries and wages, £40 in petty expenses, £83 in travelling, £35 in repairs, and £138 in printing and stationery. On the whole, these expenses show a reduction of £82. In the remaining items of expenditure there are reductions of £61 in storage of cable and £100 in depreciation, while the income-tax is increased by £44 owing to the higher rate now in force. The half-year's expenditure, in the aggregate, is less by £148 than it was in the same period of last year. The reserve fund has been increased by £4,184 interest on the investments, and by £6,000 transferred from revenue, and it now stands at £281 551. The investments have been increased during the half-year by £12,057, and now amount to £246,209 taken at cost. Their present market value shows an increase of about £32,500, or, say, 13 per cent. beyond cost. Now, gentlemen, these particulars do not show you that there has been any large increase of business during the last half-year; but I think you will remember that when I last addressed you I stated that the prospects then were not particularly bright. We were passing through probably one of the most severe commercial and financial crises that had ever happened in the United States, and I am sorry to say that the same condition of things prevails to day, although our past experience tells us that after a storm comes a calm, and after a calm there comes fine weather and brighter times. I have no doubt that that will be very much the result of our experience in our Atlantic system. The moment that trade begins to move there will be, no doubt, an increase in our traffic. The only thing is—and I am sorry to say it—that the preparations to meet that increased traffic are probably in excess of the requirements of the general traffic itself. We have just learned that one cable has been completed by the Commercial Company, and another is about to be completed by the Anglo-American Company, so that amid all these troubles there is no want of cable accommodation for carrying on the traffic. We hear rumours of another French cable being laid, and also rumours as to the possibility of a German cable being laid. I can give you no further information at present than that which the Press may have given you; but when the information does come, if it comes in such a form that it can be submitted to you, I shall be only too glad to submit it, and give you my opinion upon the opposition and the competition likely to arise from any addition to the cables in the Atlantic. You have heard, I daresay, that the suit in Paris has been finished; at all events, a decision has been given on it. It is said to be a favourable decision, but wherein the favour lies I have not yet been able to discover. I do not see that we shall get much, if anything, in return for the large sum we have spent upon it. However, we went into this under good advice—the Anglo-American Company acted under good advice in going into this suit; but if they get anything out of it I shall be only too pleased. Meantime, I do not see that the decision is likely to give us any real money return. The general working of our system has been fairly satisfactory. We had a small breakdown in Halifax Harbour, but it was very cleverly dealt with and repaired by our Manager there, with the assistance of some members of the Royal Engineers, who lent their aid with great readiness, for which I beg to thank them here before you all. They did good work in assisting us to effect that repair without our being obliged to send a special steamer to do it. We have had other little incidents and accidents, but all of very minor character; and, upon the whole, I may say that our half-year's working has been satisfactory in every respect except in that of earning power. We are, however, as I have said, short by several thousand pounds, and I attribute that entirely to the depression which has existed and which exists at the present time not only in America but also largely, as you know, all over the world. With these remarks, gentlemen, I beg to move the following resolution:—

"*That the report of the Directors, dated July 10, 1894, together with the statement of accounts to June 30th, 1894, annexed thereto, be and the same are hereby received and adopted, and that a final dividend be now declared of 2s. per share, free of income-tax, making, with the interim dividends already paid, a total dividend of 2⅝ per cent. for the year ended June 30, 1894.*"

Mr. E. M. UNDERDOWN, Q.C., seconded the resolution.

Mr. GRIFFITH expressed his satisfaction at hearing that the cable was in a fair condition, but he inquired whether there was any probability of their being compelled to lay a new cable within a short period.

The CHAIRMAN: I have often said that that was one of the factors in our position at the present time—the difficulty of being able to say how long the cable may "live"; but when a cable is getting towards twenty years old, it becomes those who are looking after it to see whether the time may not be approaching when it may be necessary to lay another cable. We have not yet taken that into consideration, because our combination with the Anglo-American and the Western Union Companies will enable us to live for a considerable time even if our cables were interrupted. But we have got a very good cable, as far as we can see, and looking at the repairs we have made in it and the considerable amount of new cable we have added to it, I hope that we may look forward for some years to a fair, moderate return on our present cable. Meantime we are not contemplating any serious expenditure upon a new cable. [He then put the motion, and declared it carried unanimously.] Continuing, he said: I think you will have observed—there has been a little general conversation about it—that while we have been obliged to reduce our dividend we are increasing our reserve fund. I am quite of opinion that with a large reserve fund we are placed in a very much sounder position, and I think it secures for the shareholders a better prospect of keeping their property at a fair price in the general market. I cannot, however, hide from myself the fact that we have a good deal of trouble before us in the Atlantic, but that is simply owing to there being more cables than are wanted for the work. There will be 12 cables in the Atlantic, and the scientific developments of the last few years enable us to carry just double the traffic that we did before the duplex invention was discovered. That is a fact which will give you an idea of the enormous carrying power which these cables possess. As I have said, I hope when the crisis passes away in America that there will be such a development of trade that a very large increase of traffic will result; and if that large increase of traffic comes, we may return to a better dividend than we are paying to-day.

Mr. UNDERDOWN, in moving the next resolution, said that on several previous occasions he had the pleasure of proposing the re-election of Sir John Pender, to whose list of honours another was added on the occasion of the brilliant fête a few days ago at the Imperial Institute. The King of Italy, recognising, as they all did, the enormous services which had been rendered to telegraphy by Sir John Pender, had signified that he had conferred on their Chairman the Great Cordon of the Crown of Italy with the Great Cross of that Order. He need not say that that was a very great honour in itself, as manifesting the international appreciation of Sir John Pender's great services. He was sure that they all hoped with him (the speaker) that that would not be the last of the acts of appreciation which their Chairman would receive, and which he deserved, not only from this country but from the colonies, and in fact, from all who were connected with the commerce and communications of the world. It was a very great pleasure to him personally to be present at the Imperial Institute, when one of the most brilliant assemblages seen for a long time came together. He wished that the same harmony that prevailed at their Board existed among the rivals of telegraphic enterprise, in which case there would not have been such haste to lay so many cables in the Atlantic, and everyone would then probably have fared better.

Admiral of the Fleet the Hon Sir HENRY KEPPEL, G.C.B., D.C.L., in seconding the motion, said he could endorse everything that had fallen from Mr. Underdown.

The resolution was carried unanimously.

Mr. UNDERDOWN afterwards proposed the re-election of Mr. James Pender, observing that that gentleman worthily filled a regretted vacancy on their Board, of which he was a most admirable member from his knowledge of the business.

Mr. C. E. GUNTHER seconded the motion, which was unanimously carried.

The CHAIRMAN: In regard to myself, the very kind words which have been used by my old friend and colleague, Mr. Underdown, are very gratifying to me. The honours which have been conferred upon me from time to time I have always accepted as an evidence of the inestimable good which submarine telegraphy has conferred upon humanity. It has been a marked success, and has enormously benefited the commerce of the world, and been a great advantage to it in a political sense. I think that all those who have taken part in it, either as shareholders or in any other way, have reason to be proud of the outcome of this great invention. I hope I may be spared for some time still to carry on this good work, in which I feel the very deepest interest. The past has been, I would say, very successful, and let us hope that the future will be still more successful. In that case I shall feel that I have done my duty to you and to the country at large, and have aided in building up that prosperity which has kept England at the top of the commercial ladder, where I hope it will remain for a long time to come. I beg to thank you again for the honour you have done me in re-electing me.

Mr. W. GRIFFITH, who referred to the excellent way in which the Company's books were kept, proposed the election of Messrs. Deloitte, Dever, Griffiths and Co., and Messrs. J. & J. Sawyer and Co., as auditors for the ensuing year.

The motion was seconded, and unanimously adopted.

Mr. W. GRIFFITH then proposed a vote of thanks to the Chairman and Directors for their able administration of the Company's affairs.

Mr. JOHN NEWTON seconded the motion, which was unanimously adopted.

The CHAIRMAN: I beg to thank you on behalf of myself and colleagues. We get on uncommonly well together. We watch as closely as we possibly can the state of business, and when things are good we rejoice, because we know it will gladden all your hearts; while when things are depressed, we feel regret because we know the state of things is not quite satisfactory to those whose support we crave. Nevertheless, we have to take these ups and downs. We keep your business in a very sound and safe state, however. You see in the reports we present to you how carefully your affairs are dealt with; and I think that our auditors will testify to the fact that our accounts will bear very close inspection indeed. That is what we desire. We feel that, after all, in these times, good book-keeping is a great necessity; in fact, through the absence of good book-keeping there has been more trouble in London in the last few years than one cares to contemplate, and sorrow has thus been brought to many homes. You will have no trouble with respect to our accounts, which "those that run

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may read." I hope that that will always be the case, and if you find us in any way going back in that matter, I hope there will be men among you who will not hesitate to call attention to it. If any fault is pointed out you may depend upon it that we shall only be too happy to remedy it. I thank you very much.

The proceedings then terminated.

United River Plate Telephone Company (Limited).

The following is the report of the Directors of this Company for the year ended March 31st last, which will be presented to the shareholders at the eighth ordinary general meeting, to be held at Winchester House, E.C., on Friday next, at 12 o'clock :—

At par of exchange the gross receipts for the year were £134,076. 15s. 10d., the working expenses in the River Plate £60,874. 0s. 3d., and the loss on exchange £54,124. 17s. 9d., leaving a profit, after the deduction of debenture interest and all other London charges, of £9,782. 4s. 4d. It is proposed to write off £500 against bad and doubtful debts, £500 against the Mendoza Land, £270 premium on the balance of the Seven per Cent. Debenture Bonds paid off, and to transfer to depreciation and renewal fund £3,000, leaving a net balance of £5,512. 4s. 4d. This sum, increased by £905. 13s. (the balance brought forward from last year's account), amounts to £6,417. 17s. 4d., which has been carried forward. The capital outlay for the year was £3,038. 5s. 8d., as against £3,394. 10s. 9d. for the previous year. The plant has been maintained in good and efficient condition at the cost of revenue. Notwithstanding the considerable and unexpected rise in the gold premium, the business of the Company has steadily improved during the year. The Directors feel confident that the shareholders, in view of the continued uncertainty in the affairs of the River Plate, will approve of the action of the Board in carrying forward a substantial balance to strengthen the financial position of the Company.

Mr. J. Irving Courtenay and Mr. George Cooper retire, and, being eligible, offer themselves for re-election as Directors, and Messrs. Cooper Brothers and Co. offer themselves for re-election as auditors.

National Telephone Company (Limited).

The fourteenth annual ordinary general meeting of this Company was held on Wednesday, at Cannon-street Hotel, Mr. James Staats Forbes (President) presiding.

The SECRETARY (Mr. Albert Anns) read the notice convening the meeting.

The CHAIRMAN: I should like to begin by calling the attention of the proprietors to the number of gentlemen interested in the undertaking. At the date of closing the books there were 7,159 holders of shares, and 1,700 holders of debentures, making a total of 8,859 individuals interested in the Company, showing a very wholesome increase upon the figures of last year. A comparison of 14 months—for that is the period covered by the report—with 12 months, involves a good deal of mental arithmetic which you will find it difficult to follow : and in order to prepare you for a real comparison we have appended to the report an extremely useful table called an abstract of accounts. The reason why we are dealing with 14 months instead of 12 months is, as most of you know, because we have decided to hold half-yearly meetings, and in order to bring our financial year into line with the calendar year we have had to make the accounts up to June 30th instead of April 30th. But for the purpose of being able to clearly see what progress we have made we have, in the abstract to which I have referred, divided the sum total with which we have to deal for the 14 months into the 12 months ending April 30th, and the two months from April 30th to June 30th. As the report shows the accounts up to April 30th have all been audited and ascertained. That is equally true of those for May, but as our desire was to hold this meeting as nearly as possible at the regular date we had to estimate the results for June. We were careful to make that estimate a safe one by fixing the amounts well within what we believe they will prove to be. I will now turn to the abstract of the accounts, for the purpose of making a comparison of twelve months with twelve months. You will see by that abstract that the income accrued in respect of the business of the year ending April 30, 1894, was £682,950, against £583,590 in the year ending April 30, 1893, or an increase of about £100,000. Then the working expenses and other charges, excluding debenture and other interest—in fact, the cost of working the undertaking as a going concern—was £311,644 in the year ending April 30, 1893, as compared with £344,168 in the year ending April 30, 1894, leaving a balance of £338,781, against £271,945 for the year ending April 30th, 1893. You will see that that sum of £338,781 is subjected to a rather large deduction in the shape of Post Office royalties. You know we hold a license on the conditions that we pay to the Post Office 10 per cent. of all the gross receipts arising from that part of our business which is called exchange business. In respect of what are called private wires, we are free from this tax. It is an enormous tax that we have to pay the Post Office. For the 12 months in question it comes to £63,254, or something like 2½ per cent. on the ordinary shares. Deducting that amount, it brings the net result for the year which we can appropriate to our own purposes to £275,526 as compared with £217,725, the net result of the preceding year. Now, what becomes of this sum? You will see that for debenture and other interest £48,266 is required, against £40,646 in 1893, and the money needed to pay the dividend we propose for 1894 is £168,957, against £149,367 in the previous year, and then we carry forward £60,496 against £32,000 in the preceding twelve months. The last item in the abstract of accounts is not the least satisfactory. It is that of rentals carried forward for unexpired terms, and it shows that the amount for the year ending April 30th last is £334,985 against £285,020 in the corresponding period. It comes, in fact, to this, that we have in our pockets already £50,000 more money in respect of subscriptions than in the previous year. The report gives the amounts for the 14 months, whereas the figures I have just put before you were for 12 months, in order to show you by comparison with the corresponding figures in the previous year the headway made by the Company. Out of the available balance of £262,311 for the 14 months shown by the net revenue account, an interim dividend at the rate of 6 per cent. per annum on the First and Second Preference Shares, and 5 per cent. on the Third Preference and Ordinary Shares has already been paid. By the next day, if you endorse the recommendation of the Board, you will be in possession of dividend warrants for a further dividend of £3. 6s. 8d., £2. 10s. of which will be for the second six months and the 16s. 8d. for the two months we have brought into these accounts, May and June. When we meet next time it will be a six months' account from June to December, and so on according to the calendar from half-year to half-year. Out of the surplus, the Board proposes to transfer £63,429 to the reserve fund, so as to bring it up to £225,000, and to carry forward £1,765. I think it is wise that proprietors should be fully informed with reference to the capital account, and I will therefore say a few words on this point. You will recollect that last year I explained that for every additional subscriber the capital expenditure was about £42. This year it was somewhat less, but if you multiply £42 by an appreciable number, suppose we say 10,000, and that goes on, as it does, from year to year, it means that every year, in order to get a larger income, we must put down large sums of ready money to provide the necessary extensions of machinery. If you look to the capital account you will see that the expenditure stands thus, as per last account, £4,023,021. During the period under review we have spent on land, buildings, and machinery £33,260 : on the purchase of the Telephone Company of Ireland (Limited) and the Home Telephone Company (Limited) £101,039 : and on construction of exchange, trunk and private lines, &c., £306,006, making a total of £4,463,327. You may take it that the capital expenditure for the purchase of other undertakings is now practically at an end. The responsibility of spending such large sums of money rests with the Board, but men who fill positions of this sort must have the courage of their convictions, and act on their best judgment, and that we do scrupulously ; and I might almost say religiously, but perhaps it is better not to drag religion in. It must at least be very satisfactory to the proprietors to find that the money we have spent has been immediately profitable. Paragraphs 9 and 10 of the report are, I think, of general interest. In paragraph 9 you are informed of the position in which we now stand with the Post Office in respect of the agreement under which we have undertaken to hand over to them the trunk lines of the Company while we continue the Exchange business. It is difficult for us on this side of the table to see the advantage of carrying on the business under two umbrellas instead of one, but we were in the position of having to agree to the arrangement, not because we liked it, but because we could not help ourselves. It is very easy to draw up the heads of an agreement and to express them in simple language, but I hope I shall not be wounding the susceptibility of any lawyer in the room if I say that lawyers have a happy knack of clouding simple phrases with dark interpretations. Therefore, it has taken two years to find out what those heads of agreement meant, because when you come to details in a business like this, made up of two factors—the known, and largely the unknown—it is difficult to deal with them. I am bound to say that the Postmaster-General and all the officials downwards have shown great regard for fair action in the matter. Happily we have now come to a conclusion in this affair, and the Postmaster-General is, I believe, now free to submit this agreement to the confirmation of the House of Commons. We, of course, are advised that the agreement is already in existence, having been signed two years ago on behalf of the Government, and this Company, and I can apprehend no such possibility as any serious objection being raised on the agreement itself by the House of Commons. Therefore, I suppose, very shortly we shall move on the new lines. What the result will be what man can foretell? We cannot. But if there are difficulties to be overcome there is only one way to overcome them. This is a Company which must be worked in the interest of the public first and then of the proprietors, and it is our duty to make the telephone service of this country the best in the world, and there will be neither skill nor money wanting on our part to achieve that result. I am sure you will be glad to hear, as stated in paragraph 10, that we are carrying out the redemption of our existing debenture debt. It seems fortunate that the Money Market has remained so long in a state to make it possible to convert that debt from Four and a-Half per Cent. Debenture Stock to Three and a-Half per Cent. Debenture Stock. It is done, of course, at some sacrifice, because we have had to redeem it at 110 ; but when it is completed the saving of 1 per cent. in interest on a million of capital will be of great importance. As you will see by the report, four of the Directors retire, and, being eligible, offer themselves for re-election. Without saying anything further I will now move :—

"That the report and accounts be received and adopted, and that dividends be paid for the eight months ending June 30th last year, at the rate of 6 per cent. per annum, less income-tax, on the First and Second Preference shares ; 5 per cent. per annum, less income-tax, on the Third Preference and Ordinary shares ; making, with the interim dividend paid on December 22, 1893, a dividend at the rate of 6 per cent. per annum on the First and Second Preference shares, and 5 per cent. per annum on the Third Preference and Ordinary shares, for the fourteen months ending June 30, 1894."

Lord BALFOUR of BURLEIGH, in seconding the resolution, said his connection with the Company during the past year had confirmed the

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favourable opinion he expressed at the last meeting as to the manner in which the business was carried on, and the prospects awaiting the Company. The question of giving an efficient service to London had specially engaged the attention of the Board during the past year, and he thought he was entitled to say there never had been a time when the efficiency of the service in London was as satisfactory as at the present time. He believed it had been greatly improved during the last 12 months, and it would be the continuous effort of the Board to improve it as much as possible. They frequently saw in the papers complaints from people who were subscribers to the telephone in London. In his opinion they could hardly make a fair comparison between London and other communities, on account of its size and the concentration of business in one part. If they could show that the telephone service given in London, with all these difficulties, was provided at a rate not only as reasonable, but more reasonable than in many other communities where the service might be expected to be cheaper, he thought they would have made a point to the credit of the Company. Now he took the first four cities in America, and he found that in New York the annual payment was £56, in Boston £37, in Chicago £25, and in Philadelphia £25—in every case considerably higher than the charge in this metropolis. Looking on the Continent of Europe he found that in Paris the charge was £16, without instruments, which might be taken as adding 40s. to that sum. He believed that outside critics often failed to make sure that they were comparing like with like in making their comparisons. In St. Petersburg the annual charge was £39. 11s., and the same in Moscow, and in these places on the Continent, if he were rightly informed, there were no royalties to be taken into account. He desired to endorse the statement of the Chairman that it would be their desire to assist the Post Office in working under the new arrangement. It struck him that as partners with the Post Office they would come into contact most with the customers, and, therefore, if anything went wrong receive all the censure. If they were to receive criticism, he hoped it would not be forgotten that there were two partners to the business, and that it did not follow that the one readiest to hand deserved it most. It was possible they might deserve some criticism, but he hoped it would be divided fairly.

Mr. GALBRAITH called attention to the letter written by the Postmaster-General on the 6th inst. to Mr. Henniker Heaton, M.P., in which he said: "On the termination of the license in December, 1911, the right of the National Telephone Company to carry on telephone exchange business will cease. All they will have to sell will be their plant, and even this the Government will be under no obligation to buy." He should like to hear what the Chairman's views were with regard to that communication. Alluding to the reserve fund, he urged that it should be invested in Consols, and be available for the equalisation of dividends amongst other purposes.

The CHAIRMAN, in reply, said: The answer of Mr. Arnold Morley to Mr. Henniker Heaton is literally true, but there are some truths which are a good deal qualified by considerations and circumstances. The statement that all we shall have to sell will be our plant is not true in fact. Mr. Arnold Morley, when he wrote this letter, believed it was; but he did not consider the fact that a large portion of our profit is made on private wire business, which is a growing quantity. At the end of eighteen years, which our lease has to run, if we know our business and play our game properly, that business will be a hard nut for the Post Office of the day to crack. Possibly by 1911 it will be worth £200,000 a year. That would be something to sell. But there was something else. Long before then the Government will have to make up their minds whether they will take over the exchange business. If they decided in the affirmative what will be the rational course for them to pursue? Will they six, or even ten years before the moment arrives, embark upon the enormous expenditure of erecting machinery and plant to supersede that belonging to our Company for the purpose of knocking down the price of our business? The idea is so reckless that one cannot believe it will enter into the mind of any responsible person. I do not believe that a great public department like the Post Office will be so lost to a sense of their duty to the taxpayer, and of fairness to this Company as to spend huge sums of money in order to confiscate our property. In reply to Mr. Galbraith's question about investing the reserve fund in Consols I may say that now that we can borrow money at 3½ per cent., instead of 4½ per cent., as formerly, the objection to putting our reserve fund into Consols has to some extent vanished. The feeling of the Board is inclined very much to the desirability of doing so, sooner or later, probably sooner than later, but we want to see our way out of this Post Office affair first.

Mr. LEAK and Dr. GALE having made a few remarks, the resolution was carried.

On the motion of the CHAIRMAN, seconded by Lord BALFOUR of BURLEIGH, resolutions were passed making the necessary alterations in the Articles of Association in view of the intention of the Board to hold half-yearly meetings.

Mr. G. Franklin, Mr. W. Cuthbert Quilter, M.P., Mr. W. A. Smith, and Mr. Alderman Joseph Thompson were then re-elected as Directors; and Messrs. Welton, Jones and Co. were reappointed auditors.

A vote of thanks to the Chairman terminated the proceedings.

Edison and Swan United Electric Light Company (Limited.)

The annual meeting of this Company was held on Thursday, at Cannon-street Hotel, Mr. James Staats Forbes (Chairman of the Directors) presiding.

The SECRETARY (Mr. H. Charles Gover) read the notice calling the meeting.

The CHAIRMAN said: This is rather an interesting meeting, as being a new departure. Either by being present at the meeting or reading the proceedings, the proprietors of the Swan and Edison and Swan Companies are familiar with what has recently taken place. As from October 1st, I believe it was, of last year the United business came into operation, and the accounts now before you embrace that united business as from that date. By looking at the accounts you will see what the result is. There is very little to be read in the report itself beyond the mere fact that such and such things have been done, and the Companies have been fused wholly instead of partially; that interest has accrued upon the £100,000 Debenture Stock for three-quarters of a year under the agreement; and that the whole of the assets and business of the Swan Company outside England has been handed over; and certain particulars as to the first result of the United Company. It is a new departure also in the sense that having emerged from the shelter and protection of our patents we are now in open competition. We have a great many extremely keen rivals, and it seems, to us at all events, prudent that we should follow the example of ordinary traders and keep a good deal of our knowledge to ourselves. I daresay there are a great many people, interested parties, who would very much like to know what our business is, where it is, where our customers are, and where we make our profits. We do not think it expedient to reveal that information to them. I do not know whether that will be your feeling. It is ours, very strongly. The accounts reveal a good deal, but they only show general results; and I propose, with your permission, to go through them, and dwell upon one or two of the most salient points. First of all, I must remind you that the present position and outcrop has been anticipated for some time. At the last meeting, about twelve months ago, I had occasion to forewarn you of what would arise when our patents expired in November, that of necessity it must be followed by a large reduction in the price of the lamp. As you know, during the period our patents ran we were entitled to try and get back in the shape of dividends what money our patents had cost us. In a certain sense it has come back, although not quite in the degree which might have been anticipated. We paid off all the arrears due to the "A" shareholders, the 7 per cent. accumulated over a term of years, and we carried forward a balance for the benefit of the united concern in the future, and we have now taken over the whole of the stocks of the other Company. The profit and loss account will reveal where we are. You must bear in mind that there is a great difference between 2s. 9d. or 3s. for a lamp and 1s. The cost of production nor of administration diminishes, and therefore what we have to look forward to is the character of our lamp, and large connection; the admirable appliances we have at hand, and, amongst other things, our very large stock. As far as it goes that is the protection of this Company now. We have ascertained beyond question that the types of lamps are so numerous, and the gradations of quality are so nice and subtle that a very large stock of lamps must be kept in hand to supply all our customers. One man wants a lamp to be fixed subject to a current of a certain pressure at one part of a building, or at a diminished or increased pressure of current somewhere else, and that means the adaptation of the lamp to the pressure which reaches it. If the lamps are put in the wrong place they perish rapidly. All that is a matter which our experience has evolved, and we have had to lay ourselves out for it, but this in itself gives us a distinct advantage over any small manufacturer. In fact a small manufacturer cannot live at it, because to compete with us he is obliged to lock up in plant and stock £127,000, that being the figure which you see our plant and stock stands at in the balance-sheet. That figure represents not only lamps but platinum and other material on a large scale. We have established two depots in London and ten in other places, making twelve in all. Each of these places has to be furnished with a stock of all kinds of lamps and fittings to be at the disposal of anyone who likes to go in to inspect them and give an order. The stock on hand on July 1, 1893, was £63,349, and you will see, on the opposite side of the profit and loss account, that on June 30, 1894—that is, at the termination of the book year—it had risen to £87,768. That increase arises from the fact that we have taken over the stock of the Swan Company, part of the purchase for £100,000 of their residuum and their going business. Then, as you will find by the account, there are the items for wages, purchases, &c., for £102,599; salaries, Directors' remuneration, rent, office expenses, insurance, income-tax, general and law charges, £11,651; and depreciation on plant, &c., £9,451, leaving a balance of £34,400. This balance is the difference between the value of the stock and the costs incurred in production to keep the stock up to replace sales during the year. On the other side of the account you will see that the returns by the sale of lamps, fittings, royalty on holders and interest, &c., amount together to £133,663. The share account stands pretty much as it did last year, with the addition to the balance sheet of £100,000 Four and a-Half per Cent. Debenture Stock—the purchase price of the Swan residuum. The reserve fund stands at £72,760, and the sundry credit balances, which is a floating quantity, at £26,269, against debtors on the other side of the balance-sheet amounting to £40,970. After deducting from the balance of £34,400 the sum required to pay the interim dividend paid on March 20, 1894, there remains £25,563. From the statement showing the proposed appropriation of payments, you will observe that to payment due on Four and a-Half per Cent. Debenture stocks for the nine months ended June 30, 1894, £3,375 is appropriated; for the payment of an interim dividend of 5 per cent. per annum on the "A" shares for the half-year ended December 31, 1893, £8,836; to the payment of a dividend of 7 per cent. per annum for the half year ended June 30, 1894, £12,371; and to the reserve fund, £9,816. During a portion of the past year we were working we were still protected, and the money benefit of that was between £16,000 and £17,000. We are not afraid of competition. So far we have managed to hold our own, notwithstanding the eagerness

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with which lamps were pressed into England from different places in anticipation of our patents running out. We have sold about the same quantity of lamps as we did before competition commenced, and we have obtained a price for them somewhat in excess of that which our competitors got, because we have a character as well as a lamp. There was a marked depreciation in the profit per lamp, but we hope to make up for that by increased sales as the development of the trade goes on, as no doubt it will. I need scarcely point out that two millions of lamps sold at a particular profit will produce as much dividend as a million sold at a larger profit. That is what we have to rest upon, and without, of course, being too prophetic or wishing to excite undue hopes, I think I may say we know enough of this business now to justify the conviction which we feel that this is a sound commercial business, with a good future before it. We could easily have paid a 7 per cent. dividend for the year, but we thought it more prudent to start as we hope to go on. If in the coming time the profits should increase to such an extent as to justify a larger dividend, we shall have the opportunity of taking your advice upon the subject. It might, perhaps, be prudent a little further on to apply a portion of our profits from year to year to the redemption of some of our capital, but that is a matter not immediately concerning us at present. We have some investments, more or less good, brought into this balance-sheet for the first time, namely, the shares in La Compagnie Générale des Lampes Incandescentes, £30,489. They may be worth more, but it is certain that they will not be worth less, because at the end of this year we have the option of going on in that Company, or giving it up, and by liquidation or arrangement recovering our portion of the value of the asset. We have made up our mind, and have communicated our feeling to the proper quarter, that it will be much better for us to be free all over Europe to sell lamps than to remain partners in this French Company, subject to the existing condition that we shall sell no lamps on the Continent except in Germany. You will see what that means. Supposing there should be a small sacrifice on the capital as it stands, in the liquidation or arrangement, we should recover our freedom for the sale of lamps over the whole of Europe as a compensation, and as we believe with our appliances we can produce lamps in large quantities in London more cheaply than they can be manufactured even in Germany, I think we shall have a good chance of establishing a big export trade. Then in addition to £40,912 in freehold property we have an investment of £25,000 in the National Telephone Company, Five per Cent. Non-cumulative Third Preference Shares. Happily these shares are now at a premium, and instead of £25,000, which the shares cost, they are now worth £27,000. Then there is cash in bankers and in hand £39,360, a considerable portion of which, after paying the dividend we now recommend, we propose to invest in some substantial security. I will now move:—

"*That the reports and accounts for the year ending June 30, 1894, be received and adopted.*"

Major FLOOD PAGE (Deputy Chairman) seconded the motion, and remarked that owing to the improved condition of their business requiring more space than they had in Victoria-street, the Company would be moving into Queen-street, Cheapside, in the course of the next few weeks.

The motion was agreed to unanimously.

The CHAIRMAN then proposed :—

"*That a dividend be, and is hereby declared on the "A" Shares of the Company, of 2s. 1¾d. per share on the 89,261 Ordinary Shares, £3 paid; of 3s. 6¾d. per share on the 5,000 £5 fully-paid shares allotted to the Edison Electric Light Company (Limited); and of 3s. 1¾d. per share on the 12,139 £5 fully-paid shares allotted to the Swan United Electric Light Company (Limited); being together with the interim dividend paid on March 20, 1894, 6 per cent. in respect of the year ending June 30, 1894. All to be distributed in accordance with the provisions of Clause 87 of the Articles of Association; less Income-tax.*"

Major FLOOD PAGE seconded the resolution.

A SHAREHOLDER inquired whether as a Swan shareholder he participated in the present dividend?

The CHAIRMAN: You are a shareholder in the Edison and Swan Company, because as a Swan shareholder you hold 60 per cent. of its capital, or rather your Directors hold it for you. It acts individually in this way: You are also now, in virtue of the recent agreement, entitled to a portion of the £100,000 Debenture Stock which has been paid for the residuum of your property not included in the Edison and Swan Company previously, and when matters are in order you will receive, not Swan shares—they will be cancelled—but shares in the Edison and Swan proportionate to your holding, plus your proportion of the £100,000 of debentures, plus the dividend.

The resolution was unanimously carried.

Major FLOOD PAGE then moved, and the EARL of LICHFIELD seconded, the re-election, as a Director, of the Chairman, which was agreed to with acclamation.

On the motion of Mr. DEED, seconded by Mr. J. W. SWAN, Messrs. Welton, Jones and Co. were reappointed Auditors.

The following is the Directors' report above referred to:—

In accordance with the agreement entered into with the Swan United Electric Light Company (Limited) the foreign business and assets of the Swan United Company have been taken over as from October 1, 1893, and the accounts now presented include such business and assets, in addition to the British business of the Edison and Swan Company itself. After providing for the interest accrued upon the £100,000 Debenture Stock there remains a balance of £31,025. 3s. 3d. available for distribution on the share capital. The Directors recommend the payment of a dividend as follows (less income-tax):—On the 89,261 Ordinary shares, 2s. 4¾d. per share; on the 12,130 fully-paid "A" shares, allotted to the Swan United Company, 3s. 1¾d. per share; on the 5,000 fully-paid "A" shares allotted to the Edison Company, 3s. 6¾d. per share. This distribution, together with the interim payment already made in respect to the first half-year, make up 6 per cent. for the entire year. Warrants will be posted on August 3rd.

The business of the Company, thus united, has resulted in a credit balance of £34,400. 3s. 3d.; of this, £8,856. 19s. was distributed on March 20th last, as an interim payment on the "A" shares. The Directors recommend a further distribution of £12,371. 14s. 7d. on the "A" shares. This, with £3,375 interest on debenture stock, will absorb £24,583 13s. 7d., leaving £9,816. 9s. 8d., which the Directors have carried to the reserve fund. The Directors consider the result as satisfactory, and also that the volume of business has increased during the year, in the face of active opposition in the lamp business since the expiration of the key patent in November last. The diminution of the money value of the sales is entirely due to the serious reduction in the price of the lamp.

Telegraph Construction and Maintenance Company (Limited).

In accordance with the resolution of the general meeting of February 28, 1871, a half-yearly general meeting of this Company was held at 38, Old Broad-street, on Tuesday, under the presidency of Admiral Sir G. H. Richards, K.C.B.

The MANAGING DIRECTOR (Mr. William Shuter) read the notice calling the meeting.

The CHAIRMAN: Gentlemen, your are aware, I know, that at these half-yearly meetings we do not produce any accounts to you. In point of fact, there is really no business of the Company to be transacted, but at the same time we are exceedingly happy to meet you and to tell you anything that may be of interest in connection with the prospects of the Company for the present year. In the first place, as you know, we have declared a dividend of 10 per cent. for the half-year, or 12s. per share. In regard to the work that we have done in the past half-year, it has been a very large amount, and we are quite satisfied ourselves with it, and therefore hope that you will be. I may say that we have laid a cable from Singapore viâ Borneo to Hong Kong in China. That is a long cable. We did this work for the Eastern Extension Company at the beginning of the year by two of our ships. Since then we have manufactured an Atlantic cable for the Anglo-American Company, a cable between Ireland and Newfoundland; and at the present moment our ships are engaged in laying it, and I hope that in the course of a few days this will be successfully accomplished. That is a very fair amount of work, as you may know. In a Company like this we cannot give you any correct information as to what we may do for the remainder of the year. Sometimes we do all our work in the first half-year, sometimes we do it all in the last half, and sometimes our work extends throughout the year. We manufacture things which are not of every-day use, and it is impossible to say what we may do for the rest of the year. We cannot tell you unless we have a contract signed, or otherwise it would be mere prophecy, and I do not think it would be right for the Directors to commit themselves to what may be an uncertainty. There are certain risks in this Company, but hitherto we have been very fortunate, and have been able generally at the end of the year to give you good accounts in our reports. I have every reason to hope that we shall give you a good statement this year. I am very pleased to be able to inform you that we have done so much in the past half-year, for which, I repeat, we are satisfied, and as I have said, I hope that you will be. I do not know that I can add anything further, but if you have any questions to ask me I shall be very glad to answer them.

Mr. CROFT: I have been a shareholder in this Company for a great many years—a great many more years than I care to remember, and I am sure that the announcement you have made to-day will be regarded as very satisfactory. In saying this I feel that I am only expressing the views of all the shareholders, not only of those who are present, but also of those who are absent. As I say, I have been a shareholder for a great many years, and I have never said or done anything which could in any way embarrass the Directors of this Company. On the contrary, I have on several occasions, I hope, supported the policy of the Board when it has been somewhat adversely criticised by the shareholders. There is, however, one subject to which I desire to allude to-day. It is a somewhat painful one; but I feel it my duty, nevertheless, to refer to it. I had intended to bring it forward at the last meeting in March, when there would have been a fuller meeting of the shareholders, but I was unable to do so, and I am now glad of it, because since then matters have developed themselves in a rather startling form, I might say. The matter I allude to is this: I hold in my hand the original prospectus of a company which has become notorious of late, and into the conduct of the Directors of which an investigation is at the present time going on. In the prospectus I find the name of one of your Board, whose name is paraded as Vice-Chairman of this Company. That gentleman has been examined on oath, and has stated that he is not related to any of the gentlemen whose names have been so notoriously connected with that Company. I therefore most loyally and cordially accept that statement; but it is a very curious coincidence, no doubt, and must have struck many others besides myself. What I do say, however, is that his name has been paraded in that prospectus, which was issued to the public, and among others to myself, and I was greatly influenced in taking shares in that Company by seeing the name of that gentleman published in the prospectus. His name appeared as Vice-Chairman of this Company—a Company which everyone will admit is one of the most successful in the City of London. When a member of another Board is put forth in that way the only object of it could be to attract the public, and to say, Here is a gentlemen who is going to act on this Company who is already the Vice-Chairman of one of the most successful companies in the City of London. What I say is, that

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gentlemen ought to be very careful indeed when they allow their names to be used in this way. As I said, I was myself influenced in taking shares in that Company by seeing that the name of the gentleman to whom I am alluding was connected with it. You might say that I ought to have made more careful inquiries, and the profession to which I belong does induce caution; but we have seen in this very case that there was another gentleman belonging to the same profession who was attracted in a similar manner. I think that many would be influenced as much as anything as by the fact of seeing the name of the gentleman who is the Vice-Chairman of this Company put forth as a Director of that Company. Probably the hon. gentleman himself regrets his connection with that Company, perhaps no one more than he. I acquit him of any sort of mismanagement of that Company. I believe that he left the management, as the other Directors did, to one gentleman, who I believe is solely responsible for what has happened. I trust that in the future no gentleman will allow his name to be put forward in this way without duly considering what the effect may be upon the public, because it is really a very serious thing indeed.

The CHAIRMAN: I am sure we are here all perfectly satisfied as to the part which Mr. Rawson has played in this matter; but I am sure that you would like him to explain it himself.

Mr. P. RAWSON: I do not propose to enter into any long explanation. I am quite ready to admit that I am heartily ashamed of any connection I have ever had with the Company referred to. I originally lent money to the particular gentleman to whom you allude, and I was persuaded to look after my own interests, feeling that while I was doing so I was also looking after the interests of others. The result has been what you know. I have lost a considerable sum of money, and am as great a sufferer as anyone. I may say that I am perfectly sure that not a single member of the Board of that Company has profited to the extent of a shilling as a Director of it. The examination is going on to-day, and I believe it will be for the last time; and I hope it will be found that we are all acquitted of having done anything contrary to the strictest integrity. I left the Company some time ago. I did not like what I saw going on, and it is more than two years ago since I withdrew from it, and I withdrew on the score of not having sufficient information laid before me.

The CHAIRMAN: I do not think we have anything more to tell you, and I am very glad that we have been able to tell you what we have done on the present occasion.

Mr. CROFT: Before we part I propose a vote of thanks to you and your colleagues for the successful way in which you have conducted the affairs of the Company.

Mr. THORNTON: I will second that.

The motion was unanimously carried.

The CHAIRMAN: Gentlemen, I thank you very much for your kindness. We appreciate your thanks very much. We have done our best to earn them, and we shall continue to do so.

The proceedings then terminated.

Globe Telegraph and Trust Company (Limited).

The following is the Directors' report to be presented to the twenty-first ordinary general meeting, to be held at Room 174, Winchester House, Old Broad-street, E.C., to-morrow (Friday), the 27th inst., at 1 p.m.:—

The net revenue of the Company for the year ended July 18, 1894, after deduction of expenses, amounts to £185,076. 13s. 9d., and makes, with the balance of £1,304. 17s. 9d. brought forward, a total of £186,381. 11s. 6d. From this amount there has been distributed the sum of £125,955. 16s. 1d. in interim dividends, leaving an available balance of £60,425. 15s. 5d. The Directors recommend the payment of a final dividend for the year of 3s. per share on the Preference shares, and of 3s. 9d. per share on the Ordinary shares, making, with the previous distributions, a total dividend for the year of 6 per cent., less income-tax, upon the Preference, and 4½ per cent. net (against 4⅝ per cent. for the preceding year) upon the Ordinary shares, and carrying forward a balance of £527. 2s. 4d.

The £62,000 Six per Cent. Debentures of the Direct Spanish Telegraph Company which were held by this Company, matured May 1st last, and were paid off. Part of this money, viz., £16,989. 1s. 9d., has already been invested as follows:—300 shares in the Western Union Telegraph Company, 250 shares in the American Cable Company, 22 certificates in the Submarine Cables Trust, 354 Ordinary shares in the Direct Spanish Telegraph Company, 346 Preference shares in the Direct Spanish Telegraph Company. The remainder will be reinvested in suitable securities.

In conformity with the Articles of Association, Lord Sackville A. Cecil and the Marquis of Tweeddale, two of the Directors, retire, and, being eligible, offer themselves for re-election; as also do the auditors, Messrs. Deloitte, Dever, Griffiths and Co., and Mr. William Griffith, B.A.

Chili Telephone Company (Limited).

The Directors' report to be submitted to the annual general meeting to be held at Winchester House, London, E.C., on Tuesday, the 31st inst., at 11.30 a.m., is as follows:—

The small addition to the tariff made towards the end of 1893 caused some subscribers to withdraw, but others have taken their places, so that the aggregate in all centres was 3,987 at the end of the year 1893-94, only 37 less than at the beginning of that year. By this increase of rates the revenue has been augmented, notwithstanding the smaller number of subscribers. The income for the year was $504,188, and that of the former year $448,661—increase $55,527. The further depreciation in the sterling value of the currency, in which the Company is paid—from 18d. per $ in 1892-93 to about 14d. for the subsequent year—has deprived the Company of all benefit from this increase of revenue. It has also increased the outgoings—many more dollars having to be given for the same services; hence the net income was—For the year 1892-93, $184,673; for the year 1893-94, $179,652—decrease, $5,021. In sterling the diminution of net income is more marked, being—At 18d. per $ in 1892-93, £13,850; and at 13·96d. per $ in 1893-94, £10,448—decrease in net income, £3,402. From this net income of £10,448 the interest on debentures and other expenditure in London are deducted, amounting to £4,943, which varies little from the aggregate of similar items in the previous year. The loss by the reduction of exchange in the sterling value of the liquid assets and liabilities in Chili amounted to £1,979, being less by £1,616 than the corresponding item in the former year. The net profit of the whole business was: In 1892-3, £5,393; in 1893-4, £3,528; diminution, £1,865. This net profit of £3,528 has been added to the reserve fund. The cash is not available for distribution, having been used for capital purposes instead of raising that sum by the issue of further capital.

The difficulty in raising the tariff has been greater than the Board anticipated. The Manager in Chili writes thus: "The revenue has been affected by the general depression of business and poverty of the people. As it is impossible for any country to experience a long-continued and severe depreciation of its currency without each individual feeling more or less the evil effects, the inevitable consequence in the present case has been a general attempt to reduce expenses. It must be remembered that the greater number of the subscribers are Chilians, and with the exception of important business centres, such as Valparaiso and Iquique, the telephone is, more or less, a luxury; and to dispense with the annual charge which keeping it involves has appeared to be one of the first economies practised." The Board has, however, instructed the manager to make a further considerable addition to the tariff, at the risk of losing some subscribers; for it must be better to do a small but fairly profitable business than a large unprofitable one. As full notice of changes must always be given, it is not likely that much benefit will accrue from this before the beginning of 1895.

The Chairman, Colonel R. R. Jackson, retires, and the Board does not propose to fill the vacancy at present. The auditor, Mr. Thomas A. Welton, also retires, and offers himself for re-election.

An extract from the Manager's Report, dated Santiago, May 18th, accompanies the Directors' Report.

City and South London Railway Company.

The following is the report of the Directors of this Company to be submitted to the half-yearly ordinary general meeting, to be held at Winchester House, Old Broad-street, E.C., on Wednesday next, August 1st, at three o'clock:—

The receipts from all sources for the past half-year have amounted to £24,294. 17s. 6d., and the cost of working has been £14,990. 3s. 2d., leaving a profit of £9,304. 14s. 4d. Inclusive of the balance brought forward from December 31st last the net revenue account shows an aggregtae total of £10,368. 8s. 2d. After making provision for the debenture and debenture stock interest, a balance remains available for dividend of £6,295. 17s. 10d. Out of this sum your Directors recommend that the full dividend of 5 per cent. per annum be paid on the Preference shares, and that a dividend at the rate of 1 per cent. per annum be paid upon the Consolidated Ordinary stock, leaving a balance of £1,335. 17s. 10d. to be carried forward to the next account.

The following table shows the number of passengers, exclusive of season ticket holders, carried since the opening of the railway in each half-year:—

	No. of passengers (exclusive of season ticket holders).	Receipts (including season tickets).		
Ended Dec. 31, 1890 (11 days)...	165.000	£1,568	3	9
„ June 30, 1891	2,412,343	19,403	6	9
„ December 31, 1891	2,749,055	19,798	16	6
„ June 30, 1892	2,813.162	20,931	4	2
„ December 31, 1892	3,117.602	22,002	17	5
„ June 30, 1893	3,146,656	22,458	6	9
„ December 31, 1893	3,093,351	22,067	14	10
„ June 30, 1894	3,383,154	23,564	10	6
Total since opening of the line	20,830.323	£151,795	0	8

The Directors have great satisfaction in stating that the increased traffic has been carried punctually, and free from accident of any kind. The closing of the Oval for football militated against the traffic for the first three months of the half-year, but subsequently there has been a satisfactory increase. The actual cost of working the line for the past half-year has been somewhat less than for the corresponding period last year, but the Directors regret that the local rates again show a marked increase.

The locomotives, rolling stock, generating and other plant have been maintained in thorough working order and repair, as certified by the engineer. The alterations at the City Terminus are complete, and the additional accommodation thus obtained is a great convenience, especially on occasions when the traffic is heavy. The parcels office and left luggage room are in operation, and promise to be a remunerative source of revenue.

During the half-year £8,200 of the Terminable Mortgage Debenture Bonds have been paid off and reissued as Debenture stock, or Preference shares, at a premium.

The Directors have instructed the Company's engineer to make experiments with the view of substituting motors on the train itself in place of the present separate locomotive, with the object of adding an additional coach to each train. Should this change prove practicable the number of passengers capable of being carried will be considerably augmented.

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NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1894, pages 274-300, *&c., &c.*]

BRITISH AND FOREIGN ELECTRIC AND ENGINEERING COMPANY (LIMITED).—This Company was registered on July 23rd with a capital of £2,000 in 50 Founders' and 1,950 Ordinary shares of £1 each, to carry on the business of manufacturers of and dealers in electric, telegraphic, surgical and scientific instruments, contractors for the sale, letting on hire, erection, and maintenance of and dealers in and suppliers of electrical engineering and other goods, and apparatus connected with the production of light, heat, power, or other force, electrical, mechanical, metallurgical and chemical engineers, electricians, electrical contractors, suppliers of electricity, merchants, &c., and also the general business of an electric light company in all or any of its branches. The subscribers (with one share each) are:—Harry E. Hopperton, Avando W. Hussey, Stanley W. Kelsey, Frederick Cottrell, William R. Reeve, Gordon R. Kelsey, and James A. Remon.

ELASTIC ENAMEL PAINT COMPANY (LIMITED).—This Company has been registered with a capital of £2,000 in £1 shares, to adopt an agreement, for the acquisition by the Company of certain letters patent relating to a new or improved composition or paint, to be used for coating and preserving metal, wood, and other substances and materials.

HARDWICK'S PURINE SYNDICATE (LIMITED).—This Company has been registered with a capital of £1,000 in £1 shares, to carry on business (*inter alia*) as chemical manufacturers, civil, mechanical, and electrical engineers, &c.

JOHN MILLS AND SONS (LIMITED).—This Company was registered on July 18th with a capital of £25,000 in 2,000 Ordinary, and 500 Five per Cent. Preference shares of £10 each, to carry on the business of brass founders and finishers, coppersmiths, tinsmiths, mechanical engineers, metal workers, machinists, metallurgists, electrical engineers, &c.

PATENT ENAMEL COMPANY (LIMITED).—This Company has been registered with a capital of £60,000, in 5,000 Preference shares of £7 and 10,000 Ordinary shares of £2. 10s. each, to acquire the business, goodwill, &c., of the Patent Enamel Company (Limited), incorporated 1883, and to carry on business as enamellers and enamelled plate and hollow-ware manufacturers.

WRAY ELECTRICAL ENGINEERING COMPANY (LIMITED).—This Company was registered on July 21st with a capital of £10,000 in £1 shares, to acquire the goodwill of the business of electrical engineers carried on at Bradford, under the style of the Wray Electrical Engineering Company, and to carry on the business of electrical and mechanical engineers, brass and other instrument makers, model makers, joiners, and dealers in electrical and mechanical goods. The subscribers (with one share each) are:—Cecil Wray, Joseph A. Jessop, Walter Ward, Harry Fox, William Wray, Richard Smith, and Frank Wall. Joseph A. Jessop and Cecil Wray are to be the Managing Directors for a period not exceeding two years.

FROGGATT'S ELECTRIC LIGHTING COMPANY (LIMITED).—The statutory return of this Company, made up to May 18th, was recently filed. The whole capital of £3,000 in 1,500 "A" and 1,500 "B" shares of £1 each has been taken up, of which the "B" shares were issued as fully paid to Thomas Froggatt. The full amount has been called and paid on the "A" shares, of which 1,493 are held by Messrs. Murrieta and Co., of 7, Adam's-court, Old Broad-street, London, E.C. A special resolution filed on May 29th had for its object the raising of the capital to £60,000, and the empowering of the Directors to purchase from Thomas Froggatt all the patents obtained by him up to the present time in and connected with electric lighting, together with the right to all improvements therein.

FROGGATT'S INVENTIONS SYNDICATE (LIMITED).—This Company is now defunct.

GREENWOOD AND BATLEY (LIMITED).—The annual return of this Company, made up to June 30th, has been filed. Out of a nominal capital of £400,000, divided into 14,000 Preference and 26,000 Ordinary shares of £10 each, 11,066 Preference and 18,052 Ordinary shares have been taken up, of which 2,666 Preference and 4,666 Ordinary shares have been issued as fully paid. Upon 6,934 Preference and 12,134 Ordinary shares the fully amounts have been called, while upon the remaining 1,466 Preference and 1,252 Ordinary shares calls amounting to £3 per share have been made, resulting in the payment of £198,834.

HOBART ELECTRIC TRAMWAY COMPANY (LIMITED).—The annual return of this Company, made up to December 31, 1893, has only recently been filed. Out of a nominal capital of £105,000, in £1 shares, 45,000 shares have been taken up, and 20,000 issued as fully paid. The full amounts have been called and paid on the remaining 25,000 shares. Share warrants to the total value of £1,250 are now outstanding.

INTERNATIONAL ELECTRIC SUBWAY COMPANY (LIMITED).—The annual return of this concern, made up to August 15, 1893, was not filed until the 9th inst. Out of a nominal capital of £25,000 in £1 shares, 21,857 have been taken up, and of these 20,000 have been issued as fully paid. Upon the 1,857 remaining shares the full amount has been called, resulting in the payment of £1,850, and leaving £7 in arrears.

IPSWICH ELECTRICITY SUPPLY COMPANY (LIMITED).—This Company has now ceased to exist, on account of the Board of Trade withdrawing the Order granted by them for the purpose of supplying the town of Ipswich with electricity, as the Company could not find the deposit of £800 required.

LONDON UNITED TRAMWAYS (LIMITED).—This Company has been registered with a capital of £50,000 in 2,500 Six per Cent. Cumulative Preference and 2,500 Ordinary shares of £10 each, to acquire the tramways undertaking and assets of the West Metropolitan Tramways Company; to purchase or construct tramways in the United Kingdom; to equip, maintain, and work with horse, steam, electric gas, or other mechanical power the tramways belonging to or leased by the Company, &c.

GEORGE MORITZ (LIMITED).—The annual return of this Company, made up to February 26th, has just been filed. Out of a nominal capital of £5,000 in £1 shares, 1,009 have been taken up, of which 1,000 (which are now vested in Mrs. Moritz), were issued to George Moritz, electrical engineer, in part consideration of the business of the Manchester and Liverpool Electrical Engineering Company, carried on by him. The full amount has been called and paid on the remaining 9 shares.

CITY NOTES.

CITY AND SOUTH LONDON RAILWAY.—The traffic returns of this Company for the week ended July 22nd were £839, as against £764 in the corresponding period of 1893, being an increase of £75. The total receipts for the half-year amount to £2,600, as against £2,609 for the corresponding period of 1893, a decrease of £9.

DISTRICT MESSENGER SERVICE.—Several alterations have been recently made in the management and direction of this Company, and applications have been invited this week for £25,000 Five per Cent. "A" First Charge Debentures, and £25,000 Six per Cent. "B" Second Charge Debentures. In addition to the services previously undertaken, the Company are now prepared to supply messengers for a variety of purposes, from delivering handbills to performing clerical work. The Directors anticipate from additional rent to be received from subscribers for call boxes, and from a material reduction promised by the Postmaster-General in the royalties, and from being in a position to more fully equip the present offices, and by the opening of new branches, to materially improve the position of the Company, and to render the service more effective.

EDINBURGH FINANCE.—The Corporation of Edinburgh have this week invited applications for £500,000 of Three per Cent. stock, redeemable at par on May 15, 1924. The issue of the stock is for the purposes of electric lighting, tramways, general improvements, &c. The lists closed on Wednesday, and applications will be opened this day (Friday), at 12 noon.

GULCHER (NEW) ELECTRIC LIGHT AND POWER COMPANY (LIMITED) (*in liquidation*).—An extraordinary general meeting of the members of the above Company is to be held at 73, Lombard-street, E.C., on Wednesday, August 1st, at 11 o'clock, for the purpose of considering and passing the following resolution:—"That Mr. Charles Fitch Kemp, the liquidator, be authorised to enter into an agreement with Easton, Anderson and Goolden (Limited), for the sale to that Company of this Company's plant, machinery and stock-in-trade at the price of £12,500, payable as to £5,700, part thereof, in cash, and as to £6,800, the balance thereof, in 680 shares of £10 each, fully paid up in Easton, Anderson and Goolden (Limited)." If the resolution is passed by the requisite majority it will be submitted to a second meeting, to be called later, for confirmation.

MANGANESE BRONZE AND BRASS COMPANY (LIMITED).—A final dividend of 8s. per share, making 14s. for the year to June 30th, has been declared by the Directors of this Company. £2,000 is placed to reserve, and £1,208 carried forward.

METROPOLITAN ELECTRIC SUPPLY COMPANY (LIMITED).—Letters of regret and allotment in the recent issue of £150,000 Four-and-a-Half per Cent. First Mortgage Debenture Stock in this Company have been posted.

SANITAS COMPANY.—A dividend at the rate of 10 per cent. per annum for the six months ended June 30th last, free of income tax, is declared by the directors of this Company, payable on and after the 1st September next. The transfer books will be closed from the 25th to the 31st August.

ST. JAMES' AND PALL MALL ELECTRIC LIGHT COMPANY (LIMITED). The share transfer books of this Company are closed up to Thursday evening next, preparatory to the payment of interim dividends on the Ordinary and Preference shares for the half-year ended June 30th last.

STOCK EXCHANGE NOTICES.—Application has been made to the Stock Exchange Committee to appoint a special settling-day in, and to grant a quotation to, the Six per Cent. Cumulative Preference shares and Ordinary shares of Willans and Robinson (Limited).

WESTMINSTER ELECTRIC SUPPLY CORPORATION (LIMITED).—The Board have declared an interim dividend at the rate of 4 per cent. per annum for the half-year ending 30th June last, payable on the 1st September next.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended July 20th (after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited), were £2,238.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share	Last Dividend.	Name.	Previous Week's Price, July 18.		Price Wednesday, July 25.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending July 25.	
			TELEGRAPHS.					£ s. d.		Highest	Lowest
£1,012,880	Stock	9 0	Anglo-American	37	40	37	40	6 4 6	Jan., Apr, July, Oct.	40	39½
£2,933,560	Stock	18 0	Do. Preferred	71	73	71	73	6 10 6	" "	73	71
£2,933,560	Stock	5/0	Do. Deferred	6½	7	6½	6¾	..	..	6½	..
£184,500	100	4%	African Direct Teleg. 4% Deb. (Reg. & Bearer)	101	104	101	104	3 16 11	January and July	..	..
130,000	£10	3/0	Brazilian Submarine	12	12½	12	12½	5 4 0	Mar., June, Oct., Dec.	12⅝	12½
£18,700	£100	5%	Do. 5 per Cent. Bonds	101	104	101	104	4 16 2	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	107	111	107	111	3 16 11	June and December	..	—
10,000,000	$100	$1¾	Commercial Cable Capital Stock	139	143	139	143	4 17 11	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	12	13	12½	13½	5 18 6	February and August	13⅛	..
6,000	10	10%	Do. Preference 10 per Cent.	19	20	19½	20½	4 17 7	" "	19⅝	..
12,931	5	1/7½	Direct Spanish (fully paid)	4	4½	4	4½	4 8 11	April and October	..	—
6,000	5	10%	Do. Preference 10 per Cent.	9½	9¾	9½	9¾	5 2 7	" "	9½	—
£30,000	Stock	4½%	Do. 4½% Debentures of £50 each	103%	106%	103%	106%	4 4 11	..	..	..
60,710	20	2/0	Direct United States Cable, 1877	8½	9½	8	9	6 13 4	Jan., Apr., July, Oct.	9⅛	8½
400,000	10	2/6	Eastern	15⅝	15¾	15¾	16	4 1 3	" "	15⅞	15⅞
70,000	10	6%	Do. 6 per Cent. Preference	16½	16¾	16½	16¾	3 11 8	" "	16⅝	16⅝
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	115	118	116	119	3 7 3	May and November	117½	116½
£102,100	100	5%	Do. 5 per Cent. Debentures, 1899	107	110	108	111	4 10 1	February & August	..	—
250,000	10	2/6	Eastern Extension xd	15⅜	15⅝	15⅛	15⅜	4 8 2	Jan., Apr., July, Oct.	15⅞	15⅛
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	115	119	116	119	3 7 3	February & August	..	..
£42,700	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103	106	103	106	3 17 3	January and July	..	..
£95,100	100	5%	Eastern and S. African 5 p. Cent. Mor. Deb., 1900	103	106	103	106	3 17 3	" "	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures, 1909 (regd.)	105	108	105	108	3 14 1	February & August	..	—
£200,000	£25	4%	Do. 4% Mauritius Sub. Debs.	107%	110%	107%	110%	3 12 9	May and November	..	..
181,227	10	2 6	Globe Telegraph and Trust	8⅜	8⅝	8⅜	8⅝	4 12 9	Jan., Apr., July, Oct.	8$\frac{9}{16}$	8⅜
180,042	10	6%	Do. 6 per Cent. Preference	15⅜	15⅝	15⅜	15⅝	3 16 10	" "	15⅝	15$\frac{7}{16}$
150,000	10	5 0	Great Northern	20½	21	20½	20¾	4 2 2	Jan., April, and July	20⅝	20$\frac{7}{16}$
£190,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	105	108	105	108	4 12 7	March & September		..
17,000	25	37/6	Indo-European	44	46	44	46	5 8 8	May and November	45½	44½
37,548	10	5/0	London Platino-Brazilian	5	7	5	7	..	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	107	110	108	111	5 8 1	March & September	10¼	—
£100,000	£100	4%	Pacific European Tel. 4% Guar. Debs. "Red" 1942	101	104	102	105	3 16 2	..	103½	..
11,830	8	4/0	Reuter's	5	6	5	6	..	April and October	..	..
3,381	£100 Cert.	25/0	Submarine Cables Trust 6 per Cent.*	108	113	108	113	5 6 2	" "	111	..
15,000	10	5/0	West African Telegraph	3	5	3	5	..	January and July	..	..
£249,900	100	5%	Do. 5 per Cent. Debentures	102	106	102	105	4 15 3	March & September	104¾	104½
30,000	10	2/0	West Coast of America	2½	3	2½	3	..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	96	101	96	101	7 18 5	June and December	99½	..
88,321	10	9d.	West India and Panama	1	1½	1	1½	..	..	..	..
31,563	10	6%	Do. 6 per Cent. 1st Preference	10	10½	10	10½	5 14 3	May and November	10⅜	10⅛
4,669	10	6%	Do. 6 per Cent. 2nd Preference	9	10	9	10	6 0 0	" "	..	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	107	110	107	110	4 5 7	June and December	..	—
64,242	15	7/6	Western and Brazilian	6¾	7¼	6¾	7¼	..	May and November	..	..
33,129	7½	7/6	Do. 5 per Cent. Cumulative Preferred	5½	6½	5½	6½	..	..	6	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	1¾	2¼	1¾	2¼	..	..	..	..
£171,900	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	107	110	108	111	5 8 1	February & August	110	..
£214,800	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	107	110	108	111	5 8 1	" "	..	..
$1,211,000	$1,000	7%	Western Union 7% 1st Mort. (Building) Bonds	115	120	115	120	5 16 8	May and November	—	..
£166,900	£100	6%	Do. 6 per Cent. Sterling Bonds	100	104	100	104	5 15 5	March & September	..	..
			TELEPHONES.								
44,000	5	10/0	Chili Telephone (fully paid)	1	2	1	2	..	..	..	..
224,850	10/0	2⅝d.	Consolidated Telephone Const. & Maintenance	¼	½	¼	½	..	May and November	¼	..
171,504	£1	6d.	Oriental Telephone and Electric (fully paid)	⅜	⅝	⅜	⅝	..	Yearly	..	..
484,597	5	2/6	National	4¾	5	4¾	5¼	4 17 7	June and December	5	4⅞
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	14½	15½	14½	15½	3 17 5	" "	15	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	14	15	14	15	4 0 0	" "	14⅞	14½
119,234	5	2/3	Do. 5% Non-Cumulative 3rd Pref.	5¼	5¾	5¼	5¾	4 6 11	..	5$\frac{9}{16}$	5½
1,000,000	Stock	4½%	Do. Debenture Stock, 4½%	109	112	109	112	4 10 0	January and July	..	..
58,000	5	1/0	United River Plate	1	2	1	2	—	" "	..	..
£146,733	Stock	5%	Do. 5 per Cent. Debenture Stock	90	100	90	100	5 0 0	" "	..	—
			ELECTRICITY SUPPLY COMPANIES.								
40,000	£10	..	City of London Electric Lighting (fully paid)	12½	13	12½	13	..	..	13½	..
40,000	10	6,0	Do. 6% Cumulative Pref. (fully paid) xd	14	14½	14	14½	4 2 9	..	14⅝	14$\frac{7}{16}$
19,900	£5	..	Electricity Supply Co. for Spain	..		..		..	..	..	..
£30,000	£5	2 0	Charing Cross and Strand Electricity Supply Corp.	4½	5½	4½	5½	—	..	..	..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	..		..		—	..	..	..
8,322	£5	..	House-to-House Electric	..		..		—	..	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	..		..		—	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..		..		—	January and July	..	..
45,000	£5	2/6	Liverpool Electric Supply (fully paid)	6½	6⅝	6½	6⅝	—	..	..	—
111,000	5	..	London Electric Supply	⅛	⅜	⅛	⅜	..	..	..	..
40,900	£10	5/0	Metropolitan Electric Supply (fully paid)	8½	8¾	8½	9	2 15 7	..	..	..
£150,000	Stock	4½%	Do. 4½% Debs. (Bonds of £10, £20, and £40)	106	109	..		4 11 9	June and December	..	..
6,452	£10	..	Notting Hill Electric	4½	5½	4½	5½	—	..	—	..
19,950	£5	4/6	St. James and Pall Mall	7	7½	7	7½	..	..	..	—
20,000	£5	7%	Do. 7 per Cent. Preference	8½	9	8½	9	3 17 9	..	8⅝	..
59,900	5	2/6	Westminster Electric Supply (fully paid)	6¼	6¾	6¼	6¾	2 19 3	—	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
90,000	3	1,6	Brush Electrical Engineering	2¾	3	2¾	3	6 0 0	..	3	2⅞
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	2¼	2½	2¼	2½	4 16 0		2$\frac{7}{16}$	2⅜
£125,000	Stock	4½%	Do. 4½ per Cent Debentures	110	113	110	113	3 19 8	March & September	112	..
20,000	5	2/6	Crompton and Co., 7 per Cent. Cumulative Pref.	2½	3	2½	3	—	January and July	..	..
12,130	5	..	Edison and Swan United	—		—		..	..	—	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	..		..		..	..	—	..
120,000	2	..	Electric Construction	½	¾	½	¾	..	—	—	—
12,845	2	..	Do. 7 per Cent. Cumulative Pref.	1½	1¾	1½	1¾	..	—	..	—
91,195	2	10/0	Elmore's Patent Copper Depositing	1½	1¾	1	1½	..	..	—	..
20,000	5	..	Fowler-Waring Cables (fully paid)	½	1½	½	1½	—	..	..	..
50,000	10	10/0	India Rubber, Gutta Percha, &c, Works xd	23	24	23	24	5 4 2	February & August	25½	23½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103	106	103	106	4 5 9	March & September	..	..
15,995	£10	6/4	International Okonite Ordinary	..		..		..	..	—	..
16,000	£10	..	Do. 8 per Cent. Preference	—		—		—	December and June	—	—
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid)	—	½	—	½	—	..	—	..
78,949	5	3/6	Swan United (£3 10s. paid)	..		..		..	May and November	..	..
37,350	12	36/0	Telegraph Construction and Maintenance	40	42	40	42	5 14 3	March and July	41½	40½
£150,000	100	5%	Do. 5 per Cent. Bonds	102	105	102	105	4 13 6	January and July	..	..
37,514	£5	—	Woodhouse and Rawson Ordinary (£3 15s. paid)	—		—		..	..	—	..
41,098	£5	—	Do. Preference (fully paid)	—		—		..	—	—	—
			RAILWAYS AND TRAMWAYS.								
£630,000	Stock	1%	City and South London Railway	36	38	36	38	1 16 2	May and November	..	120½
£37,130	Stock	4%	Do. 4% Perpetual Debenture	119	121	119	121	3 6 2	May and November	121	
7,000	10	5%	Do. 5% Perpetual Preference	12¾	13½	12¾	13½	3 15 6	..	..	..
87,500	£10	1%	Liverpool Overhead Railway	8½	8⅝	8½	8⅝	..	..	..	..
6,295	10	5%	Do. 5% Preference	12¾	13½	12¾	13½	3 16 2	..	..	..
£125,000	Stock	4%	Do. 4% Debenture	111	113	111	113	3 10 10	January and July	..	..

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THE SILVER JUBILEE

OF

SUBMARINE TELEGRAPHY TO THE FAR EAST.

CELEBRATED AT

The Imperial Institute, South Kensington, London, S.W.,

On FRIDAY EVENING, JULY 20th, 1894.

THE BANQUET UNDER THE PRESIDENCY OF

SIR JOHN PENDER, G.C.M.G., M.P.,

Chairman of the Eastern and the Eastern Extension Telegraph Companies.

THE EVENING FÊTE AND RECEPTION UNDER THE DISTINGUISHED PATRONAGE OF

HIS ROYAL HIGHNESS THE PRINCE OF WALES, K.G.,

And other Members of the Royal Family.

The twenty-fifth anniversary of the establishment of submarine telegraphy with the Far East was celebrated at the Imperial Institute on Friday last. The fête commemorating this important event, together with the various incidents of the anniversary, occupied nearly eight hours. The occasion was regarded as historic, and to do fitting honour to it, and therefore to an invention which, as the United States Ambassador observed in the course of the banquet, "has wholly changed the relations of mankind to each other," a brilliant and distinguished company assembled, including his Royal Highness the Prince of Wales, Field-Marshal his Royal Highness the Duke of Cambridge, her Royal Highness the Princess Louise (Marchioness of Lorne), Prince Edward and Prince Hermann of Saxe-Weimar, the Turkish, Italian, and United States Ambassadors, and many other members of the diplomatic body were present, together with men whose names are known throughout the world in Science, Politics, and Commerce.

At the banquet the Company numbered nearly 500, while the reception was attended by about 5,000 guests; and a party of about 60, including the Royal visitors, was entertained in the Fellows' dining-room, used on this occasion as the Royal supper-room.

The series of events opened shortly before 7 o'clock, when Sir John Pender, G.C.M.G., M.P., the Chairman of the Eastern and Eastern Extension Companies; the Marquis of Tweeddale, Mr. J. Denison Pender, and other members of the Boards of the two Companies, proceeded to the vestibule of the main building to welcome the banquet guests. The vestibule presented a splendid appearance, with its wealth of floral and other decorations. After their reception, the guests passed up the steps to the Great Hall porch, in the centre of which the Queen's statue stands, which had also been very tastefully adorned with flowers.

A few minutes after seven o'clock, in accordance with the programme, the Chairman and his co-directors, their first pleasant task accomplished, entered the banquet hall; and on taking their seats "the King of Cables"—as Sir John Pender was felicitously termed in a congratulatory telegram from the Director of Telegraphs at Rome—and his colleagues received a most cordial greeting, the Meister Orchestra, which was stationed in the gallery, welcoming the party with music. The dining-hall itself presented a magnificent appearance, and the temporary character of the structure was neatly concealed by its decorations and general surroundings. The chamber was brilliantly illuminated with the electric light, the supports of the hall were adorned with sheaves of flags of all nations, from the roof hung banners of the various colonies and dependencies of our mighty Empire, and the tables were tastefully "dressed" with choice flowers and lighted by tall wax candles prettily and effectively shaded, which served the double purpose of illumination and ornamentation.

During dinner the usual loyal toasts were given, and

The CHAIRMAN, whose rising was the signal for loud cheering, said: Gentlemen,—The first toast I have to propose is that of "Her Majesty the Queen." When the history of her reign is written it will be one of the brightest and most remarkable in English history—if not in the history of the world. Long may she live to reign over a united Empire, and a loyal and devoted people! (loud cheers.)

The toast was drank with enthusiasm.

The CHAIRMAN: The next toast I have to propose is "The Prince and Princess of Wales and the other members of the Royal Family" (cheers). His House has lately been strengthened and his home brightened by the birth of a Prince, let us hope the future King of England, and this no doubt will cheer him on in the arduous duty which he has to perform, and which he performs so well. His Royal Highness will honour us this evening by his presence, and in honouring us he shows his high appreciation of the great work which we are here this evening to celebrate (cheers). The other members of the Royal Family, following his example, are ever ready and willing to take part in any demonstration which is associated with the progress and best interests of the Empire.

After the banquet—

Lord KELVIN, in proposing the next toast, said: Sir John Pender, my Lords and Gentlemen,—In response to the Chairman's orders, I have the honour now to propose a toast unprecedented in the history of our country, "Armed Science, embracing the Army, Navy, and Auxiliary Forces." We know that every boy on the "Britannia" training-ship goes through a severe course of scientific instruction. He learns mathematics, astronomy, magnetism, electricity, chemistry, electrical engineering, and mechanical engineering. Every young lieutenant in the Navy knows more about astronomy, engineering—practical and applied—mathematics in all its branches, physics, and, I may say, science generally, than a senior wrangler of fifty years ago. Officers of Her Majesty's land forces—cavalry and infantry regiments—and the volunteer forces now possess opportunities of learning everything that is to be known in connection with scientific warfare. I have the honour of associating with this toast the name of an Irish soldier—a distinguished Irish soldier of the United Kingdom of Great Britain and Ireland. In the Crimea, West Africa, Egypt, India and Canada he has commanded Her Majesty's forces; in fact, he has served in all quarters of the world. I have the honour to associate this toast with the name of Lord Wolseley (loud cheers).

Field-Marshal VISCOUNT WOLSELEY: Sir John Pender, your Excellencies, my Lords, and Gentlemen,—I have to thank the noble proposer of this toast most cordially for the manner in which he has spoken of

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Her Majesty's soldiers and sailors, and I wish him also to accept from me my deepest feelings of gratitude for the kind manner in which he has referred to me personally. It is no easy toast to discuss, especially in an after-dinner speech, and in the presence of the noble proposer. It is, in fact, one of the greatest subjects ever proposed in an after-dinner speech, and called upon now to respond to the toast in the presence of one whom I may call the great master of science in England — the noble lord who proposed this toast — I feel great diffidence in attempting to perform the task. I have not myself any experience of the appliances that refer to submarine telegraphy and the various arts and sciences in which the noble lord has made his mark; but still I have seen enough, both at home and abroad, to be able to appreciate the great advantages which the army and navy have derived from the establishment of these great lines of telegraphs all over the world (cheers). Submarine telegraphy, like all other great sciences, bears directly on the art of war quite as much as on the art of peace. I have often thought of the great differences that exist in the art of war now compared with the days of the great Duke of Wellington. Think of the immense difficulties under which he carried on his great campaigns, which would have been so much facilitated had there existed the present means of rapid communication by railways and steamships. I have often, in reading of those campaigns, tried to calculate to myself what would have been the result of many of the great Napoleonic campaigns had the present scientific means of locomotion existed in those days. Think, for example, what would have been the result of his great campaign in Russia if he had been in communication with Paris by railways and the telegraph. War is one of those great scourges of the world which I am afraid we can never get free from. Wars have always existed, and always, I am afraid, will do so, for war has always been regarded as the great final Court of Appeal by the nations of the world. I hope that a long time may pass before we have to take part in any great European war; but I hope also that if we should have to do so we may, as in previous wars, be benefited by the great men of science who will then have to be consulted. Perhaps it is not generally known that we were the first people who made use of telegraphy in war—in the Crimea. We also laid down a line of submarine telegraph between Varna and the Crimea, and I believe that that was the first time that submarine telegraphs were made use of for the purposes of war. I repeat that I hope war may be a long way off, but if ever the time does come when we have to be engaged again, I hope we shall be prepared for it by getting ready in time of peace (cheers). Judging from what has taken place in recent years, there is a disposition now to secure that object, whatever Government be in power (hear, hear). Let us hope also that the moral training of our men, both soldiers and sailors, may keep pace with their scientific knowledge, and that they may remember in moments of victory to extend that sympathy for human suffering which, after all, has been in all times the noblest distinction and the greatest merit of truly brave men (cheers).

Then followed the toast of the evening, "Submarine Telegraphy: In its International and Commercial Aspects." This toast was proposed in two parts, the United States Ambassador treating of the subject from the view of its international importance, and the Right Hon. the Lord Mayor of London (Sir G. R. Tyler, Bart.), treating the subject from its commercial aspect.

The United States Ambassador (the Hon. T. F. BAYARD) said: Sir John Pender, your Excellencies, my Lords and Gentlemen, I am asked to deal with the international aspect of submarine telegraphy. There is said to be no royal road to the learning of science, and that it must be approached by rugged ways; and yet it would seem that in the temples of science and of learning there are chambers of delight and pathways of pleasure by which we may learn to contemplate the results which have been reached by the most vigorous exercise of the human faculties (hear, hear). Here in this beautiful hall, amid the munificent hospitality of Sir John Pender (cheers), we are conducted in luxury and comfort to a contemplation of that which was not won by ease or by comfort, but which was only arrived at through long study, through painful endeavour, through great sagacity, through courageous enterprise, through that pluck (for no other word than that English word fulfils its meaning) which stood by a conviction until the fruits of triumph were attained (cheers). And here, in this hour of his truimph and success, when, accompanied by years that have brought him honour and fortune, and the gratulations of his people and of all peoples (cheers), I cannot be unmindful of one of my own countrymen, whom I cannot but wish could have shared the feelings generated by such an assembly as this, when "the silver wedding," pleasantly so called, between the great East and the Isles of Great Britain come to be celebrated (cheers). I could wish it were possible that Mr. Cyrus W. Field could but hear the voice of his great associate and brother in this wonderful enterprise—the wonderful enterprise of which this great feast is but a very small feature. "After life's fitful fever he sleeps well." I am glad to speak his name in this assembly, and "his countryman doth call as just witness" the English brother who took his hand in the hour of dire extremity of a great experiment (cheers). But how shall we consider the subject of submarine telegraphy in a worthy way? It will not do to pass it off with jocularity; it will not do merely to shake hands over it; and it certainly will not do, on an occasion like this, when we all feel so happy and so pleasant, to make it too serious. But it is all so marvellous. I feel, in standing in front of such an idea, and an idea that has found such a marvellous practical illustration, that commonplaces will not do. Small thoughts all vanish, and yet with all there is, happily for the relief of poor human nature, what the English judges used to call "a condescension to humanity." There is a humorous side which you cannot possibly banish, and I do not know that you will blame me if I bring it in. We were wont to consign, as a final place, everything that was lost to "Davy Jones's locker," and yet it seems to me that of all the secure places on earth for the secrets of Governments, for the messages of the lover to his mistress, for exery conceivable transmission of human feeling or human thought, "Davy Jones's locker" has become the safest (cheers). Sometimes—but you know it is an injustice—Americans have been accused of certain extravagances of speech (laughter). I heard of one orator, whom we place—or locate, to use an American word —in the Western States, boasting of someone who was running for Congress, that he could dive deeper, stay under longer, and come up drier than any man in creation (laughter). Now, I think that even my friend from the Western States who made that speech would be obliged to confess that he was not at all equal to one of Sir John Pender's submarine messengers, for he can dive deeper, stay under—I will not say longer, but he stays a sufficiently long time—and he certainly comes up dry enough, as dry as could be wished (laughter and cheers). There are a thousand other sides to this subject. Believe me that an invention permitted thus to break in upon the human mind, and which we in our conceit term a "discovery," an invention, or a perception, call it what you will, that has wholly changed the relations of mankind to each other—such an invention cannot be trammelled up in any speech. But it has changed men's relations to each other. War it has changed. No men living can feel this more than the distinguished soldiers who sit at this table within the sound of my voice. They know the blessed power of the submarine telegraph to make war unnecessary, if not impossible. If there is truth in what I say, if there is not exaggeration, what more need be said for submarine telegraphy? May I give you an instance? There was a war, and please God it shall be the last war, between England and the United States—(loud cheers)—eighty years ago. A most unnecessary battle was fought, and blood was shed that all must regret, for the want of a submarine telegraph. The battle of New Orleans was fought in 1815, on January 8th, and peace had been declared in the month of December previous at Ghent, and yet there was no means of communicating the fact. There was an unnecessary battle. A gallant, able general, and his equally gallant associates, fell uselessly before those piles of cotton bales in New Orleans, and they fell because, in the providence of God, the light had not yet dawned on the brain of man that peace could be proclaimed to the end of the world. And this piece had been agreed on, but there was no means of carrying the glad tidings across the Atlantic. That is but an instance. I mention it because it was the last conflict between men who speak the same mother tongue, and whose mother tongue was never so promoted and assisted as it is now by the free intercommunication of the submarine telegraph. My friends and brothers in the Diplomatic Corps are present, but they will understand that there are family ties which all respect; and I cannot but reflect that submarine telegraphy between Great Britain and the United States needs no translation (cheers). In the same tongue in which it is sent forth so it is received, and let us who are to use that language see that it shall convey nothing that cannot clearly be understood. It is the misunderstanding, the ignorance of men of each other's motives and objects, that is the parent of suspicion and the parent of doubts, which the clear, open word of free intelligence would dissipate for ever. It cannot be otherwise when men fairly understand each other, with opportunities of meeting, with time and space annihilated, and with an element which used to be pictured by the orator and the poet as a source of danger—the turbulent ocean—serving to-day as the connecting link of peace and quiet between nations (cheers). The truth is that the subject is so vast, the results of this discovery are so far-reaching, that one cannot on such an occasion do more than touch the fringe of it. It is a subject that should sink very deeply into our minds and our hearts, and I have been made to feel it practically, for I have been a working man in the affairs of Governments since I came to manhood. The great thing would be that we should lift ourselves, or seek to be elevated, to the level of the great thought, of the great duty, of the great capacity that this discovery has permitted us. Nothing is more wonderful in the world's history than this wonderful glimpse of science. I feel that a man must go back to the Book of Job, with all its sublimity, if he desires to find fitting language in which to clothe his thoughts when the possibilities of the submarine telegraph are open to him. One idea, one feeling should pervade us. All the world over—in Egypt, the Netherlands, France, Russia, the Great Orient—go where you will (and, of course, you will go to America), there should be but one feeling: that as this great mystery of intercommunication, so instantly and fully, is open to us, we should strive to prove that we comprehend it, are worthy of it, and intend to make its agency something more for the infinite advancement of our race (loud cheers).

The Right Hon. the LORD MAYOR of London then said: Mr. Chairman, your Excellencies, my Lords, and Gentlemen,—In proposing the important toast with which I have been entrusted this evening, namely, "Submarine Telegraphy, in its Commercial Aspect," very few words of mine are needed to recommend it to your consideration. The progress of submarine telegraphy during the twenty-five years since it was extended to India and the Fast East has been remarkable, and its effect upon commerce throughout the world cannot be over-estimated. It has practically revolutionised mercantile methods, by enabling merchants to exchange views and carry through business transactions in a few hours, or even minutes, where formerly many weeks or months were occupied. Thus the area of trade has been greatly enlarged, and many comparatively small merchants have been enabled to successfully engage in business who, under the old conditions, would have found it quite impossible to live. In fact, submarine telegraphy has now become such an important factor in commercial, social, and political life that it is no exaggeration to say that it is indispensable to civilisation (cheers). This great work has been built up quietly and unostentatiously by private enterprise, and mainly by British capital, and

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when its history comes to be written, it will probably be described as one of the greatest achievements of the Victorian or any other age. Fortunately, submarine telegraphy has had associated with it distinguished men both in science and commerce, to whom the world is much indebted for the valuable facilities which they have been instrumental in providing. Twenty-five years ago submarine cable companies were looked upon with considerable mistrust by the investing public, but now, owing to the improved appliances and experience gained in laying and maintaining cables, their stocks are recognised to be first-class securities, and are, in fact, particularly free from those fluctuations in market prices that are so common to many other classes of securities. I couple with this toast the name of your Chairman, Sir John Pender. (Loud cheers).

The toast was drunk with great enthusiasm, and Sir John Pender, on rising to respond, was received with round after round of applause. When this applause had subsided,

Sir JOHN PENDER, G.C.M.G., M.P. (the Chairman), in reply, said:—Your Excellencies, my Lords, and Gentlemen: The eloquent remarks which have been made by the United States Ambassador and by the Lord Mayor of London in regard to submarine telegraphy make it a duty and a pleasure for me to refer in a few words to those early days when submarine telegraphy had its troubles, its disasters, and its triumphs. The United States was conspicuous in the part it took, not only in its scientific but also in its commercial aspect, and the names of Morse and Cyrus Field will ever be associated with it. I was connected with it at its dawn, and am still connected with it in its successful and permanent establishment. (Cheers.) When it was almost impossible to raise money for the 1865 cables, the Telegraph Construction and Maintenance Company was formed, over which I presided, and we are indebted to that Company for the good work they then and have ever since done. Even in those early days, when the 1865 cable had parted in mid-ocean, it was proved by our late colleague and Managing Director, Sir James Anderson, to be possible to pick up and repair a cable in 2,000 fathoms of water, and this important fact largely increased public confidence in submarine cables as a property. For this great work I feel that all credit is due to Sir James Anderson, who devoted the best years of his life to the development of submarine telegraphy; and, had he done nothing else, this of itself must always rank as a very great and important work in aiding and assisting the progress of submarine telegraphy throughout the world. We are also indebted to Sir William Thomson (Lord Kelvin), Cromwell Varley, Fleeming Jenkin, and many other distinguished men whose names will readily occur to you, for their scientific inventions, which enabled submarine telegraphy to achieve the great scientific and commercial success it has since become (cheers).

At the present time there are eleven cables in the Atlantic, and another is in course of submersion, so that with the aid of "duplex working," for which we are indebted to Dr. Muirhead and others, the carrying capacity is practically equal to twice that number. The first attempt to provide the public with submarine telegraphs to the East was in 1859, when a cable was laid down the Red Sea and along the coast of Arabia and through the Persian Gulf to Kurrachee. Unfortunately, this cable only worked a few days in its entire length, and was afterwards abandoned. The success attending the Atlantic cable caused the idea of submarine telegraphic communication to the Far East to be again considered, and it was carried into effect by the formation of various companies, which were afterwards merged into the Eastern and Eastern Extension Telegraph Companies, whose twenty-fifth anniversary we are now celebrating (loud cheers).

Twenty-five years ago yesterday the Company that laid the submarine system from Great Britain to the Far East was registered. At that time the nucleus of the present system of Eastern Telegraphs consisted of about 900 miles of cable, with a capital of £260,000. To-day we own 51,325 miles of cable, and have a joint nominal capital of over nine millions sterling, but which, at the present market quotations, actually represents nearly fifteen milllions sterling. Two years after the registration of the Eastern Companies, the whole submarine system between Great Britain and China was completed and in working order. A year later the Australian Colonies enjoyed the benefits of daily intercourse with the mother-country and the rest of the world.

It is worthy of note that none of these companies were, in their early days, assisted by any Government monopolies, subsidies, or guarantees, as in the case of the original Red Sea cables, so that it may be truly said that the Governments and mercantile communities of the world owe the benefits arising from direct submarine communication during the past twenty-five years entirely to British enterprise, and I am glad to be able to welcome here this evening some of the original shareholders, who took such a practical interest in our initial difficulties and risks. In those days submarine telegraphy was looked upon as a very risky investment. To-day it is recognised as one of the soundest investments in the market, and during the last two or three years of financial crisis this fact has been repeatedly demonstrated (hear, hear).

This great system of submarine telegraphs having once been launched upon its career, it was impossible for it to remain stationary, and the watchword of its Directors has ever been "Onward!" so that its benefits have been extended to all parts of the Eastern hemisphere by companies arising from the Eastern Telegraphs, and which are to a very large extent under their management. South Africa was also connected by companies associated with the Eastern Telegraphs, and quite recently communication with Chili and Peru has been further strengthened by the establishment of additional lines, under my own presidency, across the Andes, thus bringing us into direct working with the allied company that owns cables between Valparaiso and Lima (cheers).

In short, wherever the British flag flies, and commerce warrants a fair prospect of remuneration, cables have been laid, and this policy will be continued in the future. Within the last twelve months the Seychelles, Mauritius, Labuan, and Borneo have been added to our system. The Islands of the Azores have been connected with Lisbon, and, consequently, with London, and this connection will eventually be extended to America.

At present the total mileage of submarine cables is, in round numbers, 152,000 miles, of which 90 per cent. has been provided by private enterprise, and 10 per cent. by the various Governments, costing altogether over 40 millions sterling. The total length of land wires throughout the world is over two million miles, estimated to have cost about 65 millions. If the cables and land lines are added together a combined capital is represented of 106 millions sterling. The total imports of the world amount to nearly 1,940 millions sterling, whilst the total exports amount to 1,720 millions; and as commercial operations are now begun and ended by means of the telegraph, it will be seen that these vast figures have an important bearing on submarine telegraphy.

The greatest care and caution has had to be observed in the management of these companies. In the first place, the life of a cable was, and still is, to a large extent, an unknown factor. In the second place, to enable it to obtain a strong hold upon commercial life, it was necessary that submarine telegraphy should be always available, and this was only possible by having the system duplicated, and in some places triplicated and quadrupled. This has been carried out very thoroughly, the Eastern Telegraphs having expended since their establishment nearly five millions of money in strengthening their lines, and this policy has met with its reward by gaining for the Companies the increased confidence and support of the political, social, and mercantile communities. Governments have also shown their high appreciation of submarine telegraphy. Indeed, one of our leading statesmen, recently remarking on its great progress and vast sphere of usefulness, said that he looked upon it as one of the greatest achievements of the Victorian age, if not in the history of the world (loud cheers).

As you are aware, an important conference has recently been held at Ottawa, at which representatives of Great Britain and our Colonies met to discuss trade and other matters; but the main question before them was that of connecting the Australasian Colonies with Canada by a submarine cable across the Pacific. At the present moment Canada and Australia can communicate with each other through the existing system in a couple of hours or less, and at a comparatively moderate cost; but when a Pacific cable is really required, the Companies which I represent will not be backward in meeting public requirements; and as we have large experience and facilities for carrying out and maintaining such a work we ought to be able to undertake it on more favourable terms than any outsider could possibly do (hear, hear).

The Australasian Colonies during the last 25 years have shown their appreciation of the benefits of submarine telegraphy by assisting the Eastern Extension Company with a substantial subsidy to duplicate its cables between Penang and Australia. The majority of the Australasian Colonies also entered into an arrangement with the Eastern Extension Company, under a guarantee of half risk, to reduce the rates by 60 per cent., so confident were they that cheap tariffs would largely increase the traffic; and, although a considerable increase resulted, it was not nearly sufficient to recoup the loss; still, the increase had been such as to justify the experiment, and I have no doubt that, when prosperity returns to the Colonies, we shall see a very great development in the traffic, so that in time the loss will be entirely wiped out. I may mention that during the great commercial crisis that recently passed over the Australasian Colonies, and, in fact, all over the commercial world, submarine communication with Australia was found to be of enormous value in connection with the banks' reconstruction schemes found to be necessary, thus greatly assisting in restoring confidence to the commercial community, and in allaying the uneasiness which might otherwise have resulted in panic (cheers.)

Twenty-five years ago it was considered wonderful to receive a message from India in a few hours; to-day, telegrams arrive in a few minutes. We commenced business by carrying at the rate of 400,000 messages per annum; to-day we transmit over two millions. Our communications are maintained by nine steamships, fully manned and equipped with all the latest scientific appliances for at once repairing the cables when broken, and it may be mentioned that up to the present time the Eastern Telegraphs have never been unsuccessful in the restoration of any of their cables (cheers.)

A *résumé* of the history of submarine telegraphy to the Far East would not be complete without mentioning that few events of international interest take place in which submarine telegraphy has not played an important part. An event which exemplified more than anything else the capabilities of the telegraph, and proved to the world its enormous value, was the bombardment of Alexandria, and the subsequent operations in Egypt, the Soudan, and at Suakin. It is not too much to say that during this time the public were kept in hourly touch with all the events, even to the minutest detail, that were happening in Egypt, and the Eastern Company is justly proud that the immense traffic which they then carried was brought through without practically any delay at all (loud cheers).

In conclusion, it may safely be said that submarine telegraphy has been provided wherever required by commerce, and that it has been enormously beneficial to the public at large, by bringing them into closer knowledge of the every-day life of their kindred beyond the seas, and assisting in keeping together the great fraternity of the Anglo-Saxon race. It has undoubtedly equalised trade throughout the world, and brought the producer and consumer closer together, enabling the producer to obtain a better market, and the consumer the benefits of international competition. It has over and over again prevented diplomatic ruptures and consequent war, and has thus been instrumental in promoting peace and happiness throughout the world.

I cannot finish without acknowledging the good work and hearty cooperation which we have received from our Danish friends, the Great Northern Telegraph Company, who share the China and Japan traffic with

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us, and with whose officials, from their able Chairman and Managing Director (Mr. Tietgen and Commodore Suenson) downwards, we are on the best of terms. I also desire to publicly acknowledge the good work and co-operation which we have always received from our officers and staff throughout the service, many of whom are present with us to-night. Without their help it would have been impossible to attain such satisfactory results as we have been able to achieve during the last twenty-five years (loud cheers).

The LORD CHANCELLOR (the Lord Herschell): My speech must be, happily for you, and still more happily for me, very short. I have to propose "Our Colonial and Indian Empire." We all feel proud of belonging to an Empire that can boast of such colonies and dependencies; and I am quite sure that while we feel that pride, our hearts go forth to every part of our distant Empire. We rejoice when they rejoice, we sorrow when they sorrow. Until recent years we only heard of either their troubles or their sorrows weeks or months after they had occurred. We could not at that time rejoice or sorrow with them. The great system of submarine telegraphy has changed all that (cheers). We now hear of the events that move their hearts as soon as they have occurred, and our hearts move with theirs, and our sympathies are immediately with them (cheers).

The Right Hon. H. H. FOWLER, M.P. (Secretary of State for India), first responded to the toast. He said: Sir John Pender, my Lords, and Gentlemen,—I feel it a very great honour this evening to respond on the part of our Indian Empire for this toast, and to acknowledge, in the name of that Empire, the great obligations under which it is laid, both in its administration, commerce, and defence, to that institution which you are assembled to-night to celebrate on the occasion of its twenty-fifth anniversary. I quite agree that all the speeches on this occasion must be confined to short limits, and I will only say, in one sentence, that I believe that the rule of Great Britain has been an unspeakable boon to the people of India; that that rule is alike just, impartial, and effective; that it guarantees the liberties, secures the peace, develops the resources, and promotes the prosperity of the Queen's subjects in that great Empire. I acknowledge in their name and on their behalf the debt they feel towards this institution, which connects them, I may say, day by day and hour by hour, in all the details of their daily life and of their Imperial interests, with the centre of the Empire—with the Home Government (cheers.)

Sir CHARLES TUPPER, Bart. (High Commissioner for the Dominion of Canada), also responded. He said: I have great pleasure in returning thanks for the very kind and appreciative manner in which the Lord Chancellor has referred to the Colonies. I need not, I am happy to say, detain you much with reference to the history of telegraphy or to the wonderful results of that great discovery. You have listened to the graphic description of telegraphy which has been given by our distinguished chairman, Sir John Pender, and to the eloquent words that are still ringing in your ears regarding the results of the discovery upon the nations of the world which were addressed to you by the representative of the United States of America, whom I am proud to see present among us to-night (cheers). I need not say that, great as has been the progress of the Colonies during the past fifty years, that progress during the past quarter of a century has been greatly emphasised, greatly increased, by the efforts of those great Companies whose services to their country we have met here to-night to celebrate, and I have no hesitation in saying that a great deal of the success, a great deal of the advancement of the Colonies has been due to the energy and ability of the distinguished gentleman who is now presiding over us (loud cheers). I need not go further than to say that you can appreciate what submarine telegraphy means to the great continent of Australia by mentioning a fact of which I am just reminded by a colleague—that the exchange of messages of the most vital importance, which took months to effect a few years ago, can now be accomplished in a few hours by this great discovery of submarine telegraphy (cheers). I will not at this late hour venture to interpose between this gallant company and the ladies, who will be waiting to receive you at the other end of the building, but will conclude by again thanking the Lord Chancellor for the kindness with which he has referred to the Colonies, and this great and distinguished company for the gracious way in which they received the toast (cheers).

The MARQUIS of TWEEDDALE (Vice-Chairman of the Eastern Telegraph Company) proposed the next toast, "Our Guests." He said: Sir John Pender, your Excellencies, my Lords, and Gentlemen,—The toast entrusted to my hands is fortunately one which needs only to be mentioned to ensure a cordial reception. It is that of the health of those who have honoured us this evening with their company as our guests, and when I look around and see the representatives of many nations, of our great colonial Empire, of our cousins across the sea, of our Indian Empire, of our industrial and scientific institutions, and last, but not least, of the great Press of this country, I cannot but feel proud—and I believe that that pride is shared by Sir John Pender—at the reception you have given to our hospitality this evening. I infer from the manner in which you have received Sir John Pender and ourselves that you wish to show your approval of the manner in which we commenced this great enterprise twenty-five years ago, and which it has taken a quarter of a century to bring to the perfection in which it now is (cheers). I am especially proud to think that so many nations of Europe are represented to-night, because I feel that that affords the best evidence of the purely international manner in which we have conducted this great enterprise; and I am glad to be able to make an announcement to-night which I am sure will be received with pleasure by all Sir John Pender's admirers. It is in the form of a communication from His Majesty the King of Italy, who states that upon the proposal of the Minister of Posts and Telegraphs he has been pleased to confer upon our Chairman the distinction of the Grand Cordon with the Grand Cross of the Order of the Crown of Italy (cheers). This, gentlemen, is only one of the numerous honours which have been bestowed upon our Chairman by the other nations of Europe. I had intended to occupy your time at some greater length, but at this late period of the evening it would not be proper to do so, and I will therefore merely conclude by associating with this toast the name of a distinguished member of the bench of this country, one whose learning is only equalled by his wisdom and his wit. I refer to Lord Morris. I beg leave now to propose "Our Guests," and to couple it with the name of our distinguished guest, Lord Morris (cheers).

Lord MORRIS: Sir John Pender, your Excellencies, my Lords, and Gentlemen,—It certainly did surprise me that one in my humble position should be asked to return thanks in this cosmopolitan assembly for the guests of the evening. I perceive about me great ecclesiastics, great soldiers, great men of science, and great men of every position; and I again ask myself why Sir John Pender has imposed this duty upon me. I can only discover one answer—that he is anxious that one should address you who always boasts of being—and if he chose to deny it his voice would at once betray him—a representative Irishman (laughter). I am proud of the kindness which has been shown to me, and as a member of this United Kingdom—which I always hope to remain a United Kingdom—to return thanks for this great assembly of guests, who represent all parts of the world. Why an Irishman should be selected to speak on their behalf is, pealiaps, a little strange (laughter). We have it on the highest authority that the wise men came from the East: but I come from the West. I look upon it with great satisfaction that the duty has devolved on me of returning thanks for the toast of the guests, and having discharged that task—very inadequately, as I feel—I have now to address you again, and to call upon you to fill your glasses and discharge your duty as guests by drinking the health of Sir John Pender (loud cheers). It is 29 years ago since I first remember being acquainted with Sir John Pender as a member of the House of Commons. I have watched his career since with interest, as many men in this company must have watched it. He is a man who, having first devoted himself to commercial pursuits, acquired a fortune which enabled him to attend to the interests of his country in the direction of this great and important industry. He was then one of the first men, if not the first, to take a leading position in the establishment of submarine telegraphy (cheers). Several of us are old enough to remember the repeated failures with which the attempt to lay a cable between the Western Continent of America and this country was met. We remember when the "Great Eastern," carrying the cable, after repeated failures, finally lost it in mid-ocean, and nearly everyone abandoned all hope about it. There was, however, one man who abated not one jot of faith, but who assisted not alone by his personal endeavours and as a member of a Corporation, but who, if my memory serves me aright, personally offered his own security for a quarter of a million of money in order to establish a new submarine telegraph (cheers). That is a circumstance which does not often occur in practical life. But he succeeded, and I have no doubt that he has enjoyed the benefit of his success, commercially and in other senses. Having connected the continent of America with this country, his efforts did not cease. He endeavoured, and successfully, to carry out a system of submarine telegraphy to our Eastern countries, and in this manner millions have been expended. It was said by some at the outset, "Why, you might as well throw money into the sea." Well, millions have been "thrown into the sea," and with very great benefit to all who have enjoyed the blessings of this great invention (cheers). Our friend Sir John Pender is, in one word, the greatest unionist of the age, for he has not alone united these small islands, but also the whole world in one encircling girdle (cheers). Without further preface at this late hour of the evening, although I could go on for a long time on the subject of Sir John Pender and his career, I will conclude, as I am sure that he himself would be better pleased that I should wind up. I ask you, however, in conclusion, to drink the health of our Chairman with all the honours—the health of a man who has shown himself the dominant spirit of submarine telegraphy and the dispenser of generous hospitality (loud cheers).

The toast was drunk with the greatest enthusiasm.

The CHAIRMAN: My Lords and Gentlemen,—There are periods in a man's life when he opens his eyes, looks round, and wonders at his surroundings (laughter). To-night I am really astonished at the extraordinary response that has been made to our appeal to come and meet us to-night at the celebration of our 25th year. When, however, I say that, I must tell you that there is not a morning in my life that I do not wonder at the extraordinary success which has attended submarine telegraphy, and at the extraordinary power it possesses, and at the extraordinarily efficient way in which it has been conducted by these companies. The success of these companies, no doubt, has been owing to the united way in which they have been conducted. I have had the most hearty support, for which I thank my colleagues, and we have been enabled to give to the world what I believe to be one of the greatest, and probably the greatest, achievement in the Victorian reign, and also, as a very distinguished statesmen said to me the other day, probably the greatest achievement in the world's history (cheers). I am very much indebted to you for the compliment you have paid to us this evening, and on behalf of my colleagues and myself I tender you our sincere thanks. As I have said before, while our work has been great and prosperous in the past, we have still much work to do in the future, and I believe that that work will be as successful in the future as it has been in the past if the same energy, the same judgment, and the same industry are applied to it. I thank you very much for your presence and your support. You have not only given us support, but also encouragement to look forward to the future, and, if possible, to excel what we have done in the past (loud cheers).

The following is a list of the guests at the Banquet :—

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Sir John Pender, G.C.M.G., M.P.
Right Hon. the Lord Chancellor
H. E. the Italian Ambassador
H. E. the Japanese Minister
H. E. the Netherlands Minister
H. E. the Persian Minister
H. E. the U.S. Ambassador
Servian Consul-General
Sec. Chinese Legation
Sec. German Embassy
Sec. Italian Embassy
Sec. Japanese Legation
Sec. Netherlands Legation
Sec. Swiss Legation
Sec. Turkish Embassy
Sec. U.S. Embassy
Chargé d'Affaires of Sweden and Norway
Lord Mayor of London
Mayor of Blackburn
Mayor of Brighton
Mayor of Cardiff
Mayor of Croydon
Mayor of Leicester
Mayor of Norwich
Mayor of Sheffield
Master Cutler of Sheffield
Town Clerk of Blackburn
Town Clerk of Brighton
Town Clerk of Cardiff
Town Clerk of Croydon
Town Clerk of Norwich
Sir F. Abel, Bart, K.C.B.
C. Alcock
Sir A. J. Altman
Kenneth Anderson
Dr. W. Anderson
W. Andrews
W. T. Ansell
Col. Sir J. Ardagh, K.C.I.E.
J. A. Ardron
Sir G. C. H. Armstrong, Bart.
Sir E. Arnold, K.C.I.E.
W. H. Ash
J. Atter
Rt. Hon. Evelyn Ashley
W. H. Axworthy
S. Aylmer
Prof. W. E. Ayton, F.R.S.
Sir G. S. Baden-Powell, M.P.
W. H. Baines
H. F. Baker
G. W. Balfour, M.P.
G. H. Bambridge
Sir H. Barkly, G.C.M.G.
J. Bass
J. G. Bean
J. Bedford
Dr. James Bell, C.B.
C. Bertrand
F. A. Bevan
Capt. R. Birkett
T. J. Birkin
Wm. Birt
W. Blaber
W. Bolton
G. C. Bompas
J. Boon
G. Boor
Rt. Hon. Sir G. F. Bowen
Sir Courtenay Boyle, K.C.B.
Col. Sir E. Bradford, K.C.B.
W. H. Bradshaw
J. Bramston, C.B.
W. F. O'Brien
Hon. A. G. Brodrick
Hon. W. St. J. Brodrick, M.P.
A. Brown
R. T. Brown
Lord R. H. Browne
W. W. Browning
Gen. Right Hon. Sir Redvers Buller, V.C.
E. T. Bullock
T. A. Bullock
H. T. Burgess
W. H. Burman
Major-Gen. Sir Owen Burne
G. H. Burnett
C. Burt
B. Butler
E. N. Buxton
E. B. Caarten
Dr. A. Caesar
. Cambrook

G. W. Campbell
J. Campbell
J. D. Campbell, C.M.G.
Sir A. J. Leppoc Cappel, K.C.I.E.
J. H. Carson
Lord S. A. Cecil
G. Von Chauvin
H. G. Cheesman
E. Cheshire
Rt. Hon. Hugh C. E. Childers
R. Chipperfield
W. H. M. Christie
John Chumley
Latimer Clark, F.R.S.
Lieut-Gen. Sir Andrew Clarke
Sir E. Clarke, Q.C., M.P.
J. Clarke
H. Clifford
R. Collett
S. Collett
A. J. Collier
C. S. Colvin
Dr. Cooke
Rt. Hon. L. Courtney, M.P.
David Craven
W. Crocker
F. Crockford
R. E. B. Crompton
Prof. W. Crookes, F.R.S.
G. S. Crouch
J. T. Crowe
R. M. Cunningham
R. G. Davey
Capt. W. H. Davies
F. Dawes
T. L. Devitt
E. Dickens
Sheriff Sir J. C. Dimsdale
Maj.-Gen. Sir J. F. D. Donnelly
George Draper
G. Dudley
Lieut.-Col. Durrant
Sir H. Edwards
A. Eggington
R. Enfield
Baron D'Erlanger
F. Erlanger
E. Etlinger
C. W. Eves, C.M.G.
B. T. Ffinch
J. A. Findlay
R. B. Finlay, Q.C.
D. Finlayson
R. H. Finnis
T. Finnis
H. C. Fischer
Col. G W. A. FitzGeorge
Prof. J. A. Fleming, F.R.S.
R. M. Fletcher
Louis Floersheim
J. Staats Forbes
Wm. Forbes
H. C. Forde
H. O. Arnold Foster, M.P.
Right Hon. H. H. Fowler, M.P.
R. Fox
Sir M. Fraser, K.C.M.G.
Hon. Sir C. W. Fremantle
D. Gair
Sir D. Galton, K.C.B.
J. Gane
Sir J. Garrick, K.C.M.G., Q.C.
P. Gatliff
A. Y. Gayhagan
David George
C. Gerhardi
A. Giles, C.E.
W. Gilhespy
T. Gill
Hon. Duncan Gillies
Lieut.-Gen. Sir R. Gipps, K.C.B.
P. Glegg
S. G. Glover
E. Goldschmid
S. S. Goodman
D. H. Goodsall
Matthew Gray
R. K. Gray
F. J. Griffiths
J. Griffiths
J. G. Griffiths
R. Gunter
C. E. Gunther
J. H. Gwyther
Oskar Hansen

A. R. Hardie
F. Harrison
L. L. Hartvigson
F. S. Harwood
Adml. Sir L. G. Heath, K.C.B.
Henniker Heaton, M.P.
Sir R. G. W. Herbert, G.C.B.
F. E. Hesse
W. Hibberdine
F. Higgins
C. H. Hobbs
H. Holmes
Dr. J. Hoole
Prof. Hopkinson, F.R.S.
Sir W. H. Houldsworth, Bart., M.P.
R. Hovenden
A. C. Howard, C.B.
E. Howard
J. Howe
W. W. Howell
Col. H. Hozier
Prof. D. E. Hughes, F.R.S.
G. H. Hurst, J.P.
Major-Gen. Hutchinson, C.B.
Admiral Sir E. A. Inglefield
F. W. Isaacson, M.P.
Percy L. Isaac
G. C. Jack
H. Jackson
K. H. James
Earl of Jersey
Lt.-Gen. Sir W. Jervois, G.C.M.G.
Claude Johnson
W. C. Johnson
Com. H. H. Johnstone, C.B.
J. C. D. Jones
H. J. Jourdain, C.M.G.
J. S. Keltie
Lord Kelvin, P.R.S.
F. R. Kendall
Prof. A. B. W. Kennedy, F.R.S.
Adml. the Hon. Sir H. Keppel
C. Kerr
J. King
J. King, jun.
D. Kingsford
J. Kirk
F. H. Kirby
J. Laing
J. C. Lamb, C.M.G.
H. Lambert
Col. R. B. Lane
J. Latey
G. F. Lawton
Hugh Lely
John Leslie
J. L. Lewis
W. Lighton
R. London
H. W. Lucy
W. R. Lyne
A. R. H. Mackay
M. Macnamara
Sir H. C. Mance, C.I.E.
J. Martin
R. Martin, M.P.
J. G. Macmillan
Rev. W. Meeres
Philip Mennell
W. R. Mewburn
E. M'Grath
F. Moll
O. Moll
Sheriff Sir J. V. Moore
P. A. Molteno
Lord Morris
J. Fletcher Moulton, Q.C., M.P.
W. H. Mudford
Dr. Muirhead
John Muirhead
Lieut.-Col. Murray
Kenric B. Murray
A. Naughty
G. R. Neilson
John Newton
C. L. Nicholson
J. H. Nicholson
F. C. C. Nielsen
Capt. Sir A. Noble, K.C.B.
G. North
Col. J. T. North
F. Northcott
P. Nussey

Sir H. Oakley
E. Cunliffe Owen, C.M.G.
J. C. Parkinson
J. E. Patton
Capt. Pattison
F. W. Pattison
E. Payne
W. Pearce, C.M.G.
Rt. Hon. Sir R. Peel, Bart.
Bennett Pell
James Pender, J.P.
J. Denison Pender
Sir W. B. Perceval, K.C.M.G.
Capt. Perkins
Prof. John Perry, F.R.S.
F. von der Pfordten
H. E. Plank
Lord Playfair
R. Portelli
F. H. Porter
Earl of Portsmouth
A. Powell
J. R. Preece
W. H. Preece, C.B., F.R.S.
F. T. Preddle
Rokeby Price
P. R. Ranger
Sir R. Rawlinson, K.C.B.
P. Rawson
Lord Reay, G.C.S.I.
Jas. Reid
R. N. Reid
G. E. Renwick
R. M. Renwick
E. G. Richardson
E. Riddle
J. Robb
Gen. Lord Roberts, V.C.
Sir J. R. Robinson
Sir Albert Rollit, M.P.
W. H. Russell, LL.D.
J. M. Le Sage
G. A. Sala
Sir D. Salomons, Bart.
Sir S. Samuel, K.C.M.G., C.B.
H. A. C. Saunders
W. Schmidt
Louis L. Schott
Major Scobell
Jas. Scott
Prideaux Selby
Capt. Seymour
Edgar Shand
Sir E. M. Shaw, K.C.B.
C. Short
Alex. Siemens
Archdeacon Sinclair
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G. H. Turner
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F. H. Webb
Sir R. Webster, G.C.M.G., M.P.
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Dean of Westminster
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J. R. Wilson
Field-Marshal Viscount Wolseley
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Major Alex. Wood
W. Wood
Capt. Woodcock
W. Woodall, M.P.
S. Yardly, C.M.G.
F. Youle
Sir F. Young, K.C.M.G.

And the representatives of all the leading London, provincial, and Colonial journals, and of the Telegraphic News and Press Agencies.

It was shortly before 10 o'clock when the banquet guests separated, and many of them at once proceeded to the gardens, which were brilliantly illuminated, and in which the bands of the Grenadier Guards and the 1st Life Guards played.

Sir John Pender, with his co-Directors, returned to the Vestibule, where they were joined by the Marchioness of Tweeddale, Mrs. J. Denison Pender, Mrs. Bevan, Mrs. James Pender and others, when the second great function of welcoming the guests to the reception immediately began, and occupied nearly two hours, the Meister Orchestra playing during the ceremony. Between 9,000 and 10,000 invitations had been issued, and about 5,000 guests were happily able to be present. The names of those who accepted the invitations are given below. Where gentlemen represented the institutions with which they are associated, the name of the Institution is given:

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David Ainsworth, M.P.
John Aird, M.P.
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John Atter
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Dr. Allchin
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W. Charles West
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C. Walton
R. Woodford
William Wickham
Joseph W. West
F. D. Williamson
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Sir A. Wilson
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Sir Walter Wragg
Lt.-Col. H. L. Wells, R.E.
Edmond Wagner
R. Whyte
T. H. Weaver
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Captain Woodcock
Emile Wolff
G. B. Yates and Son
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J. E. Young
Arthur Young
Sir Frederick Young
I. Youle
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Hon. A. G. Yorke, M.A.
Capt. Hon. J. M. Yorke
J. E. Young
Henry Zweifel and Co.
Zecchinieos Bros.

And the Representatives of the London, Provincial, and Colonial Journals, and the Telegraphic News Agencies.

Immediately after the reception, having been provided with programmes, the guests proceeded to the grounds and the galleries, other than the upper central gallery, where the exhibition of telegraphic apparatus was placed, the first inspection of which, as the guests had been notified, was reserved for the Royal visitors. The grounds were delightfully cool, and presented a charming appearance with their brilliant illuminations. The weather continued fair till towards quite the end of the proceedings. The band of the Grenadier Guards, conducted by Lieutenant Dan Godfrey, was stationed in the West Garden, and the band of the 1st Life Guards, conducted by Mr. Joel Englefield, played in the East Garden. Refreshments were served at various places in the grounds, and also at a buffet in the North Gallery, where there was a fine display of British china, glass, and pottery. Subsequent to the Royal visit the exhibition of telegraph apparatus was open to the company generally, and, under the able guidance of several of the Eastern Company's officials, the guests were initiated into the essential features of submarine telegraphic work.

On their arrival at the main entrance shortly after half-past eleven o'clock, the Prince of Wales and the other Royal guests were received by the Lord Chancellor, chairman of the governing body; Sir Frederick A. Abel, Bart, K.C.B., secretary and director of the Imperial Institute; and Sir Somers Vine, C.M.G., assistant secretary and general sub-director of the Imperial Institute, and were conducted by them to the Vestibule curtain, where Sir John Pender and his

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colleagues welcomed them. After their reception the Royal party and suite, escorted by the acting stewards, headed by Mr. Bean proceeded by the main Vestibule steps to the eastern foyer in the upper central gallery, and, with a few specially invited guests, inspected an exhibition of telegraphic apparatus, in which and in the explanations of Lord Kelvin and Sir John Pender the greatest interest was manifested. The exhibits comprised the following:—

Case containing specimens of the Types of Cable connecting England with Bombay, via Egypt.
Case containing specimens of various Cables laid for the Eastern Telegraph Company.
Case containing specimens of the Types of Cable used in the Eastern Telegraph Company's Trieste-Corfu Section, laid in 1882.
Case containing specimens of the Types of Cable in the Triplicate Red Sea Section, laid in 1883.
Case containing specimens of Cable laid in the Mediterranean in 1887.
Case containing specimens of the Eastern and South African Telegraph Company's Cables.
Specimen of the 1861 Malta-Tripoli-Bengazi-Alexandria Cable. Recovered off Tripoli thirty years after submersion.
Picked-up lengths of Red Sea Cable, covered with marine growth.
Pieces of the original Suez-Souakim Cable with Coral growth, recovered by the s.s. "Chiltern" in 1890.
Specimens of submarine vegetation picked up in the Straits of Malacca.
Growth removed from Cable picked up in the Red Sea.
Boring worms which attack Cables, causing faults.
Microscopic drawing of the head of a boring worm.
Various faults caused by Teredo borings, and a specimen of brass-taped Cable now adopted for prevention of same.
Snake found coiled round Cable during repairs off Batavia.
Adder picked up with Cable repairs off Saigon.
"Feather" star-fish taken off Cable during repair.
Deep Sea Fish.
Profile chart of the North Atlantic Ocean, showing the Cables.
The Grapnel used in recovering the 1865 Atlantic Cable.
Model showing how light-ships are connected by Electric Cables to the shore.
Mirror and recorder key taken from Alexandria Office after it had been broken into by the rebels during bombardment of town.
Four direct-working Morse instruments, complete.
Four Saunders' fine-wire tube lightning guards.
Four Bullock and Brown's unigraphs.
The original messages which passed between Lord Monck, John Pender, Esq., and the Directors of the British Australian Telegraph Company —and the Chairman of a banquet held at Adelaide to celebrate the completion of telegraphic communication between England and Australia, 1872.
And Maps showing the complete Cable system of the World; the African Cable system; the Eastern Extension and China Telegraph Company's system and the Cables on the West Coast of America; and the Eastern Telegraph Company's Map, shewing the complete Cable system of the World, with each Telegraph Company in a distinctive colour.
Model of the s.s. "Great Eastern."
Models of the Eastern Telegraph Company's Cable Ships, "John Pender," "Chiltern," "Mirror," "Electra," and "Amber."
Model of the Eastern Extension Telegraph Company's Cable Ship "Recorder."
Model of the Eastern and South African Telegraph Company's Cable Ship "Great Northern."
Sir William Thomson's (Lord Kelvin's) first complete syphon recorder for working long Cables. (1870.)
Latest form of Thomson's syphon recorder—(designed by Dr. Muirhead)—worked by automatic sender, through an Artificial Line electrically equal to 1,000 miles of Submarine Cable.
Symbolical Drawings, by Ambrose Dudley, representing Europe, America, Asia (including Australasia), and Africa, which were placed over the instruments working to those quarters of the world, were much admired. The Prince of Wales making particular enquiries as to the artist.

The Prince of Wales and his Royal relatives had completed their inspection of the exhibits by about half-past twelve o'clock, at which time they proceeded to the Royal supper room, outside which the Roumelian National Band played. The following is the full list of those for whom covers were laid:—

H.R.H. the Prince of Wales, K.G., H.R.H. the Duke of Cambridge, K.G., H.R.H. the Princess Louise (Marchioness of Lorne), H.S.H. Prince Edward of Saxe Weimar, H.S.H. Prince Hermann of Saxe Weimar, the Turkish Ambassador, the Italian Ambassador and Lady, the United States Ambassador and Lady, the Persian Minister, the Danish Minister and Lady, the Portuguese Minister and Lady, the Netherlands Minister and Lady, the Japanese Minister and Lady, the Servian Minister and Lady, H.H. the Maharajah of Kuch Behar, the Duke of Fife, K.T., the Marquis of Lorne, K.T., G.C.M.G., Sir John Pender, G.C.M.G., M.P., chairman, the Marquis of Tweeddale, vice-chairman, and Lady, the Lord Chancellor and Lady, the Chancellor of the Exchequer and Lady, the Right Hon. H. H. Fowler and Lady, the Marquis of Salisbury and Lady, the Marquis of Lansdowne and Lady, Viscount Cross and Lady, Field-Marshal Viscount Wolseley and Lady, Admiral Lord Hood and Lady, General Lord Roberts and Lady, Lord Kelvin and Lady, the Right Hon. Lord Playfair and Lady, the Right Hon. J. Chamberlain and Lady, the Lord Mayor and the Lady Mayoress, Sir Redvers Buller and Lady, Sir Frederick Abel, Sir Robert Herbert and Lady, Sir Somers Vine, Sir A. J. Leppoc Cappel and Lady, Mr. F. A. Bevan and Lady, Mr. James Pender and Lady, Mr. J. Denison Pender and Lady, Mr. G. Draper, Mr. F. E. Hesse, Mr. H. A. C. Saunders, Mr. W. T. Ansell, Mr. W. Hibberdine, Mr. A. R. Hardie, Mr. G. C. Jack, Mr. T. A. Bullock, Mr. C. Johnson, and the equerries in attendance on the Royal guests.

The evening fête was a complete success, and was ,happily, not marred by a single accident.

The officials of the Imperial Institute, upon whom devolved the work of organisation of this magnificent gathering, were assisted by Mr. G. Draper, the secretary of the Eastern Company; Mr. F. E. Hesse, secretary of the Extension Company; Mr. H. A. C. Saunders, electrician-in-chief; Mr. W. T. Ansell, traffic superintendent; Mr. W. Hibberdine, traffic accountant; Mr. A. R. Hardie, accountant of the Eastern Company; Mr. G. C. Jack, accountant of the Extension Company; Mr. T. A. Bullock, superintendent of the London offices of the Associated Companies; while Messrs. Macmillan, Brodrick, and Porter, of the Associated Companies, acted as assistant stewards.

Only those who were present can form any idea of the precision with which the arrangements devised by these gentlemen worked, and every credit is due to them for the admirable manner in which they discharged their important duties.

Telegrams were dispatched by the Prince of Wales during the evening to the Viceroy of India as follows:—

"The twenty-fifth anniversary of the establishment of Submarine Telegraphy to the Far East is being celebrated at the Imperial Institute to-night, and taking as I do a great interest in such an important work, I desire to offer my congratulations to Your Excellency on the auspicious event, and to express the hope that its usefulness in bringing the nations into closer contact and in developing commerce may be largely increased and extended in the future."

To the Governor-General of Canada, and the Governors of Cape Colony, Hongkong, Natal, New Zealand, New South Wales, Queensland, Singapore, South Australia, Tasmania, Victoria, and Western Australia as follows:—

"I am to-night present at the Imperial Institute taking part in the Celebration of the Twenty-fifth Anniversary of the Establishment of Submarine Telegraphy with the Far East; and as the Institute has been placed in direct communication with your Excellency for the occasion, I desire to offer my congratulations on the auspicious event, and to express the hope that Submarine Telegraphy will be found as beneficial in the future as in the past in helping to cement the ties binding the Colonies to the Mother Country, and in developing and extending Commerce throughout the World."

And to the British Ministers at Lima and Valparaiso as follows:—

"The Eastern Telegraph Companies are to-night celebrating at the Imperial Institute the Twenty-fifth Anniversary of their career, and taking as I do a deep interest in their great work, and the well-being of Her Majesty's subjects in all quarters of the globe, I offer you and the British Community in Chili my congratulations on an event of such importance to the world at large."

Answers to these telegrams were received in a few minutes. Governor Duff from Sydney replied:—

"I beg to acknowledge the receipt of your Royal Highness's gracious telegram, and assure your Royal Highness that the advantage of telegraphic communication with the Mother Country in developing the resources of this colony is much appreciated by Her Majesty's loyal subjects in New South Wales."

The Earl of Kintore, Governor of South Australia, replied:—

"I most gladly avail myself of the opportunity afforded me in acknowledging your Royal Highness's message, just received, to ask your Royal Highness to express to Sir John Pender and the Board of Directors of the Eastern and Eastern Extension Telegraph Companies how entirely, in common with all South Australians, I desire to associate myself in the congratulations they are receiving from your Royal Highness at the brilliant gathering assembled to celebrate the Twenty-fifth Anniversary of the Establishment of Submarine Telegraphy with the Far East, and to testify to the happy and far-reaching results of an enterprise which has done so much to promote the unity and well-being of the Queen's empire."

His Excellency the Governor of New Zealand cabled:—

"I respectfully reciprocate the congratulations of your Royal Highness on the Twenty-fifth Anniversary of the Establishment of Submarine Telegraphy. The development of this colony during that period has been great. It appreciates the assistance of the Companies and wishes them continued success."

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SUMMARY OF THE PROGRESS OF SUBMARINE TELEGRAPHY.

The early history of submarine telegraphic communication between Great Britain and the Far East is especially noteworthy from the fact that it was fostered and assisted by the British Government. In August, 1858, the Red Sea and Telegraph to India Company was registered with a capital of £800,000, and a British Government perpetual guarantee of 4½ per cent. on its capital provided the cables worked throughout. The cables were laid down the Red Sea and round the coast of Arabia to Kurrachee, starting from Suez and calling at Cassire, Suakim, Aden, Hellania, and Muscat.

These cables, which were manufactured by Newall and Co., worked throughout for a very short time, but then failed and were abandoned. The British Government being obliged to continue the interest, the stock was converted into terminable annuities for fifty years from August, 1858, to July, 1908, so that the Government are still paying interest on this stock, and the total loss to the country will be altogether £1,800,000. At this time the telegraphic communication between Egypt and Great Britain was dependent upon the land line through Turkey and across the Continent of Europe. The Telegraph to India Company also had a monopoly for working the land line in Egypt between Alexandria, Cairo, and Suez.

In 1861 the first cable was laid between Malta and Alexandria *via* Tripoli, Bengasi, along the African coast. This cable was the property of the British Government, and was leased to Messrs. Glass, Elliott, and Co., afterwards the Telegraph Construction and Maintenance Company. Malta had previously been connected with Italy by the cable of the Mediterranean Extension Telegraph Company, a dividend of 3 per cent. per annum upon its capital being guaranteed by the British Government. In 1868 the Anglo-Mediterranean Company was formed to take over the Malta-Alexandria cables, and also to work a land line through Italy. An additional cable direct between Malta and Alexandria was laid, and from this nucleus has sprung the present enormous system of the Eastern and Eastern Extension Telegraph Companies.

The agitation for a direct submarine telegraphic communication between India and Great Britain culminated in 1869 in the registration of the following Companies :—

The British Indian Company, formed to acquire the rights in Egypt of the telegraph to India Company, and to lay direct cables between Suez, Aden, and Bombay. The Marseilles, Algiers, and Malta Company, formed to lay cables between Marseilles and Malta, touching at Bona; and 25 years ago the Falmouth, Gibraltar, and Malta Telegraph Company was registered. This Company accepted messages direct from the public in Great Britain, and by means of a leased land line between London and the Land's End, and cables from Land's End to Lisbon, Lisbon to Gibraltar, and Gibraltar to Malta, completed direct submarine telegraphic communication between Great Britain and its Eastern possessions. It is worthy of note that none of these companies were assisted by any Government monopolies, subsidies, or guarantees, as in the case of the original Red Sea cables, so that it may truly be said that the Government and mercantile communities of the world owe the vast benefits that they have received from direct submarine telegraphic connection during the past 25 years entirely to the enterprise of a few British merchants and the original shareholders in these Companies, who willingly risked their money in an undertaking which at the time appeared to be a speculation of a most uncertain character.

The extension of submarine telegraphic communication to countries beyond India had been proposed as far back as 1859-60, and in November, 1860, an expedition left London on board the ss. "Queen Victoria" to lay, on behalf of the British Government, a cable between Rangoon and Singapore. Unfortunately, the ship was wrecked in the Channel, and the idea of laying the cable was afterwards abandoned.

The revival of submarine telegraph enterprise in 1869, mainly caused by the successful laying and working of the Atlantic cables of 1865 and 1866, did not stop with extending the benefits of submarine cables to our Indian Empire; but large British colonies and foreign dependencies beyond India were not overlooked, and on October 20, 1869, was registered the British Indian Extension Company for laying cables between Madras and Penang and on to Singapore. The China Submarine Company was established on December 11, 1869, to lay cables between Singapore and Hong Kong and Shanghai, and the British Australia Telegraph Company was registered on January 4, 1870, for the purpose of connecting Singapore and Batavia. Batavia was connected by land-line with Banjowangie, from whence a cable was proposed to be laid to some point on the Australian coast. The companies having been duly formed, no time was lost in manufacturing the cables and submerging them.

The ss. "Great Eastern" laid the Suez-Aden section, and the line between Suez and Bombay was opened for through traffic on March 26, 1870. On June 11, 1870, the Falmouth, Gibraltar and Malta Telegraph Company opened its London office, and messages were for the first time sent direct from Great Britain by submarine telegraph to India. Countries beyond India were connected by telegraph on the following dates :—

Penang	January 4, 1871.
Singapore	December 16, 1870.
Hongkong	June 10, 1871.
Saigon	July 31, 1871.
Java	November 19, 1870.
Australia	October 21, 1872.

It will thus be seen that all the lines except that to Australia contemplated by the seven Companies formed in 1869 and the beginning of 1870, were laid and open for traffic by the middle of 1871. As regards the line to Australia, the cable was laid on November 22, 1871; but, owing to the non-completion of the Australian land lines and a long interruption of the Banjoewangie-Port Darwin cable, telegrams were not able to pass uninterruptedly between Europe and Australia until October 21, 1872. This long system having been fairly started as a commercial enterprise, it was impossible for it to stand still, and the watchword of its promoters has ever been "Onward!" so as to extend the benefits of submarine telegraphy to all parts of the known world.

After the seven companies had been working a short time it was found desirable to amalgamate the four Companies owning the cables this side of India into one Company, and on June 6, 1872, the Eastern Company was registered, and took over the Falmouth, Gibraltar, and Malta, the Marseilles, Algiers, and Malta, the Anglo-Mediterranean, and the British Indian Submarine Companies, and this having been successfully accomplished, the Eastern Extension, Australasia and China Telegraph Company was registered on April 24, 1873, and absorbed the British Indian Extension, the China Submarine, and the British Australian Telegraph Companies. It is, therefore, more than 20 years ago that the system of submarine telegraphs which had been inaugurated in 1869 assumed the form under which they have been so successfully worked up to the present time.

During the first few years of the working of the Eastern submarine telegraphs, several prolonged interruptions of communication took place. The Lisbon-Gibraltar cable was interrupted from November 28, 1870, to February 11, 1871, and again from April 27 to September 30, 1871. During this time telegrams to the East had to be sent from England *via* Holland, Germany, Switzerland, and Italy to Malta, the route through France being unavailable owing to the Franco-German war and the Paris Commune. The next serious interruption of communication this side of India was that of the Suez-Aden cable from November 15, 1875, to February 2, 1876. The communication between Aden and Bombay has been totally interrupted on three occasions, viz. :—

July 13, 1881, to August 9, 1881.
June 3, 1884, „ June 27, 1884.
Aug. 11, 1888, „ Sept. 11, 1888.

The only other serious total interruption this side of India was during the Egyptian war, when the land lines in Egypt were unavailable for our through traffic from July 11, 1882, to September 29, 1882. The most serious total interruptions beyond India have been as follows :—

Madras-Penang	Nov. 14, 1875, to Dec. 24, 1875
„ „	Mar. 27, 1876, „ Oct. 25, 1876
„ „	June 13, 1884, „ July 14, 1884
Java-Australia	June 25, 1872, „ Oct. 21, 1872
„ „	Nov. 8, 1877, „ Dec. 15, 1877
„ „	Sept. 27, 1878, „ Nov. 2, 1878
„ „	July 4, 1879, „ July 24, 1879

The inconvenience of these total interruptions to the Governments and telegraphing public, as well as the loss of revenue sustained by the Companies showed the management the absolute necessity of duplicating and triplicating the communications. This was carried out on the following dates :—

Duplicate Cable.	Date of Laying.
Portheurnow-Lisbon, *via* Vigo	July 19, 1873
Lisbon-Gibraltar, *via* Villa Real	Sept. 27, 1871
Gibraltar-Malta	Oct. 12, 1887
Malta-Marseilles	Oct. 24, 1887
Malta-Alexandria	Nov. 22, 1870
Alexandria-Suez, *via* Port Said	Aug. 25, 1882
Suez-Aden	Nov. 11, 1876
Aden Bombay	Mar. 7, 1877
India-Penang, *via* Rangoon	Apr. 7, 1877
Penang-Singapore, *via* Malacca	Aug. 15, 1879
Singapore-Hongkong *via* Labuan	May 4, 1894
Singapore-Java (Banjoewangie)	Dec. 9, 1879
Java-Port Darwin	Jan. 28, 1880
New Zealand-Australia	May 7, 1890
Victoria-Tasmania	Nov. 23, 1885

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Triplicate Cable.	
Porthcurnow-Lisbon	July 21, 1887
Lisbon-Gibraltar	July 27, 1887
Suez-Aden	Apr. 21, 1883
Aden-Bombay	Apr. 19, 1891
Penang-Singapore	Apr. 10, 1892
Java-Australia (*via* Roebuck Bay)	Feb. 26, 1889
Quadruplicate Cable.	
Suez-Aden	Nov. 18, 1890

It should be mentioned that the Australian Colonies, appreciating the benefits of continuous communication, and admitting the fact that the Company single-handed was unable to carry out the system of duplication, generously assisted the Eastern Extension Company by granting a subsidy of £32,400 per annum. With this exception the whole of these additional lines have been laid at the sole expense of the two Companies.

The communication with the East has been further strengthened and improved by the leasing of a line between London and Marseilles, through France, over which passes at the present time the principal portion of the traffic between Great Britain and the far East, by a direct cable between Malta and Zante, and by joint purse agreements with the Indian Government, the Indo-European Telegraph Company, and the Great Northern Telegraph Company. By means of allied companies South America has been connected with Europe, and the continent of Africa has been practically surrounded by submarine cables.

The system of submarine telegraphs which is generally known under the name of the "Eastern" may truthfully be said to be one of the greatest monuments of British enterprise and perseverance that the world has ever seen, and it has ever been the endeavour to go forward, never being satisfied with its present efficiency, but always striving to do better than before.

A few instances of the average time occupied in transit of the general traffic may be interesting:—

	Opening of Line.	Present Day.
Portugal	5 to 6 hours	30 mins.
Spain	9 to 10 „	15 „
Egypt	3 to 4 „	20 „
India	5 „	35 „
China	8 „	80 „
Australia	10 „	100 „
Brazil	8 „	25 „
Argentine	10 „	60 „
Chili	10 „	70 „
Peru	10 „	80 „

The two Companies and their allies employ nine ships, which are constantly at work repairing the cables and keeping up communication, besides which tanks for the storage of cable have been erected at many places on the Companies' system, and it is worthy of note that although the opinion of experts varies considerably as to the life of a submarine cable, these two Companies have never been unable to repair a cable, and the original lines are capable of carrying the same amount of traffic at the present time as on the day they were laid.

One of the greatest improvements which the Companies have been able to avail themselves of was the introduction of the patent for duplexing the cables whereby, their carrying capacity has been increased by at least 75 per cent. By reducing delay we create traffic, because if merchants can obtain a reply to their morning message in the same day they can send the answer before the close of business hours; indeed, in many cases three or four telegrams are exchanged between London and abroad during the six or seven hours of the day that business is carried on in the City.

When the Companies were started 25 years ago the system of code messages had not been invented, and the estimate of receipts was based upon all telegrams being sent in open language; if this estimate had been maintained the revenue of the Companies would have been very much larger than at present; but it is only fair to say that the existing cables would not have been able to carry the traffic. On the complete opening of the lines the cables carried 425,000 messages per annum; at the present time they are carrying 2,100,000; the average length of the telegrams is now, however, only 11 words, whereas it used to be 35 words. The two Companies and their allies now work 124 stations, against 25 at the time of opening of communication.

Tariffs.—The general system of tariffs in vogue twenty-five years ago was a charge based upon a message of twenty words, with a proportionate increase for every extra ten words. This system lasted until 1876, when the alterations agreed to at the St. Petersburg conference were brought into operation, and all messages exchanged with places outside Europe were charged at a tariff of so much per word. This system had been partially tried with India as far back as November, 1873, but with this difference, that a minimum charge was made for the first ten words.

When the submarine cables were first opened for international correspondence with India they had to compete with the existing overland line of the Indo-European Company through Germany, Russia, and Persia to Bushire, and thence by the Indian Government cables to Kurrachee. The tariff was £2. 17s. per twenty words, but it was soon found that the rate was quite inadequate to pay expenses, and a fair dividend on the capital invested by either route; and after a sub-conference of the States interested, held at Berne, the rate was raised to £4 per twenty words on January 1, 1871. This rate was again raised in February, 1871, to £4. 10s., and lowered to £4 in July, 1872, and after some variations it was fixed at its present figure of 4s. per word in July, 1886. Experience has shown that this is a fair rate for the Indian business, which is not an expensive one, and the traffic has practically remained stationary for many years.

The tariffs with European countries are governed by the charges *viâ* the land lines, and it may be said that wherever we have been brought into competition with the Government land lines the Companies have managed to hold their own, and to secure the principal portion of the traffic. There is nothing worthy of particular notice in the tariffs to the Far East, with the exception of those for messages exchanged with Australasia. After prolonged negotiations the rates between Europe and Australasia were reduced from 9s. 4d. to 4s. per word, under a guarantee from the Governments, the Companies taking upon themselves half the risk; the result was an increase of 50 per cent. in the number of words carried, and a gross loss of revenue equal to £55,000. In January, 1893, the rate was raised at the request of the Colonies to 4s. 9d. per word, but, owing principally to the great depression of trade in Australasia at the present time, the increase of traffic over that carried at the tariff of 9s. 4d. is not so large as might be expected.

Some years ago the Companies, with a desire to supply the general public with cheap news, introduced with this object reduced press rates, not only for supplying European news to the countries in the East, but also to enable the European public to obtain news of the doings of their friends beyond the seas. The experiment has as a whole proved satisfactory, and the Companies are always willing to extend the system wherever practicable.

In concluding, it may be pointed out that the telegraph rates for messages exchanged with the East have during the past 25 years been fair ones, not only for the Companies carrying the traffic but also for the public. The results have been different from the experience of the North Atlantic Companies; the latter, owing to competition and insufficient tariffs, are at the present time not in the position to give their shareholders a fair dividend on the capital invested.

A *résumé* of the history of submarine telegraphs to the East would not be complete without mentioning a few of the events of international interest in which the telegraph has played an important part. The Earl of Mayo was murdered in the Andaman Islands, and the news was confirmed by a special message brought through the submarine telegraphs in a few minutes (February, 1872). During the war in Afghanistan in 1878, 1879, and 1880 the Government made large use of the telegraph, and the British public was enabled to read full details of all actions almost as soon as they took place. The disaster of Isandula in January, 1879, was not known in Great Britain until some weeks after it happened, owing to the want of submarine telegraph communication, and this event probably more than anything else hurried on the negotiations for the opening of telegraphic communication with South Africa.

In 1881 all the negotiations with the Transvaal were carried on by means of the telegraph, so that the British Cabinet was practically in hourly communication with the Boer leaders. But the event which more than anything else exemplified the capabilities of the telegraph, and proved to the world at large the enormous difference in the transmission of news in the present day compared with what it was twenty-five years ago, was the bombardment of Alexandria and the subsequent operations in Egypt, the Soudan, and Suakin. It is not too much to say that during this time the public were kept in hourly touch with all the events, even to the minutest detail, that were happening in Egypt, and the Eastern Company is justly proud that the immense traffic at that time was brought through without practically any delay at all, and it most certainly reflects great credit on the management that had created a system so perfect that an influx of such an enormous traffic affected it to such a slight extent.

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THE ELECTRICIAN:

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NOTES.

The interest of the electrical profession in the proceedings of the British Association, although most commonly directed chiefly to Section A, seems likely this year to be about equally divided between Sections A and G, or even to preponderate on the side of the latter. We are able to forecast, to some extent, the proceedings of these two Sections. The electrical Papers in A will include a contribution by Lord Kelvin and Dr. Magnus Maclean on air electrification; a Paper by the former conjointly with Mr. Galt on some conditions of Leyden-jar discharge; one by Dr. Stoney, entitled "How the Misuse of the word Force in Attractions in Electricity and Magnetism may be Avoided without much Departure from Existing Practice." This last may possibly give rise to some discussion on the foundations of dynamics, and the metaphysical aspects of the word Force. Poor word! It has served its time very faithfully; may it be well pensioned when the time comes for it to go! Prof. Viriamu Jones will give some descriptions of his further researches on standards of resistance; and Prof. Schuster will contribute two Papers—one on terrestrial magnetism, the other on the construction of sensitive galvanometers. A Note by Mr. Newall on the spectra of discharges in gases without electrodes ought to prove of interest to students of molecular physics.

The regular electrical day for Section G is fixed for Monday, August 13th. Mr. Preece will contribute two Papers—one dealing with the efficiency of glow lamps, the other on signalling without wires. A direct-reading platinum pyrometer will be described by Mr. G. M. Clark. The system of electric supply at Oxford will be described in a Paper by Mr. Thomas Parker. Besides these directly electrical contributions, electrical engineers should find interesting material in the Paper on engine hunting which Mr. Swinburne will read; in a Report by the Committee on the dryness of steam; in Mr. Burstall's Paper on entropy; and in a Paper which Prof. Hudson Beare will read on "Steam Losses." Prof. Kennedy's presidential address to this section will discuss the subject of "Modern Mechanical Training, Constructive and Critical." The fusion of Sections G and A into an alloy, on Friday, August 20th, will be looked for with interest, as it is expected to be attended with the liberation of considerable amounts of energy. On that occasion two important discussions are arranged to take place: one on "Integrators, Harmonic Analysers, and Integraphs, and their Application to Physical and Engineering Problems," which will be opened by Prof. Henrici; and the other on "Flight," to be led off by Lord Kelvin and followed up by Mr. Maxim and other authorities.

We learn with some alarm that Lord Kelvin and Lord Rayleigh recently "assisted" at an experimental run of Mr. Maxim's flying machine. It may be true that guard rails were fixed to prevent any serious rise into the air, but could not these distinguished visitors have been content to watch the performance at a safe distance? If mere ballast was wanted, copies of their collected works might have been used. If Mr. Maxim must needs have a living cargo of well-known men, we shall be happy to supply him with the names of two or three men who could be spared, and who never would be missed. We cannot afford to lose Lord Kelvin and Lord Rayleigh.

The report of the Directors of the Liverpool Overhead Railway Company for the half-year ended June 30th shows that this concern continues to prosper. To pay the Preference shareholders in full, and the Ordinary shareholders at the rate of 1 per cent., is by no means a bad record for a novel type of railway that only came into operation a year ago last March. The following comparative figures for the half-year may be of interest. The "loco." expenses of the Liverpool line not comprising the items of salaries and wages for repairing work, these have been deducted from the London total.

	Liverpool.	City and South London.
Passengers carried	2,861,437	3,383,154
Train miles run	265,349	227,363
Passengers per train mile	11	15
Passenger receipts per train mile...	17¾d.	24¾d.
"Loco." expenses per train mile...	2¾d.	5¾d.

The results of practical every-day use of electric welding formed the subject of a Paper read by Mr. B. A. Dobson, of Bolton, before the Institution of Mechanical Engineers at Manchester on Tuesday last. The author has found the system to be very satisfactory on the whole, but the chief advantage is the uniformity and reliability of the work rather than any saving in cost. The extravagant promises made a few years ago have not been realised, and the onerous terms of licence and the cost and depreciation of the plant have, as seemed likely from the first introduction of the process into this country, greatly impeded its development. In the discussion which followed, the general opinion was that the process could only be worked advantageously in special

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cases in very large establishments. Electric welding by the Thomson process seems to be most valuable where it is worth while to build a machine for one definite and invariable job, and where it can be employed continuously. The smaller the work, down to, say, No. 22 wire, the more useful and satisfactory is the process, and, similarly with the Benardos process, the thinner the sheet the more remarkable are the results.

The gist of Mr. Thornycroft's interesting Paper on "The Influence of Circulation on Evaporative Efficiency of Water-Tube Boilers" amounts to the following:—That if a high evaporative efficiency is desired, rapid circulation must be promoted; that rapidity of circulation cannot be obtained unless a separate down-take for the water is provided; and that any constriction of the water in its passage through the down-take must reduce the effective head tending to lift the water in the heating tubes, and will therefore hinder circulation. Mr. Thornycroft's experiments amply bear out these conclusions, which, we may add, are perfectly consistent with the established theories of circulation and evaporative efficiency. His discovery of the critical point in certain cases will, however, be an important item of news to many boiler makers, and may lead to more scientific practice in the future. Water-tube boiler makers are in some instances also inclined to forget that constriction of the downtake is not simply a matter of sectional area of the return tubes. We could mention more than one example of well-known boilers having an imperfect circulation, even with ample section of downtake, the defect arising from the irregular motion given to the water in its passage from the steam vessel to the water vessel. Some of the speakers in the discussion on Mr. Thornycroft's Paper appeared to condemn over-circulation, as being liable to cause over-heating. Over-circulation, *per se*, cannot do any harm; in fact, it is an impossibility. What is harmful is the attempt to crowd too much heat through each square foot of heating surface. This will, of course, produce extra rapid circulation; but it is not the rapid circulation which does the mischief, it is the lack of proper heating surface. The same amount of circulation in a different boiler might prove perfectly harmless.

Not one of the least important services which Mr. Crompton has rendered to electrical engineers, in his recent Paper on "The Cost of Electrical Energy," is the emphasis he has laid on the importance of minimising the losses which occur in auxiliary plant at central stations. The use of small supplementary steam-engines for driving the feed-pumps, or the automatic stokers, is a case in point. These engines, even when worked at full load, cannot be as efficient as large engines; while, as is very well known, the greater part of their time is filled up on small fractions of full load or in absolute idleness, during which time they are "eating their heads off," as it were, owing to the enormous condensation of steam which takes place. Mr. Crompton has already discovered that it is more economical to take this auxiliary power from the main engines, even though through the intermediate mechanism of the dynamos, some yards of cable, an electro-motor and a belt, than to derive it from a special small engine. Mr. Bromley Holmes now informs us that he has adopted this practice for driving the mechanical stokers for the boilers at the Liverpool electric supply station, and kindly sends us some particulars of the arrangement. A 1-h.p. electric motor, run from the station mains, is geared to a countershaft by means of a belt, and a second belt placed between the countershaft and the stoker shaft transmits the power to the stoker. As the variations of speed necessary to the regulation of the coal feed are effected in the stoker mechanism itself, the motor may be run continuously at its normal speed. When the stoker is not at work the cutting of the motor out of the circuit obviates any stand-by losses. The arrangement is, therefore, almost as efficient at low loads as at full load, and is found in practice to give very satisfactory results.

It is a truism that the design, and especially the width, of the streets of a city reacts upon the nature of the means of locomotion. This being the case, the future of electric and other vehicular traffic in London is not unconcerned with the provisions in the new Bill of the London County Council regulating the width of London streets. In regard to the item of width, the *Builder* characterises the provisions as miserable, and "calculated to stereotype one of the greatest mistakes that can be made in a town, both for appearance and for sanitary conditions." The standard L.C.C. street of the future, it appears, is, if the Bill comes into force, represented by Chancery-lane. Compare the proportions of the narrow slot which bears this name with the ample proportions of High Holborn, or the spacious width of Portland-place, and it will readily be seen that London of the future will, to say the least of it, know very little of the electric trolley. Probably the increased surface pressures will tend to induce the citizens to travel more frequently underground, and the modification of street design will become the pre-disposing cause for an even greater number of tubular electric railways than are now under contemplation. Yet where is the need for such Chinese density of population? What adequate compensation do the proposed changes offer for the loss of æsthetic and hygienic advantages in our wider streets? What would Paris become, for example, under the ægis of such street reformers?

Portrait of Heinrich Hertz.—A Steel Plate Portrait of the late Dr. H. Hertz will be published with our next issue.

Cable Interruption:

	Date of Interruption.
Para-Maranham...	July 23rd.

Douglas and Laxey Tramway.—The new coast electric tramway between Douglas and Laxey was formally opened to the public on Saturday.

Accumulator Manufacturing in Spain.—It is reported that large works for the manufacture of accumulators are about to be established at Linares.

Professional Appointment.—Herr E. Arnold, chief engineer to the Oerlikon Works, has been appointed professor of electricity at the Technical High School at Karlsruhe.

The Telegraph in South Africa.—The telegraph line from Tati to Buluwayo, a distance of 108½ miles, has been constructed in 133 days, and at the cost of under £3,400.

Owen's College, Manchester.—A special course has been arranged on "The Technical Applications of Electricity." Further particulars will be found in our advertising columns.

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Lord Kelvin.—The Société d'Encouragement has awarded its grand gold medal for 1894 to Lord Kelvin. This medal is awarded to Frenchmen or foreigners whose labours have had the greatest influence during the preceding six years on the progress of French industry.

Chelmsford.—The arc lighting mains in the streets of Chelmsford, which were originally carried overhead, are now being placed in underground conduits, and the poles which were formerly used are being removed. The inhabitants are anxious to have the disused gas lamps also removed.

Telegraph Posts and Advertisements.—The City Council of Wellington, New Zealand, has passed a resolution "that the Government be requested to keep the telegraph posts free from advertisements, in view of the bye-law passed by the Council, which forbids the placing of advertisements on the electric light posts."

Model Answers.—In a set of model solutions to South Kensington examination questions, given by a contemporary, the question: What is a slide-valve? is answered as follows—"A slide-valve is a hat-shaped box, rectangular in plan, whose under surface is truly plane." Did the writer ever see a real slide valve?

Liverpool University College.—Notice is given by the Department of Engineering that the session 1894-95 commences on October 2nd next, when complete courses of instruction are arranged in civil, mechanical, and electrical engineering. Further particulars will be found in our advertisement columns, and prospectuses and all information can be obtained on application to the registrar.

The Institution of Civil Engineers.—The three houses, Nos. 24, 25, and 26, Great George-street, Westminster, S.W., are being rebuilt, and it is hoped that in about 18 months the new premises will be complete. The library has been removed to No. 9 opposite, where the temporary offices of the Institution are situated. The meeting-room will probably remain untouched until after next session, access being given from the street by a temporary way.

The Municipal Working of Tramways after Purchase.—At the meeting of the London County Council on Tuesday last the Highways Committee recommended that application be made to Parliament for powers for the Council to work, should it be deemed necessrry or expedient, any tramway which it might purchase under the provisions of the Tramways Act, 1870, or of any other Act; and that it be referred to the Parliamentary Committee to take all the necessary measures for the purpose.

The Epping Forest Electric Railway.—The Select Committee of the House of Lords, which had already passed the preamble of the London, Walthamstow, and Epping Forest Railway Bill, on Tuesday went through the clauses. An agreement was scheduled to the Bill with reference to the manner in which the railway is to be constructed through the estate of Mr. Bros, at Upper Clapton, and, with this amendment, the Bill was ordered to be reported. The scheme has now received the sanction of both Houses.

The Meeting of the Canadian Electrical Association.—The next convention of this Association will be held in Montreal the latter part of September, and will be one of unusual interest. The date of the convention will, if possible, be arranged to suit the usual autumn railroad excursions to Montreal and Quebec. The meetings will extend over three days. The following are some of the Papers which will be read: "The Possibility of Securing Better Regulation at Central Light and Power Stations by means of Fly-Wheel Accumulators of Improved Construction," by Mr. John Galt; "A Method of Distribution with Equalisation of Potential Difference," by Mr. D. H. Keeley, of the Government Telegraph Service, Ottawa; "Electrolysis," by Mr. J. A. Baylis; "Telephone Cables, their Construction and Maintenance," by Mr. F. J. F. Schwartz; "Alternating Motors," by Mr. L. M. Pinolet.

The City Telephone Tubes.—At the meeting of the City Commissioners of Sewers on Tuesday last Mr. Pannell moved: "That the resolution of this Court, of July 25, 1893, agreeing to a recommendation of the Streets Committee, that the Commissioners only consent to the use for telephonic purposes of certain tubes laid by the City of London Electric Lighting Company, on a guarantee being given that telephones with double wires and all the latest improvements will be supplied to the citizens at a cost not exceeding £8 per annum, be rescinded." Mr. Pannell said that the present position in which the Court was placed was a very undesirable one. The tubes which had been the subject of dispute were underground, and they represented a capital of between £80,000 and £100,000. The Commission had received an offer whereby the rates could be benefited, while it was possible also that the users of telephones would be the recipients of benefits; but as long as the present block existed the Court was simply playing into the hands of the National Telephone Company.—The motion was carried by 33 to 16.

City and Guilds of London Institute.—The Council of the City and Guilds of London Institute have conferred the Fellowship of the Institute upon Dr. W. E. Sumpner, who was awarded the Diploma of Associate of the Institute in 1887, and has since by many original and valuable researches contributed to the advancement of the electrical industry. The Council have also conferred the Diploma of Associate upon the following matriculated students who have this year successfully completed the full course of instruction at the Central Technical College:—*Civil and Mechanical Engineering:* Abbott, N., Aldis, B. S., Bushell, C. L., Carter, R. B., Cautley, A. O., Hall, A. C., Hallett, A., James, J. H., Lightfoot, C., Lloyd, H. G., Maeers, F., Stubbs, B. T., Thomas, W. *Applied Physics and Electrical Engineering:* Abrahamson, M. A., Bowden, J. R. J., Day, P. J. C., Fullerton, R. A., Harris, A. F., Leake, H. C., Mayes, A. E., Mentheth, W. F. S., O'Gorman, M. J. P. Robinson, L. L., Severs, J., Taylor, A. K., Ward, J. A. W., Wood, R. J. C. *Applied Chemistry:* Crighton, A. M., Marshall A., Schwabe, E. W. S.——At the session of the Court of Common Council, last Thursday week, the Lord Mayor presiding, a grant of £500 per annum for three years, to be made to the City and Guilds of London Institute, was recommended by the Finance Committee and was adopted.

Electric Lighting on the Embankment.—At the meeting of the London County Council on Tuesday last the Highways Committee referred to reports which had been approved by the Council recommending the establishment of an electric installation for the lighting of the Victoria Embankment at a capital cost of £10,000, while the cost of maintenance would probably not exceed £2,000 per annum. Subsequently the lighting of Westminster and Waterloo bridges and the Embankment-gardens was included, and the capital expenditure was increased to £15,000. The scheme contemplated that lamps of from 1,000 to 1,200 c.p. should be placed in the centre of the carriage-way about 50 yards apart. In March the Council decided that it was undesirable to place any lamps along the centre of the roadway. This resolution involved a reconsideration of the whole scheme, and instead of a total number of 108 lamps, as originally anticipated, by the adoption of side lighting 136 lamps would be required. The cost of the buildings and machinery would also be more than the Committee anticipated. Moreover, the period for the repayment of the loan had been reduced from 40 years to 25. They accordingly submitted a recommendation increasing the estimate to £20,000. Mr. Westacott moved that consideration of the report be deferred till next spring, as the lighting would not be available for next winter, and this was agreed to.

The Government and the Telephones.—In reply to questions addressed to him in the House of Commons this week, Mr. Arnold Morley said: "I think it may be said that an agreement has at last been arrived at between the National Telephone Company and the Post Office; but until the approval of the Company has been formally conveyed to me, and the sanction of the Treasury obtained, I shall not be in a position to lay the draft agreement on the table of the House. I think it right to add that some questions connected with companies controlled by the National Company must first be settled; but I have no reason to apprehend that this will involve serious difficulty or delay. I would point out that the agreement does not require the confirmation of Parliament, and I am, therefore,

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not aware that any special opportunity for its consideration will be necessary; but the subject is one which can, in due course, be raised on the telegraph estimates." Mr. Henniker Heaton asked whether the Postmaster-General would undertake that the question should not be finally settled before the House had had an opportunity of expressing its opinion upon it; and whether he would also give an undertaking that if the matter came on at the end of the Session he would give a promise that the carrying-out of the agreement should be postponed till next Session. Mr. Morley replied that he could not give any such undertaking. The agreement would be laid on the table of the House before it was signed. Proper time would be given to hon. members to consider it.

Screw Threads in Germany.—It is, perhaps, not generally known among English engineers that the German manufacturers are as yet unprovided with a standard system of screw threads, "every man doing that which is right in his own eyes." We learn from a Paper read to the Elektrotechnischer Verein by Mr. Th. Peters that the Imperial GermanNavy uses a thread cut to the Whitworth standard, but the dimensions made to the nearest whole millimetre; while the Royal Prussian railways use another variant of the Whitworth system; while yet a third variation of the Whitworth thread is in use in the War Department of the Prussian Government. The Verein Deutscher Ingenieure has, since 1875, been striving to bring about the adoption of some standard system, and in 1888 devised a metrical system of screw threads. Mr. Peters endeavoured to obtain from the Elektrotechnischer Verein a definite adoption of this system, but the Society preferred to adopt the following resolution: "The Elektrotechnischer Verein resolves to join the Verein Deutscher Ingenieure and the Verein der Präcisionsmechaniker in their endeavours to secure the adoption of a standard metrical screw thread," and thus avoid committing themselves to any definite system.

Glasgow.—The following additional information with regard to the working of the Glasgow municipal supply for 1893-94 will be of interest:

"Though the financial statements do not show a profit for the past year, it may be regarded as a fairly satisfactory one. A loss on the year's operations is shown, which amounts to £607. It may be mentioned that the loss on the electric lighting account in the preceding year, or rather on the operations during the period of 15 months extending from March 1, 1892, to May 31, 1893, was £1,773. It is shown by this statement that sums amounting to £120,000 had been borrowed for the electric lighting undertaking up to the end of the past financial year, and that of the amount sanctioned by the Board of Trade there was still a sum of £80,000 that might yet be borrowed. A sum of £1,200 has been paid into the sinking fund during the past financial year, and the amount now paid into that fund is set down in the statement of accounts at £2,014. For sale of current by meter during the year there was obtained a revenue amounting to £15,819, and for public lighting £1,693, the gross total revenue being £18,016. From the revenue account it is seen that the actual expenditure on the generation and distribution of electricity, attending and repairing public lamps, on royalties, rents, rates and taxes, and on management expenses, &c., was £9,592; the sum of £4,393 is set down as depreciation on works, machinery, mains, &c., and those two sums give a total of £13,985, the deduction of which from the revenue of £18,015 previously mentioned gives a balance of £4,031, which is carried to profit and loss account. The sum of £3,438 is set down in the profit and loss account as interest on loans, &c., and to it there is added the sum of £1,200, being the amount carried to the sinking fund; and these two items give a total of £4,638. When the gross profit, or balance of £4,031, brought from the revenue account, is deducted from the amount just named, there is the net balance of £607. The amount generated was 854,766 Board of Trade units, and the total quantity sold was 702,248 units. On the works there were used 13,326 units so that the total quantity accounted for is 715,574 units, and consequently the amount not accounted for aggregated to 139,192. The loss upon the total amount generated thus works out at rather more than 16¼ per cent.'

Postal Telegraph Staff Grievances.—In deference to the wish of many members of Parliament and others, the officials of the Postal Telegraph staff have prepared a statement of the case which they present for an amelioration of their position. They claim that "care has been taken to present both sides of the question. The official view is put forcibly and clearly by Sir James Fergusson and Mr. Arnold Morley. Elsewhere the telegraphists themselves, in petition and speech, tell what their complaints and desires are. Independent views, including those of Parliamentary and municipal representatives, those of members of public bodies and of the Press, are also given, so that the facts may be readily grasped and an estimate formed of the claims submitted." They add that "throughout the telegraph service there is a growing belief that without agitation wrongs will not be righted; that not until a full, impartial and independent inquiry has taken place will a satisfactory adjustment of the matter in dispute be possible. That the present unhappy state of things cannot much longer continue must be evident to anyone who ever glances at the facts here presented. A mere revision of salaries will not suffice. Reform of the whole system is demanded by every consideration, whether of departmental policy, of public interest, or of fairness to the telegraphists, and, if the circulation of this *resumé* helps forward such reform, the object of the Postal Telegraph Clerks' Association in issuing it will have been gained." The statement is put forward in pamphlet form.

Hanley.—The inaugural ceremony of the Hanley electric supply station took place last Thursday week. The generating station is adjoining the canal. Steam is supplied from three Lancashire boilers, each 28ft. long by 7ft. in diameter. Each boiler is fitted with all the latest improvements, being constructed for a working pressure of 140lb. per square inch, and mechanical stokers are used. Coal is landed direct from the barge on to a platform, from which it is fed by chutes into the stokers; thus is secured the utmost economy in labour and fuel. The main pipe is of wrought iron, 6in. in diameter, and forms a ring, with valves so arranged that any section may be isolated. The branches to the main engines are 4in. and 3in. The whole of the valves are of the parallel slide type, so that when open the steam has a straight passage through. The exhaust piping, which is of cast iron, ranging from 9in. downwards, opens into the condensers or direct to atmosphere as may be desired. The main engines are at present four in number—two of 200 I.H.P. and two of 100 I.H.P., and are of the well-known Brush compound vertical type. The alternators, which are of the well-known Mordey-Victoria type, are driven from the above engines by means of cotton ropes. Two of these run at 430 revolutions per minute, and have a capacity of 100 kilowatts each, whilst the other two run at 600, and have a capacity of 50 kilowatts each, the pressure being in each case 2,000 volts. The whole of the engine-room plant has been manufactured by the Brush Company. The distribution is effected by low pressure distributing mains at 100 volts, running from the transformer sub-stations, which are situated at convenient points in the town. The high-pressure feeder mains consist of concentric copper cables of 100 per cent. conductivity, highly insulated with vulcanised rubber and tape, braided with tarred hemp yarn, and compounded, and are drawn into cast-iron socket pipes, coated inside and out with preservative compound. Suitable draw-boxes are provided at intervals. The high-tension joints are of the Raworth-Geipel patent type, which have many advantages over the ordinary vulcanised rubber joints; the joints, being mechanical, are easily made and can be inspected by merely lifting off the cover; while the cable can easily be disconnected for testing. The transformer chambers are equipped with Mordey-Victoria transformers of the 18-kilowatt size. The principal streets are lighted by means of the Brush arc lamps fitted to ornamental posts, and worked from machines independently of the private supply. The by-streets are to be lighted by incandescence lamps, which are cut in by means of Lobley's patent automatic switch when the arc light circuits are started, so that the whole of the streets are lighted simultaneously by merely switching on at the generating station. There are two Brush series dynamos, each capable of developing 125 kilowatts at 8 amperes, running at 900 revolutions per minute. The arc light machines are driven by two vertical tandem type engines, having cylinders 6in. by 10in. by 8in. stroke, running 200 revolutions per minute. The arc light main consists of a cable highly insulated with vulcanised rubber, protected by prepared tape, compounded and drawn into cast-iron pipes. Geipel's patent telescopic street boxes, constructed entirely of cast-iron, are used for these mains. In conclusion it should be stated that the whole of the works have been carried out under the able supervision, on behalf of the Hanley Corporation, of Mr. Joseph Lobley, borough engineer; while the general design and equipment have been in charge of the Brush Company's Contract Department and Staff, under the control of Mr. W. Geipel.

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ELECTRIC MOTIVE POWER.*

BY ALBION T. SNELL.

(*Continued from page 325.*)

Motors; and Driven Machines; Selection of Type of Motor; Continuous and Polyphase Currents; Safety Motors.

The selection of the type of motor for any special work is generally not difficult, the crux lies in estimating the average and maximum torque—an approximate estimate of the power is easily arrived at, and a small error in its determination is of little importance.

For example: suppose it is required to drive a main pump, as shown in Fig. 111, on a continuous current circuit at 500 volts pressure at the motor terminals. The theoretical power in the water is known, and the losses in rising main, pumps, gearing and motor, are easily determined. The maximum torque will occur at starting, when the motor has to overcome the statical friction of the pumps and set the column of water in motion. The average torque will be simply that due to the constant load with full delivery of water. To fulfil these conditions, it is necessary to have a motor with a magnetic field sufficiently strong to give the necessary starting torque without undue sparking or an excessive quantity of current; and to give the working load at the designed speed with the highest possible efficiency consistent with a fair margin of power.

The motor winding preferably should be in series for reasons previously given.

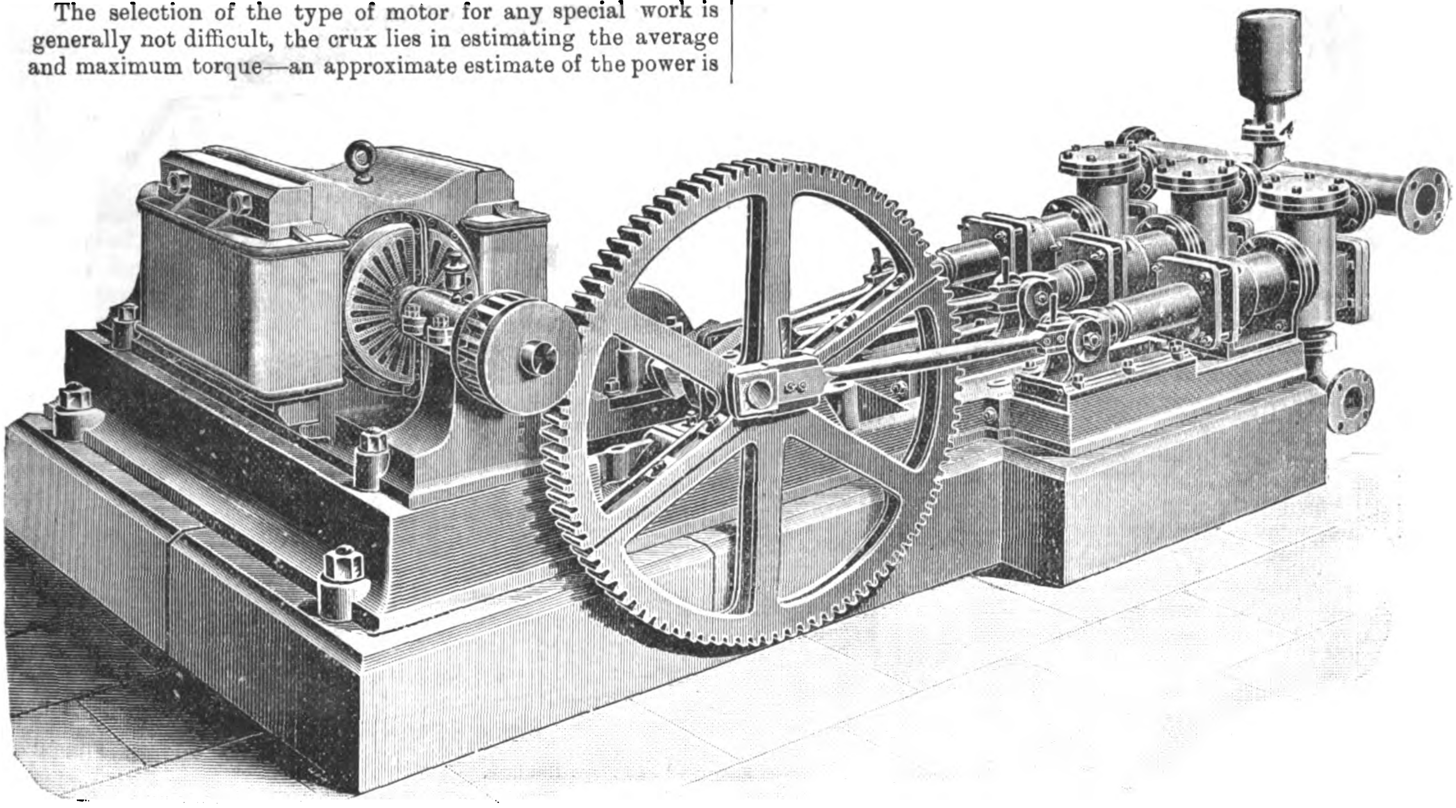

Fig. 111.—General Electric Power and Traction Company's Three-throw Main Pumps, Geared to Motor.

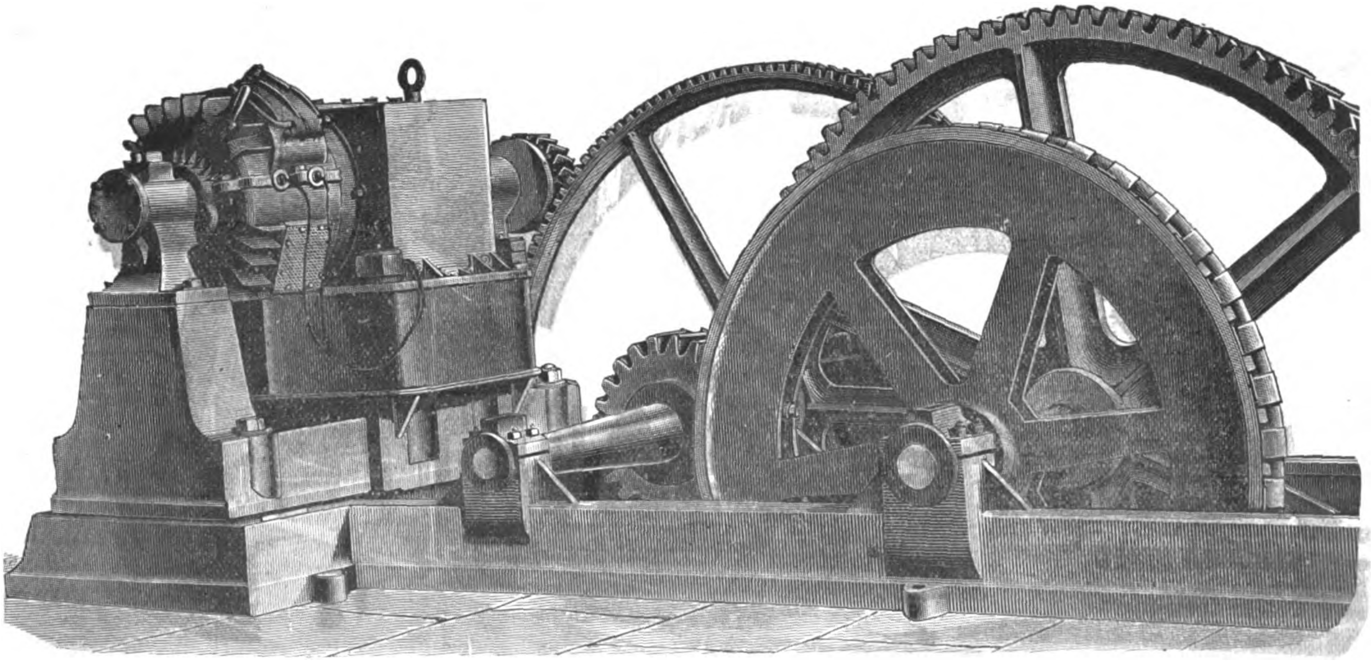

Fig. 112.—Endless Rope Haulage, with Goolden Safety Motor.

The chief constructional point is sufficient strength in the armature shaft and bearings to safely start the pumps, if this be attended to the motor will be mechanically strong enough for the running load.

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Again, assume it is required to erect an endless rope hauling plant—as illustrated in Fig. 112—on the same circuit. The various losses must first be determined, the weight of tubs loaded and unloaded, debited and credited according to the grades, and a suitable allowance made for tub-wheel, and rope friction. From these data the starting and the average torque can be determined. If the running load be fairly constant—as is generally the case with an endless rope—the series wound motor is the most suitable, and the suggestions made with reference to the main pumping motor are equally applicable. The margin of power, however, requires to be greater than with pumps, as the load may be largely

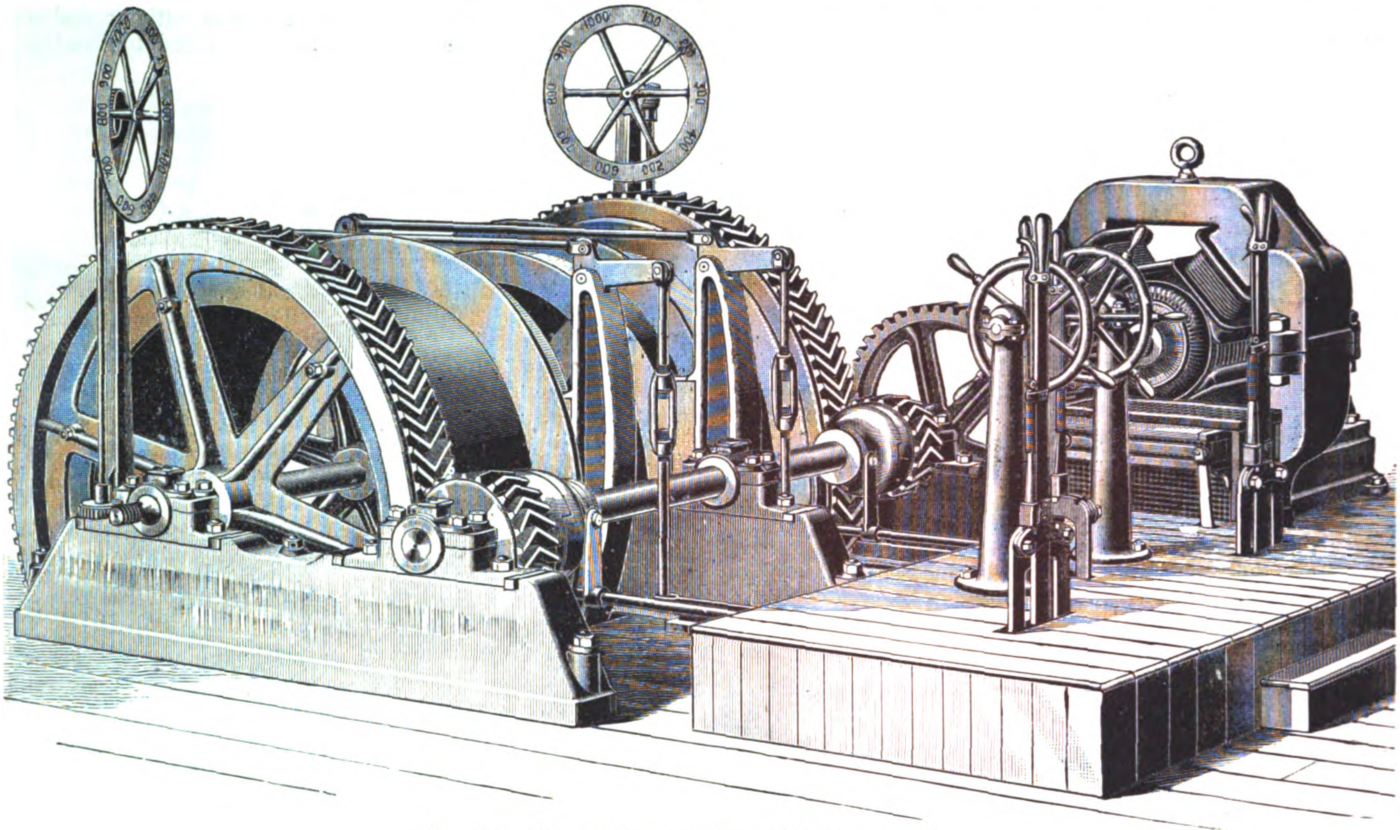

Fig. 113.—Thomson-Houston Main and Tail Rope Haulage.

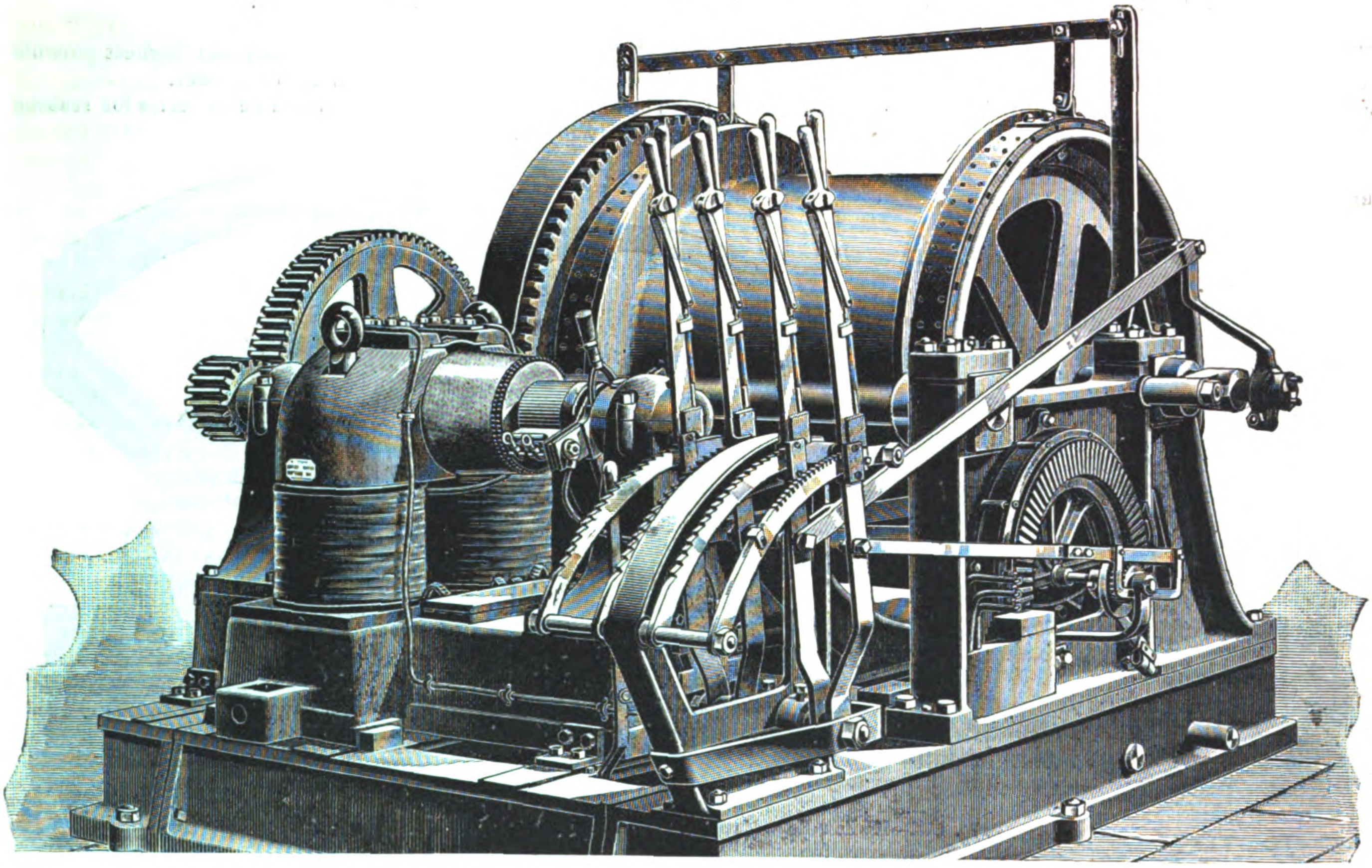

Fig. 114.—Thomson-Houston Single Rope Haulage or Winding Engine.

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augmented at times by tubs leaving the rails. There is not much fear of overloading during busy periods, because an increase of torque will slow the motor and hence decrease the actual power; but since the current will be temporarily increased, a margin for the heating effect in the windings must be provided.

If, however, the system of haulage be a main-and-tail one, as indicated in Fig. 113, where the motor has to be constantly stopped, and to deal with a continually varying load, good speed regulation and perfect control of the motor become of more importance than efficiency. In this case a specially designed cumulative compound motor may be used with a switch and starting resistance designed to keep the shunt coils always in circuit during work time, and to introduce a variable resistance in series with the armature and series-windings. Reversals of motion should be made by means of friction clutches and gearing, *not* by the motor, as this would introduce complications which are better avoided in pit work. The maximum torque in this case is generally that at starting, but not necessarily, as the load may start on the level, and afterwards have to climb a steep grade.

The best arrangement for working main-and-tail rope systems is to run the motor continuously, and to give forward or backward motion to the rope drums through friction clutches mounted on an intermediate shaft. If the motor be designed in accordance with the above suggestion, no trouble will be experienced.

The preceding remarks are also generally applicable to single-rope haulage, although in some cases, where the load is small and the pressure low, a series motor with a large starting resistance may prove satisfactory. A suitable arrangement for single rope haulage or winding is shown in Fig. 114.

For main winding gear, which is worked practically continuously during a shift, the author prefers a cumulative compound motor having a large regulating resistance, the motor running in one direction only, and the reversals being made through friction clutches as already described for main-and-tail hauling. But if the winding be used only occasionally, as frequently occurs with staple-pits, then a series motor with a large regulating resistance is preferable. The time occupied in raising the load is so short that the question of speed regulation does not enter into the problem. What is required is a large power at starting, gradually yet quickly applied, and perfect control over the cage at all parts of the run, but specially when stopping. It is also necessary to be able to raise or lower the cage a few inches. For such work the author has found series motors to give excellent results. He finds it convenient to couple the brake lever to the friction clutch so that when the brake is applied the circuit is opened, and the motor is then ready for raising or lowering as required.

(*To be continued.*)

ENTROPY.

It has sometimes been stated that the truths about entropy and its relation to heat and energy are mere algebraic abstractions which cannot be illustrated or exemplified by any physical facts. That this view of the case is erroneous everyone who has really grasped the true significance of entropy will readily admit. Not only has entropy abundant illustration in the phenomena of hydraulics and electricity, but we may depart entirely from the region of physics, and find an analogue in the principles of value and finance. Let a man have a quantity of some goods or other, by the exchange or sale of which he can derive commercial benefit. The gross value of these goods may be called the financial energy of the man and corresponds to his wealth. This amount of financial energy is the product of two factors. The first factor is the intensity of value, or "exchange rate," or what we may call the financial potential of the goods; this corresponds to the absolute temperature of a hot body. We may fix the absolute zero of financial temperature, or potential, by taking a standard substance, *e.g.*, gold, and considering the financial temperature of this standard as a datum. The second factor is the entropy of the goods, or what we may call the financial entropy of the valued material. The entropy will, of course, be directly proportional to the quantity of goods. Now, just as there are two definite processes by which a hot body may gain or lose heat energy—the adiabatic and the isothermal processes—so there are two corresponding definite processes by which a man may grow richer or poorer. A man—the financial working substance—grows richer or poorer adiabatically, as it were, when his goods do not alter in quantity, but improve or fall in their intensity of value—*i.e.*, their financial temperature. A cute business man buys his goods at a low temperature, and floats them up, adiabatically, to a high temperature, when he discharges the improved value into the store of—not heat—wealth, *i.e.*, the bank. He is a reversed Carnot engine, speaking financially. Now the other fellow, the bad man of business, works himself the other way round. He takes in entropy at a high temperature, and drops down the market to a point where he has to unload at a lower price, *i.e.*, financially his goods have become cooler. Probably he, himself, is in a fever, but that is another story. All the time, in either of these cases, that the goods are moving up or down the market —*i.e.*, the thermometer—their quantity, or entropy, does not alter in the least.

The second way in which a man may become richer or poorer may be called the isothermal method. This consists in varying the quantity of the goods without altering their intrinsic value per unit of quantity. The total entropy will then, of course, increase if the goods are increased and decrease if the goods are decreased. When a man drops a sovereign through a hole in his pocket he becomes poorer in the isothermal way; and when he picks up a like coin he becomes richer along the same curve, as it were. The value in gold—the financial temperature of the stuff—does not alter one bit during either of these processes. Penny-in-the-slot cigarette machines afford another example, when the penny passes isothermally to the owners, the cigarette remaining in the machine. The temper, if not the temperature of the disappointed smoker is, however, likely to rise. Another instance of isothermally becoming richer is the case of a farmer who sows, say, a peck of grain at a certain price per peck, and sells a crop of a hundred pecks at the same price per peck. Again, the acquisition of wealth by bequest from a dead person is an instance of an isothermal rise in financial energy; and this case is more especially like the flow of steam into an engine through a leaky pipe, the leak being called "death duties."

One point more and our analogy must be concluded. There is often a difficulty in understanding the statement that entropy tends to a maximum. We may illustrate this financially in the following manner. Suppose wealth, like physical energy, to be a conservative system; *i.e.*, suppose the magnitude of wealth to be a fixed quantity. Consider any given quantity of wealth, the magnitude of this is the product of the two above-named factors. Now, in the physical universe, the temperature tends to fall to a minimum. In the financial universe, if the given quantity of wealth falls in its intrinsic value per unit of goods, its fixed amount can only be maintained by an increase in the quantity of goods. Thus, the lower the intrinsic value of any thing, the more of it will be required to make up any given amount of wealth. The financial temperature of copper is lower than that of gold; therefore, if a given amount of wealth is to be stored in copper, a greater quantity of the material will be required than if stored in gold, *i.e.*, there will be a greater entropy necessary in the former than in the latter case. If we could conceive of a substance being at the absolute zero of value, we should require an infinite amount of it to obtain any wealth at all. In the same way, heat entering or leaving a substance at the absolute zero of temperature requires an infinite change in the entropy of the substance.

There are many other points of similarity between the laws of entropy-temperature and the laws of value and wealth; but these we must leave to the imaginative faculties of our readers to evolve for themselves. The little we have already given may suffice to indicate the nature of the analogy; and our purpose will have been attained if we have in any way contributed to the enlightenment of an unmathematical mind upon a somewhat difficult branch of physics.

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AN ELECTRIC HEATER.

Mr. H. Ward Leonard has taken out a patent for an electric heater which is likely to mark an advance in that line. It is very important for the operation of such tools as electric soldering-irons, flat-irons, embossing-irons, and many other similar tools, that the heat developed in the resistance shall be conducted to the working surface as rapidly as possible, and with the least amount of waste. The necessity of a resistance which would stand a very high temperature has been such that platinum wire is often used in the construction of such tools, the expense of which is, of course, extremely high, but even this has failed under such conditions.

Mr. Leonard has many modifications of the general principles of his invention, but the description of one modification will give a general idea of the invention. The resistance, which is a metal wire, is thinly coated with some form of fireproof insulation, which hermetically seals the conductor from the air, such as enamel or glass. The wall of insulation around the conductor is quite thin. The conductor so insulated is placed in a mould, and a suitable metal is cast about the insulated resistance so as to completely embed it in the cast metal. This surrounding body of metal as it cools subjects the insulated conductor to strong pressure, insuring perfect mechanical contact throughout. The surrounding metal also hermetically seals the resistance from any possible contact with the air, and from all chemical action. While the insulation surrounding the conductor is of comparatively poor quality as a conductor of heat, the wall of this insulation is so thin that it affords the least possible resistance to the flux of heat from the heated resistance of the surrounding metal body; consequently, the temperature of the heated resistance and the temperature at the surface of use will be as nearly the same as possible, and the resistance is, therefore, not subjected to a temperature appreciably higher than that of the surface of use. It is possible, it is said, to operate tools heated by the Leonard system at a bright red heat without any destructive effect whatever, and this possibility opens up a very wide field for the application of electricity to various tools used in the various arts and industries which have heretofore necessarily been heated by gas, charcoal stoves, &c. The Carpenter Enamel Rheostat Company, of which Mr. Leonard is President, will manufacture apparatus under this patent.

TELEGRAPHIC COMMUNICATION BY INDUCTION BY MEANS OF COILS.*

BY CHARLES A. STEVENSON, B.SC., F.R.S.E., M.INST.C.E.

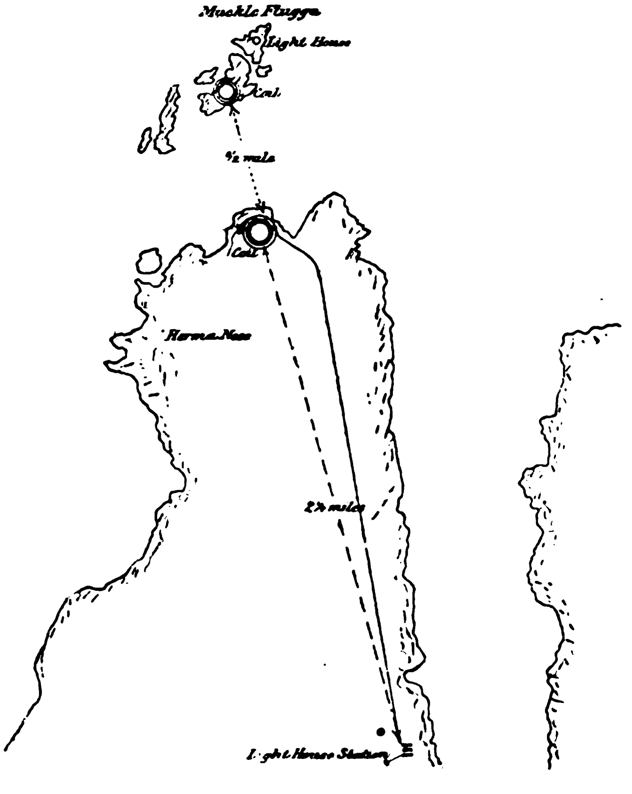
In 1892 I suggested that communication could be established between ship and ship by means of coils,† and as a trial of the system on a large scale has recently been made with the view of establishing communication between North Unst lighthouse, situated on Muckle Flugga, and the mainland (*see* Figure), thence to the lighthouse station at Burrafiord, a distance of two miles, a record of the trials may be of interest to the Society.

A number of experiments were made in the laboratory to discover the laws of the action of coils on each other, with a view of calculating the number of wires, the diameter of coils, the number of amperes, and the resistance of the coils that would be necessary to communicate with Muckle Flugga, and after a careful investigation, it was evident that the gap of 800 yards could, with certainty, be bridged by a current of one ampere with coils of nine turns of No. 8 iron wire in each coil, the coils being 200 yards in diameter.

Two coils, about 850 yards centre to centre, were erected at Murrayfield, one coil being on the farm of Damhead, and the other on the farm of Saughton, and as nearly as was possible on a similar scale and the coils of similar shape as was wished at Muckle Flugga. On erecting the coils, communication was found impossible, owing to the induction currents from the lines from Edinburgh to Glasgow, the messages in these lines being quite easily read, although the coils were entirely insulated and were not earthed. The phonopore which the North British Railway Company have on their lines kept up a nearly constant musical sound, which entirely prevented observations. On getting the phonopore stopped, it was found that 100 dry cells, with 1·2 ohms resistance each and 1·4 volts, gave good results, the observations being read with great ease in the secondary by means of two telephones. The cells were reduced in number down to 15, and messages could still easily be sent, the resistance of the primary being 24 ohms and the secondary no less than 260 ohms. If the circuit had been of good iron, with soldered joints, and well earthed, the resistance should have been only 60 ohms.

The calculation of the diameter necessary to hear a given distance is simple, from the fact that the hearing distance is proportional to the $\sqrt{\ }$ of the diameter of one of the coils, or directly as the diameter of the two coils, so that, with any given number of amperes and number of turns to hear double the distance requires double the diameter of coils, or double the number of turns, and so on. But this is within certain limits, for when the coils are close to one another the law does not hold.

The author then briefly described some experiments made to test the relative merits of the "parallel wire" systems and "coil" systems. With regard to the question whether or not the parallel wire system is actuated by induction or conduction, it will, he says, depend how the ends are earthed, or, in short, what is the distance bridged in comparison to the breadth of base, which predominates. Where the wires are long in comparison with the distance bridged, conduction will be the main working factor, but when the base is small, and the distance bridged is large in comparison, induction will be the main factor, and the number of turns then increases the effect.



The primary coil was insulated in the Murrayfield trials, as at Muckle Flugga it must be so, the impracticability of making and maintaining the sea connections necessitating this, and the secondary was earthed, as is most convenient at Muckle Flugga. When the secondary was also made a complete insulated metallic circuit, there seemed to be little difference in the result.

There is one other point to which reference must be made. Mr. Preece has been repeating the experiments brought before this Society on January 30, 1893, and he found, if rightly reported, that when the hearing wire was floating he got results, but when it was allowed to descend that no observations could be got; he attributes this to reflection from the surface of the water; this, however, is unlikely, as the reason that no sounds were then heard was that the major part of the wire lay on an equipotential line. Electro-magnetic waves enter or leave salt water practically unimpaired. On trial, it was found, as stated in my paper read before this Society in January, 1893, that there was no *practical* difference in air or salt water to the propagation of electro-magnetic waves, in or out the distance to which waves went—*i.e.*, the distance to which the currents could be heard being immaterial whether the detector was sunk or in air.

It has been attempted to be shown that the coil system is not only theoretically but practically the best. Meantime, my brother has recommended the Commissioners of Northern Lighthouses to erect the coil system at Muckle Flugga, and the Commissioners have

* Abstract of a Paper read before the Royal Society of Edinburgh, March 19, 1894.

† *Engineer*, Vol. LXXIII., p. 292.

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approved, and I hope that we may soon hear of this novel system of communication being erected at the most northern point of the British Isles, where the laying-down and after-maintenance of a submarine cable is practically impossible. This system is also applicable to our warships, to assist in their manœuvring, by the establishment of instantaneous communication unaffected by wind or weather.

The application of the coil system to communication with light-vessels is obvious, namely, to moor the vessel in the ordinary way, and lay out from the shore a cable, and circle the area over which the lightship moorings will permit her to travel by a coil of the cable the required diameter, which will be twice the length of her chain cable. On board the vessel there will be another coil of a number of turns of thick wire. Ten cells on the lightship and ten on the shore will be sufficient for the installation. The system erected at Kentish Knock and other light-vessels is expensive in moorings, and is liable to derangement, and requires special appliances; whereas, by the coil system there can be no derangement, and the vessel can be moored in the ordinary way. A call arrangement and telephones complete the installation.

COST OF ELECTRICAL ENERGY.

(*Concluded from page 357.*)

Mr. CROMPTON (in reply): The length of the discussion, the number of speakers, and the number of subjects touched upon, make it necessary for me to group these subjects, instead of replying to each speaker individually.

Several gentlemen ask why I selected works having such a large output as 5,000,000 units per annum as a basis for my ideal figures; and Mr. Hammond rather scared us when he said that the gross income of very few gas works would reach the sum of £62,000 a year, which is the gross income corresponding to 5,000,000 units at 3d. He, however, has now found out that he is mistaken in this, and that the income of a very large number of gas undertakings greatly exceeds this figure. At any rate, I have no doubt that, in London, the works of the Westminster Company, the Metropolitan Company, and probably the City of London Company, will reach this rate of output within two or three years; and that even the smaller companies with which I am personally connected will approach it so nearly that my ideal costs, so far as they depend on scale of output, may be also closely approached.

As to the capital cost of works capable of dealing with this output, I can assure General Webber, and Messrs. Geipel, Raworth, Hammond, and others, that I went very carefully into the existing figures before I satisfied myself that a works capital cost of 2s. per unit sold was a correct figure to adopt. I arrived at this figure in the manner which Gen. Webber himself would approve of—*i.e.*, I took the actual figures from the companies with which I am in close connection, and from these I prepared my calculations. I did not use the antiquated plan of calculating by lamps connected to the system, which for many reasons, is no longer a useful guide. The two quantities or factors required are those which enable us to calculate the load-factor for any district, and can be easily ascertained from existing experience of works supplying electricity to a similar district; these two quantities are the maximum in kilowatts of load observed during the year, and the output in units sold per annum. The relation which this latter quantity bears to the observed maxima in various works enables us to say that the maximum rate of output, and hence the size of the plant, may be obtained by dividing the output per annum in units by a figure which is a number of hours, and which varies from 900 hours, or a load-factor of 10·3, in the case of some provincial towns, up to 1,300 hours, or a load-factor of 14·8, in my Kensington district, and to even higher figures in other parts of London. The quotient thus obtained is the maximum load in kilowatts. For the purposes of my Paper I took the very safe figure of 1,000 hours, corresponding to a load-factor of 11·4, so that for an output of 5,000,000 units I require 5,000 kilowatt plant. In these works the generating plant must necessarily have from 20 to 25 per cent. of machinery in reserve, although the distributing plant need only be of the exact capacity, so that the 5,000-kilowatt load may be dealt with without undue fall of pressure in the mains.

My capital expediture of £500,000 is therefore a very safe estimate—in fact, I believe it to be an outside figure; but, much as I should like to enlarge on this point, space does not permit me to labour it. Messrs. Geipel and Hammond, and even General Webber himself, have, however, put figures before you showing that, in their opinion, it can be done at from £75 down to as low a figure as £60 per kilowatt; whereas it will be seen that I have adopted £100; and, as I am in a responsible position in regard to certain works designed by me, I know with reasonable certainty that the present plant in its completed state will, when working at present load-factors, not cost more than this sum—in fact, I hope it will cost considerably less.

The next point raised in the discussion was whether I am correct in asserting that the management and profit items in working costs are outside the province of us engineers. Messrs. Geipel and Mr. Hunter, the engineer of the Newcastle and District Company, in his communicated remarks, have pointed out that these two items cannot be left out when considering the whole cost of production, and I agree with them; but why do they speak as if I had left them out? I think that the words in my Paper, paragraph 2, p. 397, sufficiently explain why I did not take up unnecessary time on this point; in fact, Gen. Webber criticises me rather sharply for the little that I did say.

Coming now to my estimate of ideal costs, three speakers—Gen. Webber, Messrs. Geipel and de Segundo—criticise me rather severely. Eight other speakers—among them Messrs. Raworth, Robinson, Kennedy and Holmes—have, however, criticised them favourably, and taken these costs in the manner intended by me, viz., that my ideal costs were intentionally pitched high, and difficult of attainment. The fact that several of those who contributed to the discussion have already been able to show figures in some measure approaching to these ideals is a cheering one, and is the best answer to my first-named critics.

Mr. de Segundo has dealt with my ideal figures at length; but it will be more convenient to deal with his remarks, and those of others, on the subject of ideal boiler and engine efficiencies when dealing with these two matters further on, but Messrs. Hammond and Holmes offer serious matter for consideration on the depreciation question. On this question of depreciation opinions differ very widely, and I can only give my own as one among many; but I venture also to give my reasons for my opinion, which is sometimes said to be a dangerous course. I believe that in working costs there should be no allowance whatever for depreciation of plant. Of course, I am not dealing with the case of plant owned by local authorities, who by the regulations of the Local Government Office are obliged to set aside certain annual sums as a sinking fund, so that at the end of a fixed period the whole capital that has been borrowed for the works will be paid off; but in the case of supply companies holding a concession for a limited term of years, I believe that the true course is to spend annually and charge against revenue such a sum as is sufficient to maintain the plant in perfect working order. During early years the annual sum required will be smaller than at a later date, when the plant has become worn; so that it is advisable during these early years to set aside a sum in excess of the sum actually spent on repairs, in order to equalise these maintenance costs from year to year; but if this has been properly done, at the end of the concession there should be no balance left over one way or the other—that is to say, the plant should be in perfect working order, and there should be no depreciation fund existing.

We are indebted to Mr. Hammond for inventing a highly useful word—"antiquation." This is an entirely different matter from depreciation, and I think no provision should be made for it. I do not think that other public companies, such as railway companies, water companies, or gas companies, ever have thought of providing an antiquation fund. What is the use of such a fund? I presume, to enable us in the future to purchase, and use for purposes of reducing working costs, any future inventions which we are now ignorant of; but surely, before the adoption of any such future improvement would be decided on, it must be shown to pay—that is to say, not only to reduce the working costs below their then level, but to such an extent as to pay the interest on the sum sunk on the improvement; and if it is of this nature there could be no difficulty in raising fresh capital to introduce the improvement. Why should present ratepayers, or present shareholders, pay for improvements destined to benefit those who follow them?

Further than this, I cannot help feeling that this desire for an antiquation fund is due to an uneasy feeling in the minds of some engineers that their present plant is not quite what it should be—that it is already antiquated, and that they had better, as soon as possible, begin to set about replacing it by something better. I am happy to say that this is a feeling which has not oppressed me. When we already have such good generating plant as we have at present, and when our distribution losses are only 10 per cent. it is not easy for us to see what we are likely to gain from further improvements. Such improvements as are continually introduced into the best class of plant concern only the cheapening of the manufacture of that plant, and the future purchasers of it—that is to say, the plant in the future will be probably very little better than the present, but it may be very much cheaper; this, however, is no reason for antiquating present good plant in order to purchase cheaper plant of the same type and efficiency. It is for these reasons that I have left out depreciation and antiquation from my ideal costs, and only put in a sum of 0·4d. per unit, which I think will, on the scale proposed, be sufficient to keep the plant in perfect working order.

Value of Fuels.

As I had expected—I may say hoped—this important subject has been well discussed by those who are most competent to offer opinions on it. The discussion has only confirmed my views that the fortunate users of Welsh coal ought to congratulate themselves as having escaped the worries and uncertainties attending the use of the bituminous and other coals which contain so much of their thermal efficiency in the form of hydrogen. I see that Mr. Raworth and Prof. Kennedy support me strongly on this point; and although Prof. Unwin quotes tests to contradict my views, he only quotes test runs which, as I have shown by my Chelmsford experience, only lead to erroneous conclusions, whereas those who support me do so from their knowledge of the continuous figures of the many works with which they are connected; but I think that the words Mr. Hunter, of the Newcastle and District Company, makes use of in his communication are most significative. Mr. Hunter, in wishing to reduce the figure which I give in Table VI. of 310 units per watt-hour sold, says that the calorific value of the Newcastle slack used by him is only one-half that of Welsh coal—that is to say, 7,250 British thermal units—and on this basis he corrects or reduces my figure of 310 to 204 British thermal units. Now I thoroughly sympathise with Mr. Hunter in this. I know that, with ordinary boilers and ordinary care in stoking, the slack that he uses will only evaporate about half the water that he could evaporate with Welsh coal; but from my own experience at Chelmsford, where I have been using precisely similar coal to that he uses, I am convinced that if he has a calorimeter test made of his slack he will find that I under-estimated its value, and that it contains from 12,500 up to 14,000 British thermal units, a large proportion of these being in the hydrogen form, and thus extremely difficult to utilise; and he will also find out the

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truth of Mr. Halpin's remarks on the extent that this small slack deteriorates by exposure to the air. I do not think that Prof. Unwin has any right to say that the use of Welsh coal is one of the factors of my formula. I pointed out, and I now re-affirm, that we in practice find out that it is easier to get a good result with Welsh than with the other coals. I never said that it was impossible, but only that it was difficult, to get good results with the other coals.

We now come to the vexed question of flued *versus* tubular boilers. Some speakers will have it that it is Lancashire *versus* Babcock, but it is not so. Here my friendly critics are more numerous than the adverse ones. I fully expected to call a storm down on my head when I raised this question; but I raised it advisedly, after carefully watching and comparing the results in works using the two types, and after many and careful tests had been made by me personally. It is unnecessary for me to refer individually to the advocates of the Lancashire boiler. Their one cry is that in the past Lancashire boilers have given good results as steam raisers, and that on tests they have shown practically as good results as other types; but no advocate of these Lancashire boilers has attempted to explain why in the works E, N, O, and J the evaporation is so low. I have given my explanation. I have shown that, whereas at works J the results on test runs were 9lb. of water evaporated per pound of fuel, the year's accounts show that only 5·21b. were evaporated. I have traced this difference in results to the falling-off in evaporating efficiency which always occurs when the Lancashire or Cornish type of boiler is irregularly fired, as it always must be when used in electrical works, and to the further difficulties which arise with this type of boiler if the coal varies even slightly in composition. I have shown that these differences can be reduced by the use of economisers—which virtually are a tubular addition or extension to the Lancashire boiler, making it partly a tubular boiler—and that these differences do not exist to the same extent when tubular boilers are used, whether of the Babcock type or of the internally fired type, such as the "Economic" or marine; and if all that has been said in the discussion is carefully read, it will be seen that no one has seriously controverted this view.

I object strongly to the statements made in the course of the discussion, and in the leading articles in the technical journals, that I hold a brief for the Babcock and Wilcox type of boiler. This is a cheap form of criticism, which happens to be exceedingly wide of the mark. Three years ago, when discussing the best type of boiler for electrical works, I thought that the internally fired boilers ought to beat the Babcock, or any externally fired type, on account of reduced losses during periods of banking the fires; therefore it was only simple justice on my part that I should state the results of my more recent experience during the last three years, when I find that, after fair trials of all types, the Babcock, which is an externally fired boiler, still holds its own.

Mr. Rosenthal has very fairly defended this type of boiler from the attacks made upon it during the discussion. So many well-qualified speakers have admitted that it is free from the defects of producing wet steam, and that it gives good evaporative results in supply works, that the only important point necessary to notice is how this class of boiler stands in regard to forced firing. I believe in this respect it is the best of all the boilers I have tried. I have, for the reasons given by Mr. Rosenthal, and which I consider to be very fair ones, never considered the question of heating surface in regard to this boiler, or, in fact, of any other boiler. The practical question which we engineers have to consider is not the one of heating surface, but of the space occupied, and of the evaporative efficiency of a boiler which at certain times must give a certain output. When tested by this standard, I find that the method of preparing a figure of merit advocated by Mr. Halpin is not correct. His method is to obtain from the three factors of evaporative efficiency, pounds of water evaporated per square foot of heating surface, and cost of heating surface, a figure which he shows to be from two to two and a-half times greater in the Lancashire boiler than in the Babcock. In reply to this, I have prepared during the last six years a very large number of estimates of boiler plant, and have most carefully considered the cost per 1,000 gallons per hour which can be evaporated at periods of maximum load; that is to say, when the fires of both types of boiler are being forced. I find that under such conditions, when all items of cost, exclusive of economisers, are added in in both cases, at this size the prices of the two types of boiler are practically identical; but that the evaporative efficiency when Welsh coals are used is, in practice, at least 25 per cent. in favour of the Babcock; and when we add to this that the Babcock boiler occupies just about half the floor space, and that it is far easier to deal with, there is little wonder that those who have had experience of both types exhibit the preference that I do. Still, as I have explained above, the question is not between Lancashire and Babcock, but between flued boilers generally and tubular or tubulous boilers; and I do not offer any strong opinion on the comparative merits of these two last-named types. I have had as good results from one type as the other, and no doubt the choice between the two will be determined in each case by special circumstances. How local circumstances affect design is very well shown by the remarks of Messrs. Burnett and Peache, on behalf of Messrs. Paxman. Both gentlemen are makers of what I have called the semi-marine type, but which Messrs. Paxman call the "Economic," and Mr. Burnett the "Dry-Back" type. Mr. Paxman makes the boiler longer, and smaller in diameter, which suits the Welsh coals we find in the South of England; whereas Mr. Burnett, having to deal with Scotch coals, prefers a large-diameter short boiler; and both types are giving excellent results.

Mr. de Segundo has been at great pains to show that my ideal boiler efficiency is an impossible one; but his method of first deducting the principal source of boiler loss—*i.e.*, the heat units which go up the chimney—before he calculates the boiler efficiency, is very unusual, and differs from the system usually adopted. Of course, under such circumstances, when the one large source of loss has been eliminated, the boiler efficiency can show exceedingly high.

The figure of a possible 12lb. and a 10lb. working evaporation adopted by me is, I am convinced, not an impossible one, as so many authenticated tests show; among these, I will point not only to the trials made by Prof. Robinson at St. Pancras with the Babcock and Wilcox, Prof. Kennedy at Eccleston-place with an "Economic," and Prof. Kennedy with a Thornycroft boiler, which in each case show an evaporation in excess of what I require, but to the well-authenticated trials made by the Royal Agricultural Society of England at Cardiff and Newcastle, and to the 60 extended trials quoted by Mr. Halpin with Lancashire boilers.

I note Mr. McLaren's preference for locomotive boilers, which is not to be wondered at, as he has obtained such high results in competitive trials when these boilers are used; but Mr. Halpin and Mr. Burnett have admitted that the type of locomotive boiler usually now built is a very awkward one to deal with in central stations; and, moreover, I think Mr. McLaren would not find that a locomotive boiler comes out well when required to be of the large sizes we generally require in supply works.

Mr. Geipel seems to think that the use of boiler fluid should be discouraged, and that it is an unworkmanlike method of dealing with the question of deposit; that where water is bad, special purifying plant should be used. Here, again, it is a question of special circumstances. There is no doubt that where the water is beyond a certain degree of hardness, purifying plant must be used; but there are many cases, such as that of the Thames water supplied by several of the London companies, where the hardness is not sufficient to warrant the use of purifying plant, and where the use of small quantities of boiler fluid at the proper time will result in keeping the boiler absolutely free from any deposit whatever. It is not a question of allowing the deposit to form, but of keeping the boiler absolutely clean; and this can be done, and is done in practice in the best works.

On the question of oil fuel Mr. Henwood is evidently an enthusiast, and I should be very pleased to see the rosy figures named by him realised in practice; I for one shall be well content if we get a much lower duty from the oil than that given by him. The great obstacle to the large introduction of oil fuel is the present price of the oil; and until this is considerably reduced, all our experiments must be in the nature of adopting oil for periods of forcing only. So far as experiments have gone, I believe that with the Babcock type the output of boilers under conditions of forcing will be nearly doubled; and I am glad to say that even under these circumstances this type of boiler still produces dry steam.

It is disappointing to see that the question of economisers has been so lightly touched on in the discussion. I had hoped to hear the experience of gentlemen who are large users of this class of plant, more particularly as to the cost of the upkeep of this extra item of plant. What we electrical engineers want to know is the cost of maintenance of economisers exposed to the very high pressure now prevalent.

On the subject of high *versus* low-speed engines, it is very evident from the discussion that opinions have advanced very rapidly in the same direction as my own; and that, whereas, as I have stated, in my Paper six years ago I was almost alone in advocating their use, now the great majority of speakers either admit that they are the most economical and convenient form to use in supply works, or they have arrived at the half-way stage of admitting that direct driving is of great importance.

I challenge the correctness of the remarks of Mr. Wilmshurst when he says that in the most modern stations rope driving, alternators, and Lancashire boilers have been, and are to be, used in overwhelming numbers. On the contrary, there has been a distinct tendency in all recent specifications to do away with rope driving. A notable conversion to direct driving has been Mr. Raworth, and the only two speakers who still speak lovingly of the long-stroke horizontal engine are Prof. Unwin and Mr. Gray. I think both these gentlemen have been influenced by their surroundings—that is to say, by the very beautiful steam plant of this type which has been manufactured of late years on the Continent. The eye of a mechanical engineer is taken by the design, workmanship and high efficiency shown by the engines of Van der Kirkhove, Carels, and others; but even among these famed makers a feeling in favour of high-speed engines for electric supply works has already set in, Messrs. Van der Kirkhove being the first on the Continent to take up the manufacture of the Willans type of engines, and are now advocating its use for such works.

I have already taken objection to Prof. Unwin having fathered on me a formula for the design of supply works plant. It may be true that the figures which I have collected for purposes of comparison show that certain supply works containing that class of plant have done better than others, but nothing could be further from my thoughts than to suggest a hard-and-fast formula to suit all cases. Prof. Unwin says that in my Paper I convey the idea that high speed of rotation is the one and only method available for reducing cylinder condensation, and that I have neglected the other methods—namely, use of jackets, superheating, and expansion by stages. With great deference to Prof. Unwin's high-standing and special knowledge on this subject, I must point out to him that here he is wrong—that high speed of rotation is not a method alternative to these other methods, but it can be superadded to all or any one of them; and that, in addition, high speed of rotation offers us great advantages by reducing the size, space occupied, weight, and hence the cost, of both the engines and dynamos, while at the same time it increases their economic efficiency; so that from all points of view it is the most satisfactory modification of design which the special requirements of electric lighting supply works have forced upon us.

As to my ideal figures of steam consumption, I have already said that these were intentionally pitched high, and difficult of attainment; but Mr. de Segundo's figures are evidently too much the other way. It is no use to compare them with mine, as he deals with non-condensing, whereas mine refer to condensing engines; so that his best possible figure of 4lb. of coal per unit sold with a non-condensing engine cannot be compared with

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my 2½lb. with a condensing engine; but even with non-condensing engines Mr. Barley, at Knightsbridge, and Prof. Kennedy in more than one of his stations, have already reached a point below 5lb. in some of the winter months, and at Knightsbridge 3½lb. has been reached during test runs of considerable duration.

I have now to deal with the lengthy criticisms which have been made on Table VI. Several small errors have been pointed out, which I have duly corrected. These lie chiefly in the efficiency of distribution, and consequently alter the thermal units used per unit generated. General Webber is the only speaker who has impugned its accuracy as a whole, on the grounds that he is able to state from personal knowledge that the Chelsea Company, of which he is a Director, refused to supply the information requisite to correct and supplement the published figures. It is true that this refusal caused an error in the distribution efficiency of the Chelsea Company, which I have already admitted, but it was the only refusal that I received. It did not cause me to draw any false conclusions, as I did not use the Chelsea figures in my averages, and I have based no arguments on them. It is, however, evident, as the order of merit in this table is based on column 4—that is, the B.T.U. per watt-hour sold—that the Chelsea Company, costing 1·11d., and using 142 B.T.U. occupies a figure of merit somewhat higher than that of the Charing-cross and below that of the St. James and Pall Mall Company, which is a high position, on which Mr. King and his staff are to be congratulated.

I hope Mr. McLean does not think I intended to throw doubt on the Oxford figures. On the contrary, when I said that they appeared almost too good to be true, I certainly intended to congratulate him on the splendid results obtained in such a short time after the starting of this station. I indeed consider them very encouraging to those who, like myself, think that the Oxford system is in many respects a more satisfactory method of dealing with the supply of scattered districts than the ordinary converted alternating system. Again, I thoroughly agree with this speaker as to the advantages of keeping records in very full detail; but he quite misunderstood my remarks on the distribution efficiency obtained at Chelmsford. I pointed out that, although the efficiency shown was high, it was not fair for us to take credit for it when compared with companies who supply throughout the 24 hours, as we gain considerably in efficiency from switching off the energy during a part of the daylight hours.

I am glad to find that Mr. Dykes has been able to so satisfactorily explain the Preston figures. At the time I worked out these figures for my Table I felt sure that some explanation would be forthcoming. His explanation shows clearly that a direct system, if used without accumulators, loses many of its economical advantages.

I value Mr. Holmes's remarks very highly indeed. He has had the longest experience of central station supply of any one of us, and has been so uniformly successful in his results that I am glad that his own calculations corroborate so closely my own ideal figures. He is, no doubt, right in attributing his rather heavy coal bill to the peculiar circumstances of last year's working, which, owing to the opening of new stations, led to light loading of his engines; but I still think that he has suffered more than he will admit from the difficulties I have dwelt on in my Paper in efficiently burning slack coal in the Lancashire boilers.

I am afraid I cannot enter at any length on Mr. Wilmshurst's communicated criticism, further than to say that he is mistaken in thinking that Table VI. does not allow us to draw useful comparisons. Take the case of the works D, belonging to the House-to-House Company, on the one side, and compare their costs with those of works K, U, and W. All of these four works supply a residential district of the West End of London, and the conditions as regards compactness of supply are very similar throughout; yet we find that works D use fuel in the proportion of 265 to works K 142, to works U 116, and to works W 84. Surely such great differences (which in these four cases have been taken very accurately indeed) are instructive as to the relative economical value of the systems used; and we may carry the comparison a step further, and point out that this is a case where the smaller first cost of the works D, on account of the reduced cost of their mains, ought to have led them to compare favourably from the point of view of dividend-paying with the other three works, whereas the working costs of D have been so high as not to permit of this.

Again, Mr. Wilmshurst's conclusions as to Lancashire boilers are in direct contradiction of the data obtainable from Tables III. and VI.; so much so that I cannot think he has ever studied these tables, or attempted to check their accuracy with the recorded figures that he mentions.

I am glad that Prof. Kennedy and other speakers agree with me as to the great importance of studying and tabulating all the sources of loss which he has called "obscure works losses." These, which are common to all systems, have been very generally under-estimated, and hence have been neglected, and have gone on from year to year unchecked, and I hope that my Paper may have done real service in calling attention to their importance.

Coming to the question of losses in distribution, or efficiency of distribution, several speakers have raised this point, and the admirers of the converted alternating system of distribution have been anxious to show that the heavy losses in the first group of Table VI. are exceptional, and that the 82 per cent. efficiency of the City of London Company is what we are to expect in the future from improved converted alternating supply. I hope this may be so, but I am convinced that up to the present time the average distribution efficiency of 66 per cent., shown in Table VI., has been the rule and not the exception; and it remains to be seen whether the attempts to better this figure by employing extra plant and staff to switch transformers in and out of circuit may not result in such an increase in the wages of staff as will counterbalance the gain in efficiency, and this will be especially the case in smaller works serving scattered suburban districts.

I take this opportunity of saying that my own personal conversion to the advantages of alternating distribution, which Messrs. Raworth, Geipel and others so obligingly state has already taken place, must be deferred until I have had better evidence than exists at present as to the possibilities of reducing the working costs of the alternating system. This evidence is not yet forthcoming. The accounts of the two companies at Newcastle, Bournemouth, the House-to-House Company, and even the City of London, are very, very far from showing any such marked improvement as might lead me to be so converted to the converted alternating system, or to ignore the converting losses.

The published accounts of Continental and American supply works, and the reports and conclusions based on these accounts by Continental engineers, show that the majority of these gentlemen hold opinions very similar to my own, but I specially refrained from dragging the question into the discussion. This weighty question can now only be settled by results. Time will show who is right, and it is only wasting the time of this Institution to prolong arguments on a matter like this, which at present can be only one of opinion. It is for this reason that I did not mention in my Paper the question of saving by use of accumulators: although the above-mentioned Continental engineers have quite recently shown that the best results on the Continent, as in England, have been obtained from stations where accumulators are used to a judicious extent. At the same time, I thank Mr. Shoolbred for showing this so clearly in the case of the Bradford works.

Similarly, on the question of maintenance, Mr. Gray has raised a very interesting question, which, however, deserves a Paper entirely to itself—that is, the comparative maintenance cost of different systems of underground conductors. The subject is far too important, and involves such large issues that I only touched upon it as far as to give you our own actual figures for the Kensington and Knightsbridge Company. Mr. Gray, however, quotes figures to show that the continuously insulated cables belonging to the Metropolitan Company cost even less for maintenance than the system of the Kensington and Knightsbridge Company, which is three-quarters of it bare copper in culverts. Although I willingly testify to the extremely high quality of Mr. Gray's cables, yet I do not think that the case he brings forward is a fair one to quote, as the peculiar system adopted by the Metropolitan Company, and which is not likely to be repeated elsewhere, happens to be one which does not expose these continuously insulated conductors to the peculiar source of wear or decay which is generally found. I allude to the point of weakness which occurs at the points where the insulation of the cable is cut into to form a T-joint for the attachment of a customer to the mains. A company such as the Kensington and Knightsbridge Company has at present about 2,000 such T-joints on its system; and we find that, whereas all T-joints of continuously insulated cables require some attention and give some trouble, the same T-joints on bare copper give no trouble whatever; and I should mention that the major portion of the cost of upkeep of the Kensington and Knightsbridge system, as given by me in my Paper, is expended on the maintenance of the T-joints of the continuously-insulated portion of that system.

I hope Mr. Schönheyder will understand that I had no intention of adversely criticising his water meter, which I use so largely in boiler trials, when I said that it is advisable to frequently recalibrate it; the reason is that, although Mr. Schönheyder's meter is one of the best I know, yet, as in order to eliminate errors due to leakage as much as possible the meters used on these trials must be placed at a point on the line of pipes as near the boiler as possible, it has, therefore, to pass hot water through it, so that there is a constant liability of cutting and friction from gritty deposit.

I have to thank Mr. Hammond for his appreciation of the object of my Paper; he has himself done good service in the preparation and publishing of statistics, so that he is in a position to sympathise with anyone who, like myself, has to face the difficulties of getting data together. But I am glad to say that in some works the data are already in such good order that it was an easy task to obtain what I wanted from them; in other cases it was far more difficult; and yet it was quite impossible to take a bird's-eye view of the situation, so that I could get on with the Paper, until I had got the figures for the Tables III., VI., and VII. in a rough form. This task, simple as it now seems, was a work entailing much labour and correspondence. Although a few errors may still exist in these tables, no one has brought forward evidence to show that these exist to a sufficient extent to detract from their value as a means of comparing the present economic efficiency of the electrical works that were in operation at the commencement of this year.

Electrostatic Hysteresis.—Some further experiments by Riccardo Arnò, described in the *Rendiconti dei Lincei*, serve to emphasise the analogy between magnetic and electrostatic hysteresis pointed out by this observer. The relation between the energy W dissipated by a dielectric suspended in a rotating electrostatic field, and the electrostatic induction B is given by the equation $W = K B^e$, where K is a constant, and e differs with the strength of the field. From previous experiments e had been found to be 1·6 for values of B between 0·99 and 2·78 C.G.S. electrostatic units, and 1·9 for values of B between 9·90 and 14·58. As a result of the new series, for very weak fields, e comes out as 1·83, when B ranges from 0·06 to 0·17, and the complete equation for this case is $W = 287{\cdot}240 B^{1{\cdot}830}$. The apparatus was nearly the same as that used in the previous series, the dielectric being a closed hollow cylinder of paraffined cardboard, weighing 2·011gr., and 26mm. long.

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COMPULSORY PURCHASE OF TRAMWAYS.

The judgment which was delivered in the House of Lords on Monday by the LORD CHANCELLOR and Lords WATSON and SHAND is, as Lord ASHBOURNE, the dissentient judge, remarked, "a decision of deep moment to all the tramway companies in Great Britain, and involves interests of considerable magnitude." To English electrical engineers also this judicial pronouncement is of considerable interest, not only by reason of the somewhat similar purchase clause in the Electric Lighting Act of 1888, but on account of the effect which this final interpretation of the words of the 43rd Section of the Tramways Act of 1870 may have on the future of electric traction in this country.

In August, 1892, the Edinburgh Town Council gave notice to the Edinburgh Street Tramways Company of its intention to purchase that Company's undertaking in the manner laid down by Parliament. Needless to relate, the parties differed as to the sum to be paid. A referee, Mr. HENRY TENNANT, of York, was thereupon appointed by the Board of Trade to fix the price, and in November, 1893, he awarded the Company £213,000, and gave it as his opinion that by the statute the sum to be paid should be such as would pay for the construction and establishment of the line in a condition similar to that in which it was at the moment of sale. The Company, like OLIVER TWIST, asked for more, and in due course the case reached that legal *ultima thule*, the House of Lords, whence comes so much common-sense law, simultaneously with the similar suit of The London Street Tramways Company *v.* The London County Council. In this latter case Sir FREDERICK BRAMWELL was the referee, and he also gave the statute what seems to the lay mind to be its obvious plain English meaning, and, in consequence, failed to satisfy the Company. On Monday the judges of the House of Lords upheld the decision of the two referees and those of the majority of the Courts below.

By the 43rd Section of the Tramways Act it is enacted that a Local Authority may purchase a local tramway undertaking "upon terms of paying the then value (exclusive of

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any allowance for past or future profits of the undertaking or any compensation for compulsory sale, or other consideration whatever) of the tramway, and all lands, buildings, works, materials, and plant of the promoters suitable to and used by them for the purposes of their undertaking within such district. . . ." How, in face of such a clause, the contention of the companies that the value of the tramway must be ascertained by taking into consideration what rental could be obtained for it, if let, was not laughed out of court long before it reached St. Stephen's is a mystery as great as the meaning of the laboured arguments which counsel brought forward, either in their own or their clients' interest, in support of this extraordinary position. How, also, in face of this clause, the British public ever came to invest something like £11,000,000 in tramways is another mystery upon which that well-versed student of human nature, the company promoter, might no doubt be able to throw some light. Probably they thought that the legislators who formed the purchase clause attached some meaning to the term "value"—a meaning which it ceases to have if the thing valued can neither be worked nor rented, nor sold. The cost of construction has nothing to do with the "then value"; and to have been logical the referees should have appraised the "value" at the selling price of the rails and granite stones. Parliament did not mean that; but if not that, what?

Fortunately for the capital of the small investor, the average yield on that eleven millions does not exceed 5½ per cent., so that in but very few cases is it likely that he bought at a premium, and in most cases he may consequently look forward to the day of municipal purchase with tolerable equanimity. At the same time, notwithstanding the now admitted clearness of the tramway purchase clause and the fortuitously happy circumstance that tramway shares in this country are not usually at a premium, the penny-surprise-packet sort of investment to which the Legislature and the company promoter between them are in these days so frequently treating the public must of necessity send capital seeking for investment elsewhere. The foreign penchant for monopolistic concessions has not hitherto borne strikingly healthy fruit, but at any rate, it is more likely to do so than the new British variant; the former, as a rule, confers a long period monopoly during which a tariff sufficient to pay a normal rate of interest and to build up an adequate capital redemption fund, may be levied; the latter, as a rule, expressly excludes the very idea of monopoly, curtails the grant to the shortest possible period, and as often as not provides for the popular revision of tariff at frequent intervals. So long as capital can be made to flow forth on such terms, the wisdom of municipalisation is, of course, temporarily justified of her children.

Capitalists hoping to finance electric traction undertakings, manufacturers hoping to equip electric lines, and consulting engineers hoping to advise on electric tramway undertakings, will, however, be more concerned about the immediate effect of the House of Lords' decision on their respective prospective profits than about ulterior and general results. As regards existing systems, it seems to us that the conversion of horse-lines into electric-lines, a painfully slow process before this legal decision, is now likely to come to a complete standstill. It is scarcely to be expected that the shareholders of a tramway concern will dream of sinking further capital and adopting electric traction if, a few years hence, their property is to be bought up at a price which would not cover the previous expenditure on equipping the line for the horse system. As to the effect of the negatively famous 43rd clause on tramway construction, now that its purport has been publicly made plain to all whom it may concern, we cannot do better than endorse the weighty words of Mr. Justice MATTHEW in the Divisional Court: "I cannot help thinking that very few tramways would have been constructed under these circumstances, because a shareholder proposing to take shares must satisfy himself that the profits of the undertaking would not only pay him interest upon his investment, but would restore to him wholly or partially, at the end of 21 years, his capital." However, most evils work their own cure, and should the net result of the now publicly-explained 43rd clause be the prevention of all tramway improvements and the cessation of all tramway extensions, it may be safely predicted that one of two things will soon happen: Either the obnoxious clause will be amended, or municipalities generally will be permitted not only to work tramways but also to construct and lease them. Then will arise pæans on the virtues of municipalisation, with its hard cash payments, and of town councillors with their abnormally-developed bumps of business-like shrewdness and public spirit; for it is not given to everyone to perceive, and it is the business of no one in particular to point out, that what is not to the interest of the whole swarm is not to the interest of a single bee.

ON IMPULSIVE CURRENT-RUSHES IN INDUCTIVE CIRCUITS.

BY ALFRED HAY, B.SC. (EDIN.).

(Continued from page 361.)

§ 19. The initial magnetic state of the iron being one of the most important conditions in bringing about a rush of current, it is interesting to investigate how the rush is affected by varying the normal maximum of magnetic induction to which the iron is pushed. We shall consider the case in which the normal maximum does not exceed about 450 C.G.S. ines per sq. cm.

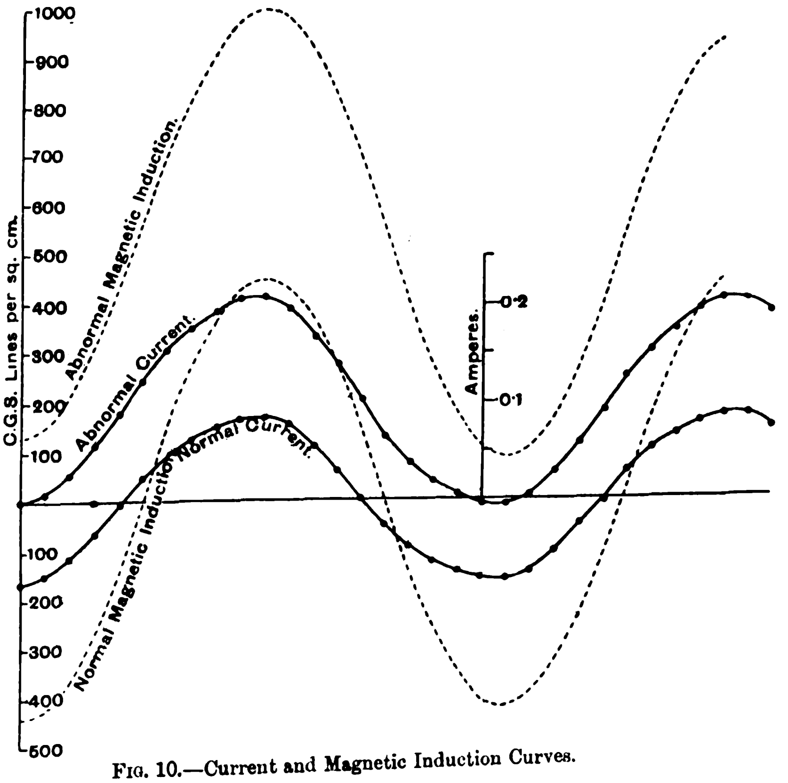

FIG. 10.—Current and Magnetic Induction Curves.

After the readings which are plotted in Fig. 9 had been taken, the connections of the transformer were altered, coil A (§ 13), of 576 turns, being used as the magnetising coil. The resistance of this coil was 1·21 ohms, and the non-inductive resistance connected in series with it was 3·58 ohms, giving a resistance

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total resistance of about 4·8 ohms. The large amount of non-inductive resistance was necessary on account of the smallness of the magnetising current, whose normal maximum was only about 0·085 ampere. The normal and abnormal curves of current are shown in Fig. 10, as well as the corresponding curves of magnetic induction. The current-rush in this case amounts to $\frac{0\cdot2\text{-}08}{0\cdot085} = 2\cdot45$. The effect of hysteresis being but slight, the deviation of the normal current wave from the pure sine form is comparatively small. The cigar-shaped hysteresis loops corresponding to these curves are shown in Fig. 11, where the thin-line loop is the normal loop, and the dotted one the abnormal. In comparing the loops with those given in Fig. 7, we note the following points of difference: (*a*) In Fig 7 the first descending branch of the abnormal loop crosses the

ings with precisely the same arrangement of circuit as that described in § 19. The results are given in Fig. 12. A comparison of Figs. 10 and 12 at once reveals the fact that the small alternating magnetic force was not sufficient to wipe out the effect of the previous treatment of the iron. The normal hysteresis loop corresponding to Fig. 12 is shown in Fig. 11, being the thick-line loop in that figure. In the case of the loops corresponding to Fig. 10, the origin, which is assumed to be the point of zero induction, in reality corresponds to a certain initial induction. But for the loop corresponding to Fig. 12 it is the true zero of induction. We see that the effect of completely demagnetising the iron to start with is two-fold: (1) it reduces the *area* of the loop, thus diminishing the amount of energy dissipated by hysteresis; and (2) it has the effect of tilting the loop towards the axis of magnetic induction. The abnormal hysteresis loop, to avoid too great complication, is omitted from Fig. 11; but in general shape it would not differ greatly from the dotted loop there shown, being merely somewhat smaller in area and tilted towards the vertical axis. The current rush in Fig. 12 is $\frac{1\cdot61}{0\cdot075} = 2\cdot14$, as against 2·45 in Fig. 10. Thus the effect of

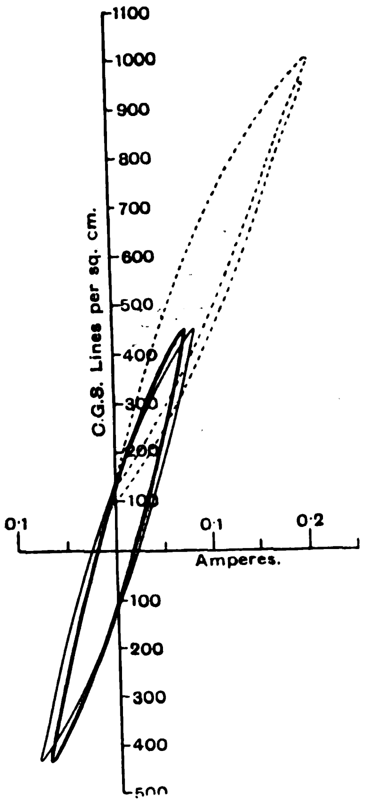

Fig. 11.

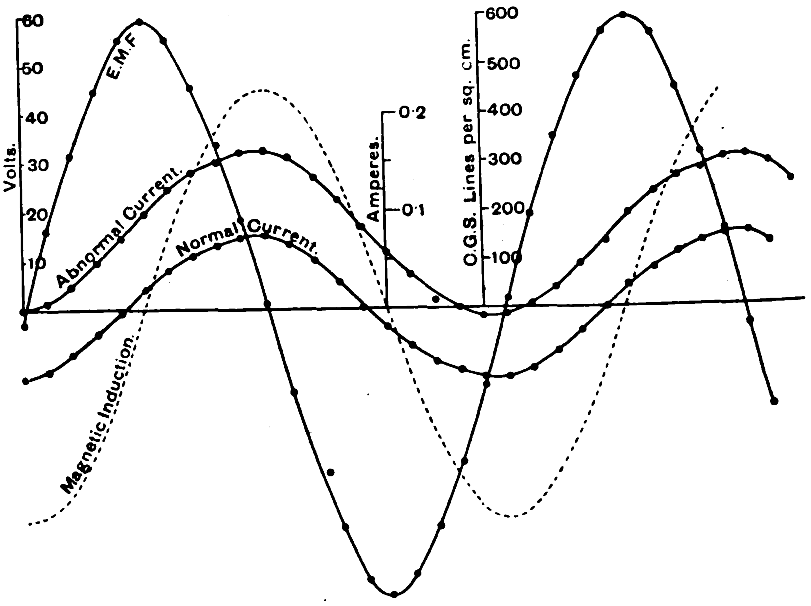

Fig. 12.

axis of magnetic induction a considerable distance above the starting point; in Fig. 11, on the other hand, the first descending branch practically passes through the starting point; (*b*) the second ascending branch of the abnormal loop in Fig. 7 crosses the first ascending branch; in Fig. 11 these two branches are almost parallel to one another, and the point of crossing is between the first ascending branch and the second descending branch; (*c*) the *shape* of the loops, both normal and abnormal, is widely different in the two cases.

The great reduction of the negative half-waves of current in Fig. 10 is very striking. During the first few waves, in fact, the current is all but unidirectional.

The greatest reduction of the maximum value of the abnormal current during the first half-wave which it was possible to obtain by varying the switching-off point amounted to 18 per cent., the extreme values being 0·2-08 and 0·17 amperes respectively.

The effect of altering the resistance of the circuit was also tried. The non-inductive resistance was reduced so as to make the total resistance equal to 2 02 ohms instead of 4·8. This was found to increase the maximum value of the abnormal current by about 3 per cent.

§ 20. It has already been mentioned that the readings for the curves of § 19 were taken after the transformer had been working at a much higher magnetic induction. The next experiment consisted in completely demagnetising the iron by the method of successive reversals, and repeating the read-removing every trace of initial magnetisation is to reduce the currents, normal and abnormal, the amount of energy dissipated by hysteresis, and the "current-rush."

(*To be continued.*)

ELLIPTICALLY POLARISED ELECTRIC RADIATION.

BY DR. OLIVER LODGE.

Since the delivery of my lecture to the Royal Institution, on June 1st, Herr Zehnder has published* a mode of getting elliptically and circularly polarised electric radiation. He takes a couple of plane-polarising grids, such as are depicted in Fig. 21, *The Electrician*, June 22nd, page 205, and places them parallel to each other at a little distance apart with their wires crossed.

If the two grids are close together they will act like wire-gauze, reflecting any kind of polarised radiation equally; but if the warp and woof are an eighth-wave length apart, and the plane of the incident radiation is at 45° to the wires, the reflected radiation will be circularly polarised. A change in the circumstances will, of course, make it elliptical. Such a pair of grids acts, in fact, like a Babinet's compensator.

* *Berichte der Naturforschenden Gesellschaft zu Freiburg i. B.*, Bd. IX., Heft 2, June 21, 1894.

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THE INFLUENCE OF CIRCULATION ON EVAPORATIVE EFFICIENCY OF WATER-TUBE BOILERS.*

BY JOHN I. THORNYCROFT, F.R.S., VICE-PRESIDENT.

To obtain the highest evaporative duty from a given tube service, it is necessary that the contents of the tube should consist of, as far as possible, water only ; and to attain this result the steam must have the freest possible egress from the tubes, and must also be carried from them by an energetic circulation of water in a constant direction. To some of the leading features which affect these conditions I would now call your attention.

Considering the boilers shown in Figs. 1 and 2, if the pressure in the lower vessel—that is, at the bottom ends of the generating tubes—is that due to the full depth of water in the boiler, in

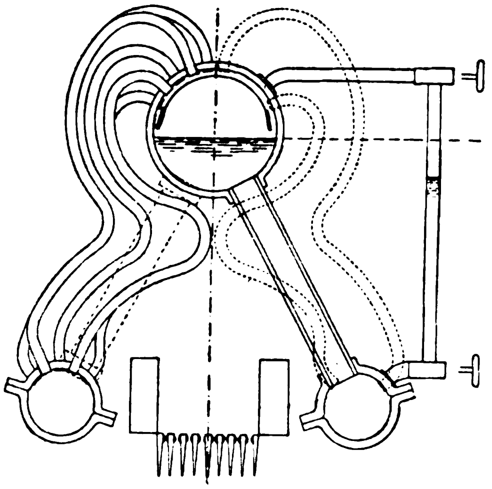

Fig. 1.

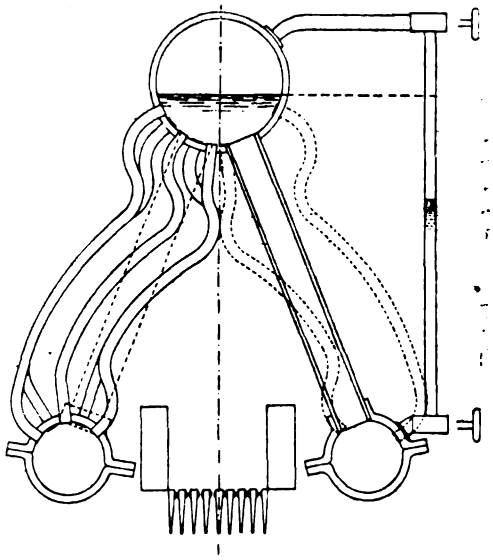

Fig. 2.

addition to the steam pressure, then any reduction of density in the generating tubes will all be available for causing circulation ; and thus any reduction in pressure in the lower vessel, below that due to the head of water in the boiler, is a direct loss to the energy of circulation, so that variations of this pressure are of great importance. These variations can be conveniently measured by a pressure column formed of a long gauge glass connecting the steam space of the upper vessel with the lower vessel. The difference of the water-level in this glass from the water-level in the upper vessel is a direct measure of any reduction of pressure in the lower vessel.

(3) Generating tubes delivering below water (without any special downtake tubes).

The curves given in Diagram 3 show graphically the results of these experiments ; the falls of pressure in the lower vessels are plotted as ordinates, and the rates of working as abscissæ. It will be seen that the rate of working has been taken up very high, probably more than double ordinary working, the object in doing this being to ascertain up to what rate each arrangement can be worked with safety. In the first series of curves the results recorded are obtained from the boiler (Fig. 1) with the generating tubes delivering above water. It will be seen from the curve that, as the rate of working is increased, the pressure column falls slightly, and at an evaporation of 20lb. of water per square foot of heating surface stands at 85 per cent. of the maximum ; and by halving the working pressure the results are not sensibly changed.

The next series of curves is taken from the boiler (Fig. 2) which has the same heating surface, &c., as Fig. 1, but the top ends of the tubes deliver below water. It will be seen that the curves fall much more rapidly than the first series, and that by halving the working pressure the pressure is distinctly reduced in the lower vessel.

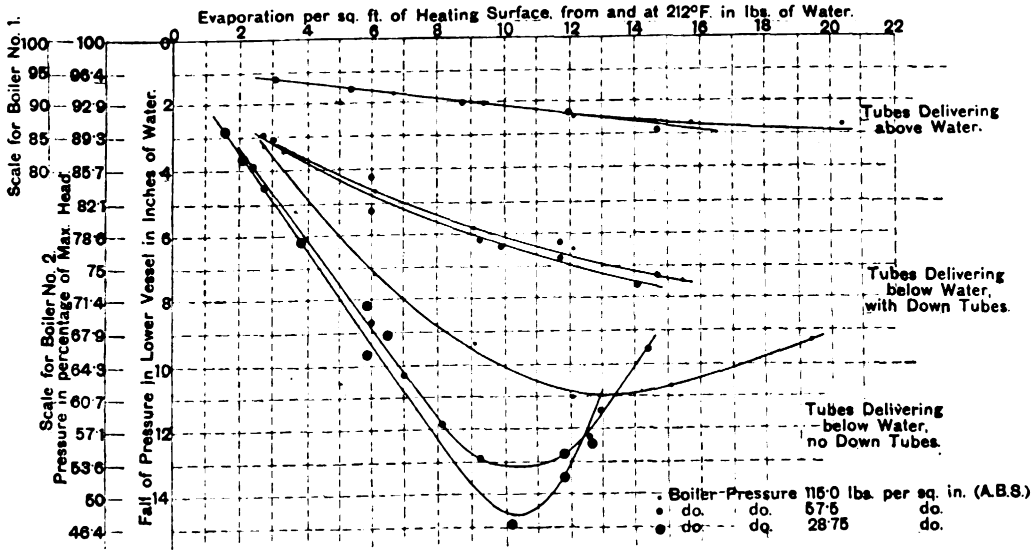

Fig. 3.

I have made experiments, taking observations from such pressure columns fitted to the boilers shown in Figs. 1 and 2, when they were working under different conditions. The rate of evaporation and steam pressure being varied for the several arrangements of boiler, which were :—

(1) Generating tubes delivering above water.
(2) Generating tubes delivering below water.

* Read at the Thirty-sixth Session (Summer Meeting) of the Institution of Naval Architects, 1894.

The third series was obtained from the boiler (Fig. 2) by plugging up the down-tubes, so that some of the generating tubes had to act as down tubes for the supply of the others ; the feed-water all being delivered into the upper vessel. In this case the character of the curves changes from the first two series very much. A diminution in pressure of working causes the pressure column to fall very much ; in the case of the pressure being only 28·75lb. per square inch absolute, it fell to about 46 per cent. of the maximum. The most important point, however, apart from this low pressure,

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but a result of it, is that for any given pressure a critical rate of working is arrived at when the pressure column begins to rise again with increased rate of working, thus showing an increased pressure in the lower vessel, caused by the steam being unable to get out at the top ends of the tubes fast enough, and so comes out at the bottom ends as well.

It will be seen from the curves that the lower the pressure of working the sooner this critical point is arrived at, and I found that when the evaporation was pushed beyond this critical point the tubes were not safe from overheating; but, by taking the tubes intended for downtakes, and extending their upper ends above the water surface so that water could not go down, and the steam in the lower vessel could readily get away to the separator, it was possible to increase the rate of evaporation somewhat, inasmuch as the facility for the tubes getting rid of their steam was increased.

Contrasting the different conditions of working of the water-tubes in the three series of experiments I have described, and noting what slight differences these conditions may necessitate in the design of a boiler, the nearness to success which a boiler intended for hard forcing may be, and yet fail, is clearly shown.

In conclusion, I would submit that the absence of special down tubes limits to a great extent the amount to which a boiler can be safely forced, and shows that to obtain the highest rate of working with safety and efficiency these special down tubes must not be neglected; and, still further, the tubes should deliver above water, as then the circulation, as I have previously shown, is double that when the tubes deliver below water. So that this rapid circulation is a most important condition for hard working.

DISCUSSION.

The first speaker on this Paper was M. NORMAND. He said that it had been a matter of surprise to him how boilers of this type could have been worked without the down-comer tubes for circulation. The Belleville boiler, as first designed, had no return tubes, and the result was that sometimes the water got to the top, and the steam to the bottom of the boiler, which was by no means a desirable result.

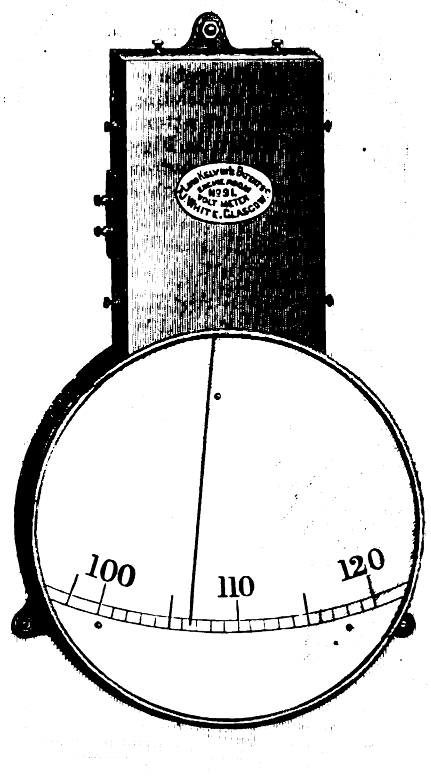
Mr. WATT said that, in the water tube boiler referred to by the author, the tubes were very small in diameter, and, therefore, they had to depend on rapid circulation. There might, however, be over-circulation in a boiler, and the consequent result would be over-heating of the tubes. In some of these boilers the tubes had been galvanised internally, and the zinc had decomposed the steam. He thought that the same action occurred in a lesser degree with iron or steel tubes, and so, unless means were taken for stopping the over-heating of the tubes, the life of the boiler would be very short.

Mr. PILCHER, referring to the question of circulation in water-tube boilers, described the means adopted by Mr. Maxim in the boiler of his flying machine. This boiler was of the Thornycroft type, the generating tubes being of excessively thin copper, and $\frac{3}{8}$in. in diameter. The maximum horse-power was 300 indicated, the pressure in the boiler being 300lb. to the square inch, and the weight of boiler 3lb per indicated horse-power. With the excessively high rate of evaporation and thin tubes, it was found impossible to produce sufficient circulation to keep the tubes from burning.

Mr. THORNYCROFT, in replying to the discussion, said he was afraid that he had not fully explained himself in the Paper, as he gathered some of the speakers had not quite grasped his meaning. Referring to the device described by Mr. Pilcher, he thought that for ordinary purposes it would not be advisable; and he was of opinion that if the generating tubes were not excessively long they could be worked at the small diameter Mr. Maxim had adopted. That is to say, at 300lb. pressure the tubes could be made to stand at $\frac{3}{8}$in. in diameter, though doubtless the fact remained they had broken down in the instance referred to. He himself had found that a $\frac{3}{8}$in. tube could not be burnt in a smith's fire, even working at atmospheric pressure. In steam-generating tubes of large diameter there would be no change in the water due to circulation, for the steam would find its way through the water when working slowly. Mr. Watt had said there might be over-circulation, but that the speaker looked on as impossible. In a water-tube boiler constructed on his principle by his firm the tubes had been worked five years, and at the end of that time they had been found still good. They were originally 15 B.W.G., and when taken out were 16 B.W.G., there being no evidence of local pitting. These were steel tubes.

LORD KELVIN'S LARGE DIAL VOLTMETER.

The large dial voltmeter is quite the same in its principle and action as the ampere gauge, but is fitted with an arrangement by means of which the instrument does not give indications through the part of the scale which is not required, and the part which is necessary is made very open. This is managed by means of a weight which is lifted by the soft iron plunger when it is a little above its zero position. This weight is made heavy enough to hold the plunger down until the voltage reaches the desired point, when the plunger lifts the weight off its support and begins to indicate. For example, an instrument which is intended to work at 100 volts would have its weight, and would not be able to lift it till the E.M.F. rose to 90 volts. The instrument would then indicate on a scale of very large divisions from 90 to 110 volts. The desired range of the instrument can be made to suit any circuit where a short open scale is required, such as from 90 to 110, 95 to 105, or from 100 to 120 volts. The main advan-



tages are that the instrument uses only a small current, though it has a quick action and is very free from friction. It gives a large open scale only at the part required, and has a clear zero indication. The space between divisions on a scale from 90 to 110 or 100 to 120 fully $\frac{1}{2}$in.

ON MAGNETISATION OF HOLLOW OR SOLID CYLINDRICAL CORES.*

BY H. DU BOIS.

The vexed question of hollow *v.* solid cores is once more discussed in this note. Von Feilitzsch's well-known result that the magnetic moment of short hollow cores is hardly inferior to that of solid ones (other circumstances equal, and saturation not being approached) has been elegantly explained by Prof. Silvanus Thompson in a general qualitative way by the simple remark that the external air resistance is approximately the same in both cases. There is no need whatever, therefore, for the assumption that the central fibres of cores are less easily "reached" by steady magnetisation than those near the skin; such a state of things would only be proved if the same result were obtained with hollow endless rings, which is improbable.

Von Feilitzsch's experiments having been lately repeated and extended by Prof. Grotrian (*Wied. Ann.*, 50, p. 705, 1893), the author seizes the occasion for attempting to go into the matter a little more fully. The particular case of a cylinder being one of those, in which the modern "magnetic circuit" notion does not lead up to quantitative results so well as the more orthodox theory of induction, the latter had to be applied, and immediately yielded the following general rule:—

If for cylindric or prismatic bodies of given length and any shape of section the "demagnetising factor" be proportional to the latter, and not too small, then the magnetic moment will be practically independent of the section for fields, which are not so strong as to produce an approach towards saturation.

It is further shown that both *præmissæ* of this rule apply to thin hollow cores, for which it is thereby easy to draw the curves of magnetic moment and impressed field up to thorough saturation for any given dimensions. An illustrative diagram of such curves is given, which presents exactly the same aspect as the experimental diagram of Prof. Grotrian's Paper. Finally, the question of hollow cores for dynamos is touched upon. Signor Ascoli has since independently criticised Prof. Grotrian's results much on the same lines.

* *Wied. Ann.*, Vol. LI., p. 529.

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RING-ELECTROMAGNET FOR PRODUCING STRONG FIELDS.*

BY H. DU BOIS.

The large ring employed, made of the best Swedish iron (50cm. mean diameter, 10cm. thickness) is slit radially in one place, tangentially in another, so that the width of the former air-gap may be conveniently varied. It bears 12 coils, each having a resistance of 0·2 ohm, and covering 90deg. (1/18) of the circumference; by means of these a maximum magnetomotive force of 108,000 ampere turns may be applied, requiring about 6·5 H.P. The highest value of the inductance is about 180 henries, corresponding to a "time ratio" of 180/2·4=75 seconds; the mean values are, of course, less. Ballistic measurements are, therefore, out of question.

When provided with flat pole-pieces the apparatus represents the simplest possible type of magnetic circuit, and is, therefore, well suited for an experimental verification of its laws. By a special method, which is described *in extenso*, the author was able to verify his form of the theory of magnetic circuits (*Phil. Mag.*, Nov., 1890, *Wied. Ann.*, Vol. LXVI., p. 491, 1892) with sufficient approximation. The leakage was roughly determined by a compass; its absolute amount was found to reach a maximum for a comparatively low magnetising current, and to *diminish* considerably as the current was increased. This final decrease of leakage, which, of course, is more marked still when referred to unit flux of induction through the circuit was previously found with a smaller ring by H. Lehmann (*Phil. Mag.*, April, 1893) and discussed by the author (*The Electrician*, Vol. XXIX., p. 450, 1892). It was explained how this simple fact constitutes an *experimentum crucis* against the fallacy of assuming—arguing from analogy with a voltaic battery immersed in an electrolyte—that leakage must always increase when saturation is being approached. It was also found that leakage is considerably diminished by the ampere turns near upon the air-gap; these "pole coils," as it were, fulfil the useful function of keeping the flux of induction together, preventing the lines from spreading.

The principal object of the apparatus is the production of strong fields by concentrating this flux through properly-shaped pole-pieces. A theory of the latter was developed almost simultaneously (1888) by Stefan and Ewing and Law, in which the assumption of absolute saturation is made. As this condition can never be fulfilled in practice, the author redetermined the best shape for the poles in an empirical way; it was found—in good accordance with Prof. Ewing's prediction—that it is best to take a straight truncated cone of semi-vertical angle 60° (instead of the theoretical 54° 44′).

The field obtainable in air with such pole-pieces falls short of the theoretical value by several thousand units; however, it beats the previous record † (about 30,000 C.G.S.) by a considerable amount. It was found

for a=5mm. H=36,800 C.G.S.
for a=3mm. H=38,000 C.G.S.

where a denotes the diameter of the small truncated faces.

To give an idea of this field the author points out that a bit of good thin iron wire would easily get saturated up to I=1750, corresponding to an induction

$$B=38{,}000+(4\pi\times1{,}750)=60{,}000 \text{ C.G.S.}$$

This corresponds to a tension of $B^2/8\pi$ dynes per cm.^{2} or 144 kilog.-weight per cm.^{2} A concentrated aqueous solution of ferric chloride in a U-tube (Quincke) would be lifted about half a metre; finally the resistance of a bismuth spiral would be nearly trebled in this field.

The author concludes that it is possible to obtain fields of, say, 40,000 C.G.S. with ring electro-magnets of reasonable size; but that stronger fields can probably only be reached by means out of all proportion with the purpose in view.

* *Wied. Ann.*, Vol. LI., p. 537.

[† We alluded to this fact on p. 541, Vol. XXXII.—Ed. *E.*]

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *July* 23, 1894.

Underwriters' Rules.—About two years ago, at the initiative of Mr. C. M. Goddard, of the New England Insurance Exchange, a meeting of electrical insurance inspectors was held, where the subject of a national set of insurance rules was taken up, and the Underwriters' International Electric Association organised to furtheir their adoption. Taking a set of excellent rules for safe wiring prepared by the National Electric Light Association as a basis, a tentative code of insurance rules was drawn up and submitted to the various underwriters' associations for criticism. At subsequent meetings proposed changes were discussed, and, finally, a definite set of rules adopted and offered to the various underwriters' associations throughout the United States for adoption. With scarcely an exception the rules have been welcomed by insurance companies and associations, and their adoption by the Southern Tariff Association a few weeks ago brings almost the last of the general underwriters' organisations within the fold.

Railway Networks.—Rumours are again current in the daily Press in regard to a great electric railway "network" between Camden, opposite Philadelphia, and Jersey City, opposite New York. According to the printed accounts, a main electric line will be built, and all of the towns in the State of New Jersey between the places named, which are about 90 miles apart, are to be inter-connected, and all act as feeders to the trunk line. It seems probable, however, that the real object of such projects is to secure more favourable terms from town governing bodies for local franchises. The term "electric railway network" seems to have a charm for the public, only approached by "long distance electric traction," which also, it is to be feared, is made to serve ulterior ends.

CORRESPONDENCE.

VACUUM TUBE EXPERIMENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Sir David Salomons' letter of the 19th inst. suggests the thought that, perhaps, he did not trace out his connections for continuity before assuming that no light was produced by the passage of a current through a vacuum. Was there any indication of heat? What proof of an actual current flowing was there?—Yours, &c. L. PYKE.

34, New Tothill-street, Westminster, S.W., July 28, 1894.

THE SHARP FLY-WHEEL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to your article on "Central Station Practice" in your last issue, I think you have failed to realise that the conditions to which the rim of a fly-wheel such as I propose would be subjected are entirely different to those to which the rim of a cast iron wheel, with a small number of arms, is subjected.

The rim of a fly-wheel is simply a metal ring rotating rapidly about its geometrical axis, and the stresses to which it is subjected are principally due to centrifugal force. If the rim of the fly-wheel be subjected to no constraint by the arms, and its speed be 100ft. per second the circumferential tension will be less than half a ton per square inch. Now, it is well known that 100ft. per second is a dangerous speed for cast-iron fly-wheels of the usual type with a small number of arms. The difference between this low stress and the breaking stress of the material is supplied by the bending stresses on the rim due to the constraint of the arms. Now, in my fly-wheel "the rim being supported at small intervals by the numerous spokes is nowhere subjected to large bending stresses due to centrifugal force, as in the case of large wheels with a small number of arms; it may, therefore, be run at a much higher velocity with safety." In fact, the bending stresses vary directly as the square of the distance between the ends of the arms or spokes, and, therefore, inversely as the number of spokes. Thus, in a wheel of a given diameter, if in my design the spokes are four times as numerous as the arms in the usual design, the bending stresses due to centrifugal force will be only $\frac{1}{16}$th of those in the usual design. At a speed of 300ft. per second the centrifugal stresses in the rim, considered unconstrained by the spokes or arms, will be 4·2 tons per square inch, which seems a low enough stress for mild steel. But the actual stresses in the rim while the wheel is rotating can be reduced by simply putting an initial compression on the rim by tightening up the spokes; in fact, by using a sufficient number of

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spokes the stress in the rim may be reduced to zero, the centrifugal force being taken up directly by the spokes.

I think if my flywheel design be carefully considered it will be seen that a speed of 300ft. per second will be safer than a speed of 100ft. per second with the usual type of flywheel. I beg to enclose a pamphlet in which I give a short analysis of the stresses in my flywheel, a copy of which I shall be glad to send to any engineer interested in the question.

As a matter of fact, the above speed has been exceeded in "Parson's Steam Turbine," where the material is necessarily less advantageously disposed to resist the centrifugal stresses.

Yours, &c., ARCHIBALD SHARP.

Central Technical College, Exhibition-road,
London, S.W., July 30, 1894.

LEGAL INTELLIGENCE.

Woodhouse and Rawson United (Limited).

FRIDAY, JULY 27TH.

The REGISTRAR having asked Mr. F. L. Rawson (who was again sworn) as to the reasons of his leaving out from the circular announcing the retirement of three of the first Directors the statement which they wished to have inserted that any applicant might withdraw his application,

WITNESS said it certainly was not an accident that it was left out, as the point was most carefully considered. He certainly told Mr. Johnson of the minute, and was much annoyed when he first heard it said that he ought to have seen Mr. Budd, and not Mr. Johnson, because he felt that he had done all that he ought to do in the matter.

A SOLICITOR said he had asked Mr. Johnson about this point, and he said he could not recall the circumstances after this lapse of time, but he certainly would not have passed a circular of that kind had he known of the special nature of the Board minute.

The OFFICIAL RECEIVER said in the balance-sheet of 1891 there was included an item of £2,640. 11s. 3d., being, according to the description in the journal, surplus assets of the Kidsgrove purchase. There were £1,000 in 1890, and £2,640 in 1891, under this heading. Mr. Pilling, who was the auditor of that branch of the business, had reported that the surplus shown was "a fictitious surplus."

WITNESS said that was certainly not the case. It was the result of a re-valuation after the purchase, when it was found that the plant and stock came out at £3,640 more than was paid for it. In 1890 the Directors felt uncertain as to this matter, and determined only to include £1,000 on account of this surplus; but the next year it was found that the revaluation was undoubtedly correct, and the remaining £2,640 was then included in the accounts.

The OFFICIAL RECEIVER: Was the report of the auditor read to the Board?—I do not think so. It was a surprise to me to learn that there ever was a report at all. I found that Mr. North purposely kept back this report from me. Mr. North opened the letters at the offices.

Mr. STUTCHBURY was recalled, and asked by the Official Receiver if he had ever seen the report in question. He said he remembered seeing it. It came at the same time as the audited balance-sheet was received. He did not think there was any concealment of the report, and he was under the impression that it was brought either before the Board or the Finance Committee. Mr. North showed it to him. He would not like to say that Mr. Rawson ever saw the report, but he had the opportunity of seeing it. He could not see that Mr. North had any reason for concealing the report.

By Mr. Jenkins: He was at most of the meetings of the Board and of the Finance Committee, and usually drew up the minutes, although they were subjected to revision and alteration by the Managing Director and Chairman. He could find no reference to the report in the minutes of either the Board meetings or those of the Finance Committee.

By the Registrar: The minutes may sometimes have been curtailed; he would not go so far as to say that anything was ever struck out.

By Mr. H. G. Rawson: If his draft of the minutes had stated that this report was read, and the minutes as ultimately entered omitted such reference, he would undoubtedly have called the Board's attention to the fact.

By the Registrar: He could suggest no reason, if the report were laid before the Board, why there was no record of the fact in the minutes.

By Mr. F. L. Rawson: The Board were extremely surprised to learn that advances had been made to Messrs. King, Masterman and Terry, the vendors at Kidsgrove Works, to which there was reference in Mr. Pilling's report. It might have been the case that if they had known of these advances, which were known to Mr. North, it would have led to Mr. North's affairs being closely looked into; but he believed Mr. North himself informed the Board of the matter towards the end of his time.

Mr. F. L. RAWSON'S examination was then resumed. He still adhered to his statement that he had not seen the report until the commencement of the winding-up proceedings. He thought Mr. Stutchbury had made a mistake in regard to the date at which he saw the report; witness had heard something of the report having been discovered amongst North's papers. Replying to further questions regarding the Kidsgrove accounts, witness said the amounts written off on account of losses at the works had no connection whatever with the surplus of £3,640. There was no doubt at all but that Messrs. King, Masterman and Terry had made a mistake in their valuation of plant and stock; they had gone on purchasing new plant and stock, regarding which there was no entry in their books, and when they estimated the book values of plant and stock they overlooked this new plant and stock. He saw no reason whatever why they should not take credit in the accounts for the mistake of the vendors. One item referred to a sum which was paid into King, Masterman and Terry's account by a firm who had formerly had business with them instead of being paid into the United's account. King, Masterman and Terry admitted the facts, and said they were very sorry, but that it was done with Mr. North's knowledge. So careful was he with regard to the purchase of Kidsgrove that he went fully into the financial position of Messrs. King, Masterman and Terry, and he found that by the statement made out their assets amounted to £75,000, and their liabilities to about £35,000 or £40,000. A certain part of their assets, however, consisted of Barbadoes debentures, which were taken at par, and those debentures turned out practically unsaleable. Had he seen Mr. Pilling's report he certainly would still have allowed the item £2,640 to appear in the accounts in the way it did, as it was a question of plant and stock. The Directors were aware that there was a loss on the Kidsgrove works, but may not have known the exact amount. With regard to the Phœnix Trust Company, the Founders' shares held by the United Company were acquired for £25, and were valued in the balance-sheet of 1891 at £15,000. The Phœnix Trust paid a dividend of £1,465 in cash in January, 1891, and in May of that year a dividend of £5,160 in shares in the Austrian and French Elmore Companies. Those were the only dividends paid by the Phœnix Trust Company. Witness did not know whether those shares had only realised, up to the present time, £3,295. Woodhouse and Rawson United really had nothing to do with the promotion of the companies named. On the whole of the transactions with the Phœnix Trust they had taken in the accounts a profit of £36,658, but had only realised up to the present about £9,000. Witness had himself been offered £10,000 for the United Company's holding of 25 founders' shares, and he conveyed that offer, which was made by Baron Grant, to the Board, who, however, considered that if the shares were worth £10,000 to Baron Grant they were probably worth much more to them and declined to part with them. They arrived at the valuation of these shares at what they were taken in the balance-sheet by an investigation as to what would be the amount of their share of the assets of the Phœnix Trust Company if that company were wound up at that date, taking everything at the current market price, there being a quotation of nearly all the shares concerned. This investigation showed that their share would be £20,000, but the Directors decided to put it in at £17,500. Subsequently, at their request, witness again went into the affairs of the Phœnix Company, and found that he had at first omitted a liability of £2,000, of which he had not known. To guard against over-valuation, and the possibility of other mistakes having been made, the Directors then decided to put the value of the shares in at £15,000. It might be taken that the whole of this £15,000 represented entirely holdings in the Elmore Companies. There was once a mistake in regard to the meeting of a bill by the Phœnix Trust Company, the money having been paid in to the wrong bank, or something of that kind; otherwise they always met their bills when due, unless they were renewed. The Phœnix Company complained that the reason why the Elmore Company did not pay a dividend was that it was mismanaged by the Directors, for which they blamed the United Company. The rebate of £12,000 on the guarantee fund was also taken in as a profit. This represented the return to the Limited Company of £63,000 in lieu of £75,000, the full amount of the guarantee, in consideration of its being paid 18 months in advance. The result of that was that they had to borrow from their bank to the extent of £13,000 at an average rate of interest of 7 per cent., and this interest, together with the payments on the £50,000 worth of Five and a-Half per Cent. Debentures, amounted to £3,660 for one year, and in the accounts for 1891 they omitted any consideration of the fact that they would have to pay that sum in the next year; this was a very involved point, and he could not say that he really understood why that was not charged.

The OFFICIAL RECEIVER: You were taking credit for your financial profits for 13 months, and you were only debiting yourself with your losses on the industrial business for 11 months, so it is a fair criticism, is it not? to say that had you made your year for the industrial business end at the same time as that of the financial business, there would have been an additional loss to put in of another £4,000?—No, because we gave the whole of the charges for the 13 months. There might have been a small loss, but not so much as that.

Examination continued: His communications with Baron Grant, of the National Financial Corporation, practically ceased before the date of the passing of the resolution by the Board calling upon him to discontinue those relations. The Merxem Company, with which he afterwards had dealings, had nothing to do with the National Financial Corporation. The reason why the bringing out of the Epstein Company was deferred till the last day of the year was that he was in constant negotiation with regard to the matter, and getting better terms the longer the matter was deferred. The business might have been closed at the end of May or the end of June as easily as at the end of July; but then the United Company would have had far less beneficial terms. There were two independent Directors on the Board of the Epstein Company, and it was with them that terms were arranged. To the best of his knowledge and belief the Epstein Company was capitalised at a lower figure than any other accumulator company. They paid only £70,000 for the whole of their patents, whereas their chief rival paid something like £300,000 or £400,000, and the patent for England alone stood in their books for something like £70,000. Mr. Epstein went to America with a power of attorney to sell the patents for that country for £20,000, and the Thomson-Houston Company sent over an expert, who made a long report; he was absolutely satisfied on every point with the exception of two, which were the applicability of the accumulator to the purposes of

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traction, and the cost. They claimed then that the cost did not exceed 1d. per car mile, 2d. per car mile being the accepted figure, which rendered traction commercially possible by means of accumulators; subsequently they found the cost with the Epstein accumulator was as low as ½d. per car mile. The original cells used at Birmingham were still running, and were thoroughly satisfactory after 21 months use. His recollection was that Mr. Epstein told the Board that £50,000 had been spent in bringing the invention to its present state, but Mr. Epstein now said he did not mention quite so large a figure as that; he said £30,000 had been spent apart altogether from what they (Woodhouse and Rawson) had spent on it. Then Mr. Stepney Rawson, as well as witness himself, had spent an immense amount of time for over a year, and this would bring up the value of the patents a good deal. They had a report from the late Mr. Reckenzaun, perhaps the leading expert upon accumulators, and himself an inventor of one, who said that the Epstein was as good as his own on all points, and better in many. If the capital had been paid into the bank so that the Epstein Company could have used it as they wanted it, the position of the Company would have been very different from what it was now, but Woodhouse and Rawson United could only deal out the money in driblets. There was a fire at the Epstein works, which threw them back 18 months.

After the luncheon interval,

Mr. PHILIP RAWSON was re-called, and said the date given at his previous examination as that at which he first learnt of the connection of the Managing Director with the Phœnix Trust was incorrect, and he should have said 1891 instead of 1892. He did not think he knew in September, 1890.

Sir JOHN STOKES was also re-called, and said he was not present at the meeting of the Board in September at which Mr. Rawson gave the explanation referred to on the minutes concerning the Phœnix Trust Company. He certainly had knowledge of the interest of the Managing Director in the Phœnix Company; but when that knowledge was first gained he could not quite say. He was not aware, until he heard it in court, that practically the whole of the Phœnix Company's shares were held by Mr. and Mrs. F. L. Rawson, Baron Grant and the National Financial Corporation.

Mr. F. L. RAWSON, in further explanation of Epstein matters, said it had been inferred that the profit made by the inclusion of the Epstein shares would not have come in in the 1891 balance-sheet had they not taken the financial business up to the end of July. The reason for the closing the year's accounts on one side of the business at one time, and the other at another date was that Mr. Pixley suggested that, in order to get over the difficulty of the long time it took to get the accounts from the outstanding branches, they should take those branches in the following year up to the end of May, and it was settled to do so; then it was considered by the Board best to take the whole of the industrial branches up to the end of May, instead of part to May and part to June or July.

By the OFFICIAL RECEIVER: If it had not been for the stingy way in which the United Company dribbled out the money to the Epstein Company all might have been well with that Company. As it was £13,280 was "dribbled out," but £4,000 of that was paid before the Epstein Company was formed, and the last payment was a long time afterwards. At a meeting of shareholders he was asked about cheques and cash in hand, amounting to £31,000, and he replied that that was in consequence of one cheque for £30,000 which was not paid into the bank on the actual night of the closing of the balance-sheet. His impression was that that cheque was paid in two or three days afterwards.

The OFFICIAL RECEIVER: Were you aware that the reason was that there was no balance to meet it?—No, that was not the case. There was plenty of money to meet it without the application money of Woodhouse and Rawson.

If I show you the banking account of the Okonite Company, showing that they had not the funds, would that affect your answer?—Not at all.

Do you suggest that the cheque would have been honoured if presented on the day after?—I do not suggest it.

Were you aware that it would not?—I do not know. I think probably it would have been.

Why did you hold it over?—Because it was agreed with the Okonite Company. They had to pay us by a certain date, but asked me not to present the cheque just at once. It is true that about £6,000 was paid in by Woodhouse and Rawson subsequently.

By Mr. Squire (a shareholder): The profit on the Okonite promotion was entered in the balance-sheet for 1890, although it was not actually received until two months later. The profit was properly made in the year ending June, 1890, and they were advised by counsel that it was quite proper that it should be entered in the books as belonging to that year. Had it not been entered that year the profits of course would have been less, but not to the extent of £37,240, as Mr. Squire suggested. He offered, as that profit was partly made in shares and debentures, not to take his percentage at all that year, but to wait until those shares and debentures were realised, or he was willing to take his commission in shares and debentures at the price at which they stood in the balance-sheet, and it was decided that that should be done. He also stated that if they thought his contract an unfair one he would cancel it altogether, and make any other contract they might wish. In the second year the value of their holding in the Phœnix Trust was estimated upon the same principle as in the first; they estimated they would receive £9,000, but as a matter of fact they received £12,000. Asked why the Phœnix Trust was formed, witness said the Directors of the United asked him to endeavour to sell the Elmore shares that they held, and he approached various Trust Companies, but was unable to get the price they wanted. At almost the same date an offer was made by some people in the City to bring out the French Elmore Company. He had been asked to see if the Directors of the United would bring out that Company and underwrite it, but he said they certainly would not. He asked them, however, but they refused. He thought he might be able to get a profit for the United if they would allow their name to be used on the prospectus as having looked into the proposed company and satisfied themselves on the technical points. He went to one or two Trust Companies, who made offers which were refused, and he then got up a syndicate consisting of about 30 City people to find the necessary money to purchase the Elmore shares from the United and underwrite the French Company, and all those people took shares. Those people not only insisted that he (Witness) should become a Director, but also that he should give them assistance and advice, and offered him a large number of Founders' shares if he would oblige them. He reported all the facts to the Board. When Mr. Phillips, Chairman of the Syndicate, saw Witness's father, he mentioned Baron Grant's name, and Sir Rawson asked what his connection with the Trust was, Mr. Phillips replying that he wanted to become a shareholder. When the others went out of the Phœnix Company he got Mrs. Rawson to take a thousand shares, took a thousand himself, and Baron Grant also took a thousand. Woodhouse and Rawson United required a deposit at the time the contract of purchase was made, and that deposit was made. Witness lent the Phœnix Company £5,000, and took payment in paper. He got a trifle more than the United did when the Phœnix Company was wound up in consequence of his holding Ordinary shares.

By Mr. Pilling: Woodhouse and Rawson United made no advances to the Phœnix Company. They paid the expenses of the promotion: but that was after the Company was a successful one, and there was no risk whatever. The United never ran any risk in any promotion, either directly or indirectly.

The further examination was adjourned till Monday next, August 6th.

Cassel Gold Extracting Company v. The Cyanide Gold Recovery Syndicate, and Others.

In the trial of this action, which was continued before Mr. Justice Romer, evidence for the defence was taken.

Mr. CLAUDE VAUTIN said that he had been an analytical chemist for over twenty years, and had applied himself to the study of gold. Sixteen years ago he knew of the solution of gold by cyanide of potassium. It should have been known to persons engaged in metallurgical chemistry in 1887 that cyanide of potassium dissolved gold in a state of fine division. In 1855 he was in Melbourne, and was then acquainted with Sanders's patent. He carried out experiments on the lines of the patent. A number of patents was tested, and Sanders's was thought to be an extraordinary one—the extraordinary thing was that Sanders should use an acid which would dissolve gold. Witness gave the results of some experiments with cyanide of ammonium and cyanide of potassium, and said he found that that mixture acted on natural gold quicker than the plaintiffs'. He had dealt with, or seen dealt with, thousands of tons of ore. Witness described experiments he had made with two beakers, into each of which a solution of 7 per cent. of cyanide of potassium and some water were put. In one beaker a piece of gold leaf was suspended between two pieces of muslin, the same as in the other. In one beaker he introduced an electric current, and passed it from the anode to the cathode. The time was taken, and the gold leaf with the current broke up and became disintegrated five times quicker than in the other. Faraday's method was followed, and there was no possibility of connection between the anode and the gold leaf. He found that Faraday's principle was perfectly correct. The gold leaf submitted to the electric current was broken up, and it rapidly dissolved in the muslin bag. In another experiment the result was that the gold was not found on the cathode. He believed that if Rae's directions were carried out they would dissolve suitable ores. He had no hesitation in saying that gold would go into solution by that process. That would take place if the electric part were operative or not.

It was his opinion that electricity helped the process of solution.

The best paper on the solution of gold by cyanide of potassium was Dixon's; but Rae and Simpson knew the process also. Simpson had no gold anode; Rae proposed physical contact, and the solution of the gold in the same way as the electro-plating process. Witness had not put forward Sanders's process as disclosing new knowledge. With respect to his experiments with the two beakers, it was very difficult to get two leaves of gold of exactly the same weight, because the gold was so very thin. He used four cells and 7 volts electricity. The gold disappeared to a great extent. It was not, he thought, a fact that the mere passage of the current would break down the gold leaf with that pressure.

Mr. R. H. HARLAND, F.C.S., said he had conducted experiments in respect to the process of the defendants. The object of these was to ascertain the difference in the gold dissolved in ore when electricity was used in tank "A" and when it was not. He began experimenting with 2lb. of ore, and increased it to 4lb., and then to 25lb. He assayed the ore he used before it had been through the process and afterwards. Where the electrical current was present the amount of gold extracted was 83·4 per cent., and in the case without the current 73·6 per cent.—a difference, roughly, of 10 per cent. in favour of the employment of the current. His last experiments gave better results than the former. In the course of his experiments he used the defendants' apparatus. The electrodes were of the full size. Witness challenged the results of Mr. Tatlock's experiments on the ground that it was unsatisfactory to assay the tailings. The error was so great as to nullify the results. A large quantity of ore gave more reliable results than the small one which Mr. Tatlock took. With regard to the selective operation of cyanide of potassium, witness said that the operation began on the baser metals at the same time as on the gold. With regard to his experiments with defendants' apparatus, the apparatus was about the same size as the model in Court. What he operated upon was ore, not tailings. The object of the experiment was to see whether

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electricity had any effect. The experiments with electricity were made with the Pielsticker process, and the experiments without electricity were made in a separate vessel. In the former experiments he had circulation, and in the other he had no circulation, but stirred up the ore.

Mr. Justice ROMER asked why the witnesses did not take the test in the ordinary way; that was to say, take Pielsticker's machine, work it for 24 hours with a current of electricity, and then 24 hours without the current, and then see how much more gold was deposited in the one case than in the other. He did not see why the experiment should not be tried if both parties were agreed that it was important. He did not say that it was essential to decide this case; but, still, it might be. It would, however, be an absolutely certain test to find whether electricity did produce more gold or not.

Mr. RILEY, F.C.S., F.I.C., said that it had been known for many years that cyanide of potassium would dissolve gold. It required no inventive faculty to know that cyanide of potassium was a solvent which would operate upon gold ore; it was simply the application of a well-known chemical solvent under special conditions. Rae's process would be operative for the purpose of dissolving the gold if the gold were in a fine state of division. Simpson's also would be efficient. Prior to the plaintiffs' patent the knowledge that cyanide of potassium could be practically used to extract gold from ore was scattered through all the chemical books. Perhaps the electricity in Rae's process would not have much effect. He preferred to leave the electrical part to the electricians.

Mr. Justice ROMER: Would any chemist in the beginning of 1887 have felt any doubt that a solution of cyanide of potassium would have dissolved that gold and silver?—I should have had no doubt myself.

Mr. JAMES MACTEAR, F.I.C., said that in 1887 the fact that cyanide of potassium would dissolve gold and silver was well known. There was no invention in the application of that knowledge to gold ore. Witness was present at the experiments of the defendants, the result of which, he said, was that the gold was dissolved more rapidly when electricity was used. Rae's process would be effective for getting gold into solution, but it was impossible that it could be a financial success because of the difficulty of getting the gold out of solution. Cyanide of potassium had been reduced in price from 17s. per lb. to 1s. per lb. Faraday disclosed as much as any of the extracts relied upon in the particulars of objection, but in chemical literature there were more specific references to the solubility of gold in cyanide of potassium than those which the defendants relied upon. In 1885 the price of the cyanide of potassium he would use for this process would have been 2s. 6d. per lb. He considered that the electrical pressure and current with which Lord Kelvin worked was too small to produce any electrical result. In 1887 the process of getting the gold out of cyanide by zinc was not practicable—that was to say, only some of it could be got out.

Prof. ATTFIELD, F.R.S., said that he had read a Paper on the solution of gold by cyanide of potassium before the Chemical Society thirty years ago. Rae's process would dissolve gold. He thought that in that process the cyanide of potassium was the main agent, and he inferred from the language used that the electric current was only to materially facilitate the action. He did not find any indication in Rae that a person was to abandon his electricity and get his gold by means of a solution of cyanide of potassium only.

This was the case for the defendants, and Mr. NEVILLE on their behalf said they were sufficiently satisfied with their lines, and did not desire to have any further experiments on the question of electricity.

Mr. Justice ROMER: You will try the case on the same footing as if you had not used electricity?—Yes.

Mr. NEVILLE then summed up the case for the defendants. They might, he said, have gone on almost until Doomsday about electricity, but there was one broad point. The plaintiffs claimed the use of any solution which contained cyanogen or cyanide, or any cyanogen-yielding substance. If that were so, that obviously applied to Simpson and to Rae, who both used a cyanogen-containing solution for the purpose of extracting gold from ore. There was an end of the case. He proceeded to attempt to dispose of the argument that the plaintiffs' was such a meritorious invention that it ought to be favourably viewed by the Court. Not one ton of gold ore was treated until the plaintiffs had arrived at a suitable method of getting the gold out of solution. If the plaintiffs' patent was not for the use of cyanide of potassium alone, then Simpson's patent was fatal to it, because there there was only a slight admixture of another chemical. All the evidence went to show that Simpson's patent would do the work of the plaintiffs' patent, and it was an absolute absurdity to say that all the world might use cyanide of potassium if they put in half an ounce of carbonate of ammonium, but that the plaintiffs alone had the use of cyanide of potassium. Having dealt with the sort of publication necessary to anticipate the patent, he now proposed to examine the existing state of knowledge from the points of view of what the general knowledge showed and what specific exposition showed. It was common ground that there was no prior user in this case.

Mr. Justice ROMER: In England.

Sir R. WEBSTER said he should show that there was evidence of no user of Simpson or Rae anywhere in a sense that would invalidate the patent. The two most important points in this action were the alleged anticipations of Rae and Simpson. The defendants, he said, came into Court to win this case upon Rae's specification; they came to prove that they were electrically depositing the gold out of the ordinary solution, and not using the chemical action. He did not hesitate to say that his lordship had seldom heard so complete an abandonment of the case the defendants came into Court to prove. How did the matter stand? The plaintiffs described the Pielsticker process, and called evidence to prove that when the electric current was passing, as the defendants used it, it had no effect on the dissolving action of the solvent as distinguished from the depositing action. His Lordship had, during the case, said that the state of the evidence was so unsatisfactory that further experiments ought to be tried. The plaintiffs had called Lord Kelvin, who might have been right or wrong; but he prescribed his own apparatus, and the experiment carried out by him did prove that there was less gold when the current was passing than when it was not. The defendants took the apparatus away, and they gave evidence that Lord Kelvin's experiment was untrustworthy, because the solution could pass through the second carbon division. Thereupon, the plaintiffs in open Court offered that these experiments should be renewed. What happened? The defendants abandoned the electricity distinction; they were obliged to admit that they could not rely upon any distinction due to the fact that they had superadded electricity to what Mr. McArthur had patented. With regard to Rae, he asked the Court to remember that the evidence was that Rae had abandoned the cyanide of potassium, and worked by electricity alone. What was necessary in order that Rae could be used as an anticipation of the plaintiff's patent? He said, without hesitation, that sufficient directions must be found to tell people to abandon the electricity, and to rely upon the dissolving action of the cyanide of potassium.

Mr. Justice ROMER said that what would be said against the plaintiffs was this: That the general knowledge was that cyanide of potassium would dissolve gold under certain circumstances; and though there possibly might be a doubt whether you could dissolve gold in crushed ore, here was Rae saying, "You certainly can, and the use of the electric current will facilitate it."

Sir R. WEBSTER: I say the electricity is to make the solution.

Mr. Justice ROMER did not take that view, having regard to the language of the specification, and said that the defendants said that if any person had any doubt whether cyanide of potassium would dissolve the gold in the crushed ore, after reading Rae he could not have had a doubt about it.

Sir R. WEBSTER said that was the strongest thing in his favour. Rae had told people that they could have a perfect solution by the aid of electricity; he had never told people that they could get a perfect solution by the action of the chemical. What Rae said was that if you desired to get the maximum solution of gold you must have an electric current. He (Sir Richard Webster) denied that the defendants were entitled to eke that out by saying that it was previously known that cyanide of potassium had a solvent action on gold in ore. Rae told people that cyanide of potassium had a certain solvent action on gold in ore; but that, if it was desired to make it a practical solution, you must have electricity to aid it. He submitted that Rae could not be read as if the electricity was not there. He knew of no case in which in order to invalidate a patent the defendant had been allowed to rely upon that which was contrary to the directions of the alleged anticipating patent.

Mr. Justice ROMER said that this was not put against the plaintiff as anticipation directly, but on the question of anticipation generally. It was said by the defendants that if cyanide of potassium was found to dissolve gold, presumably it would dissolve gold in ore; but if there were any doubt that it could be applied usefully, Rae said that it could be usefully applied to ore, though it was better to have electricity.

Sir R. WEBSTER denied that Rae showed that, and submitted that this kind of anticipation was not sufficient to invalidate the patent. With regard to the suggestion that persons had paid £117,000 for a step which was merely the omission of a chemical from Simpson's patent, he asked the attention of the Court to the greatness of the step taken by the plaintiffs' invention. It was not until the reply that any suggestion was made that it was not a great step. In conclusion, the learned counsel said that this case was to be decided by the evidence, and he submitted that this most useful invention, which had been pirated by the defendants because it was a useful invention, was the result of experiment, research, and the bringing to bear of great skill and knowledge; that it had not been generally or specifically anticipated; and that the defendants ought to be restrained by injunction from taking that which had been proved to be a new and useful invention.

Mr. Justice ROMER reserved judgment.

Hamilton v. Vaughan-Sherrin Electrical Engineering Company (Limited).

This case, which came before Mr. Justice Stirling, raised the question as to whether a person who has, during infancy, entered into a contract to take shares in a company is, upon repudiating the contract, entitled to recover from the company money paid in respect of such shares. The defendant Company issued a prospectus, on the faith of which the plaintiff applied for shares, and paid £20 on application. On October 6, 1890, shares were allotted to her, and on the 18th she paid £40. At that time the plaintiff (a lady) was aged 18, and on November 18th following she wrote a letter to the secretary asking for repayment; and on May 19, 1892, she issued a writ; and on June 10th following the Company went into voluntary liquidation. On June 27th the liquidator removed the plaintiff's name from the register of shareholders. The action now came on upon a summons for the purpose of deciding whether the plaintiff was entitled to the return of the £60 paid by her to the Company.

The learned JUDGE, in giving judgment, said that the action was based on the ground that there had been a total failure of consideration. Then the plaintiff was an infant, and it seemed to his lordship that the true rule was to consider whether the infant had derived any advantage under the contract. In this case no dividend had been declared, and the plaintiff took no part in the Company and attended no meetings. The only advantage she got was the allotment of the shares, and the fact that for a certain period her name remained on the register. That was not an advantage within the meaning of the judgments in "Corpe v. Overton." There was here a total failure of consideration, and the plaintiff was entitled to recover.

Judgment accordingly.

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The Printing Telegraph Company v. Drucker.

This was an action for calls. The plaintiffs appealed to the Master of the Rolls and Lords Justice Kay and Smith from an order of Justices Wills and Williams affirming a direction of a Master and a Judge in Chambers for a commission to Paris asked for by defendant to prove his plea of non-liability consequent on misrepresentation.

The Master of the Rolls said the defendant, in answer to an action for calls, pleaded misrepresentation; and, to prove his case, desired the evidence of people abroad who had been heard under another commission in another action, and who had, it was true, given answers to questions part of which undoubtedly related to the same issue as the defendant raised, and part not. This evidence having been given in another action, he thought there was no power to make it available in the present, and that defendant was entitled to the commission. Were it otherwise, he knew of no power in this Court to make something evidence which by law was not evidence, as the evidence in Lord Windsor's case would not be in the respondent's action.

The appeal was dismissed.

Edison-Bell Phonograph Company v. Hough.

The hearing of a motion for an interim injunction to restrain the defendant (trading as the London Phonograph Company) from infringing certain rights which the plaintiffs claim to possess in a patent of 1886 for improvements in phonographs, was concluded before Mr. Justice Stirling on Tuesday.

The Defendant having offered to pay £25 into court, his LORDSHIP said that upon that sum being paid in, and on the parties undertaking to prosecute the action without delay, he thought there ought not to be an injunction, but the defendants must keep the usual account.

The injunction was, therefore, refused.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

The 1894 Edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK contains 1,000 closely-printed pages, and several new and useful features have been added. The price of the Directory and Handbook is 7s. 6d. Postage in the United Kingdom, 9d.; abroad, 1s. 4d. *The 1895 edition is in active preparation.*

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," being four Lectures delivered before the Royal Institution in April-May, 1894, by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is in preparation, and will shortly be published.

"THE WORK OF HERTZ."—The lecture delivered by Dr. O. J. Lodge at the Royal Institution on June 1st is being reprinted with corrections and additions, and many illustrations, and will shortly be ready, price 2s. 6d.

"ELECTROMAGNETIC THEORY," by Oliver Heaviside, is now ready, price 12s. 6d. (abroad 13s.). Prospectus on application.

"THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application to the Publisher.

"DRUM ARMATURES AND COMMUTATORS."—This book, written by Mr. F. Marten Weymouth, is also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. (abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application to the Publisher.

TENDERS INVITED.—The Cheshunt Local Board invite tenders for the public lighting of their district by gas, oil, or otherwise. Tenders must be in not later than Monday next, the 6th inst.

——— The Vestry of St. Pancras (London) are prepared to receive tenders for the supply and laying of armoured cable mains. Specifications, &c., can be obtained at the offices of Prof. H. Robinson, 13, Victoria-street, London, S.W.; and tenders must be sent in to Mr. Albert E. Pycraft, chief clerk, Electricity and Public Lighting Department, Vestry Hall, Pancras-road, N.W., by noon of Thursday, the 16th inst. Further particulars appear in our advertisement columns.

——— The City Council of Melbourne (Victoria) invite tenders for the supply and delivery of 500,000 arc lamp carbons required in connection with the electric lighting scheme. Tenders have to be sent in by September 11th next to the Town Clerk, Melbourne.

TENDERS ACCEPTED.—The Electric Lighting Committee of the Tunbridge Wells Town Council recommend the acceptance of the tenders of Messrs. Langley and Co., of Crawley, for the erection of the central electric lighting station buildings for the sum of £2,789.

——— The West Ham Town Council have accepted the tender of the Brush Company for the electric lighting of the Public Hall and Library at Canning Town. The plant is to include duplicate engine-power and footlights for the stage; but is exclusive of buildings and foundations for the machinery, and is subject to the employment of Crossley's Otto gas-engines. The following is a list of the tenders received:—

Fanshawe and Grant...	£917	Ronald A. Scott (Ltd.)	£1,508
Henry F. Joel and Co.	1,055	Leonard G. Yate	1,535
Brush Electrical Eng. Co.	1,075	J. H. Holmes and Co.	1,536
Rayner, Smith and Co. (part)	1,127	Thames Ironworks Co. (Ltd.)	1,537
Fowler, Lancaster and Co.	1,196	Ditto	1,697
Harry South	1,215	Ditto	2,047
Fenton and Barnes...	1,225	J. G. Statter and Co. (Ltd.)	1,549
Wenham and Waters	1,230	Lund Bros. and Co.	1,551
Paterson and Cooper (part)	1,257	Stone and Co.	1,561
F. Suter and Co.	1,261	Parr and Gillies	1,576
B. Verity and Sons...	1,340	Crompton and Co. (Ltd.)	1,584
Rowland, Barnett and Co.	1,345	Brown and Co.	1,600
C. A. Hemningway (part)...	1,350	Hill, Percival and Co.	1,611
Roger Dawson, Ltd. (part)	1,369	John C. Christie (part)	1,668
Laing, Wharton and Down	1,370	Edmundsons, Ltd....	1,674
W. Mackie (part)	1,374	Marryatt and Lillywhite	1,709
Peter Jones...	1,423	New and Mayne	1,725
Vaughan and Brown	1,429	Hulett and Co. (Ltd.)	1,779
J. C. Howell, Ltd. (part)	1,439	Douglas C. Bate	1,824
British Electric Light Co.	1,448	Benham and Sons	1,876
Strode and Co.	1,487	Rashleigh, Phipps and Co.	1,888

TENDERS RECEIVED.—The following tenders have been received by the London County Council in connection with the electric lighting of the Victoria Embankment and Waterloo and Westminster Bridges:—

(1) *For the supply of engines and electrical appliances:*

Electric Construction Company (Ltd.), Wolverhampton...	£4,410
Crompton and Co. (Limited)	4,444
Greenwood and Batley (Limited), Leeds	4,565
J. G. Statter and Co. (Limited)	4,629
Paterson and Cooper	5,000
Johnson and Phillips	5,200
C. A. Parsons and Co., Newcastle	5,471
Brush Electrical Engineering Company (Limited)	5,437
T. Scott Anderson, Sheffield	5,660
W. Mackie	8,880
Laing, Wharton and Down	12,100

(2) *For the supply of boilers, &c.:*

Yates and Thom, Blackburn	£2,436
J. Watt and Co.	2,450
Babcock and Wilcox (Limited)	2,554
Maudslay, Sons and Field (Limited)	2,765
Spurr, Inman and Co. (Limited), Wakefield	3,375
Davey, Paxman and Co., Colchester (informal)	1,403

(Remainder of London.)

(3) *For the erection of generating station buildings:*

Foster and Dicksee (London)	£5,562

The consideration of the contracts has been deferred until next spring.

APPOINTMENTS.—The Electric Lighting Committee of the Hampstead Vestry have finally considered the question of the appointment of chief electrical engineer to the vestry, for which six of the candidates had been selected as being eligible. Eventually Mr. R. A. Chattock received the appointment. The salary commences at £200 per annum. Mr. Chattock is a young man with considerable experience. He has been superintending engineer at the Amberley-road Station of the Metropolitan Electric Supply Company since 1892, and was senior Gilchrist scholar at University College, London.

——— Mr. A. Grundy, late Manager and Director of Baily and Grundy, London (Limited), has been appointed electrical engineer to the Battersea Polytechnic Institute.

BANKRUPTCIES.—At a recent sitting of the London Bankruptcy Court, Arthur French St. George, of Marine-street, Bermondsey, applied to pass his examination upon accounts showing a total liability of £1,033, with a deficiency of £529. The bankrupt had previously failed in 1883 and again in 1886, and since the latter failure had been occupied in perfecting and patenting inventions. The examination was ordered to be concluded.

——— Alan Kirk, electrical engineer, was, at a recent sitting of the London Bankruptcy Court, allowed to pass his public examination on accounts showing liabilities of £328, and assets £3. The bankrupt commenced business in July, 1892, on money advanced by his father to purchase a third share in the business of medical electricians, carried on under the style of the Electro-Medical Apparatus Company, at St. Martin's-lane, London, W.C., the bankrupt's partner being Mr. H. Newman Lawrence. The business failed, and the bankrupt has since travelled for an electrical firm on commission. The examination was concluded.

OBITUARY.—The death is announced of Sir George R. Prescott, Bart., Chairman of Callender's Bitumen Telegraph and Waterproof Company, and Director of the Chelsea Electricity Supply Company.

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SALE OF MACHINE TOOLS, &c.—Messrs. Wheatley Kirk announce that they have for disposal lathes, screwing, punching and shearing machines, tools, &c., for which offers are required for a prompt sale to close an estate.

PRESENTATIONS.—A few personal friends of Mr. J. Rance, jun., presented him on Monday last with a pair of binocular glasses and a pocket compass, prior to his departure to the Transvaal for Messrs. Johnson and Phillips, to erect a transmission plant for the Sheba Gold Mining Company.——On Thursday evening, last week, the staff of the Birmingham district of the National Telephone Company presented Miss Bailey, late chief operator, with a testimonial and address on the occasion of her leaving the service to be married. Miss Bailey was the first telephone operator in the district, and has been chief for more than 14 years.

THE BEAUMONT-WALLINGTON HIGH-SPEED STEAM ENGINE.—The demand for highly efficient high-speed, vertical, enclosed steam engines for electric supply stations has stimulated inventors, and has led to the introduction of a class of engine little known before the days of electric lighting. The latest of these new engines is the "Beaumont-Wallington" engine. This engine is constructed with from one to three cranks, and is arranged for simple, compound, or triple expansion, the cylinders in the two latter cases being arranged tandem fashion. The crank case is completely enclosed when the engine is working, but may be readily opened out for repairs or inspection of the interior. The steam acts only on the down stroke, and the pistons are balanced. The steam distribution is effected by a central piston valve, and is regulated by automatically varying the point of cut-off. A new and ingenious form of radial gear has been introduced for the purpose of controlling the action of the valve. An indicator diagram taken from one of these engines shows several good points in the distribution, among which full admission, quick cut-off, and free exhaust may be mentioned.

HOLIDAYS.—The Automatic Standard Screw Company give notice that their works at Halifax will be closed from the 18th to the 25th inst. inclusive.

BANK HOLIDAY POSTAL ARRANGEMENTS.—Circulars can be obtained at the principal post-offices throughout the country, giving particulars of the postal arrangements for the Bank Holiday. Special arrangements have been made with regard to express letters, and parcels for special delivery.

OUTING.—The technical staff and officials of the Electric Construction Company (Limited), of Wolverhampton, held their annual picnic at Enville on Saturday last, and by the courtesy of Countess Stamford were enabled to view the beautiful gardens on the estate.

ABERDEEN.—The Gas and Watching Committees of the Town Council are anxious to arrive at a new understanding in regard to the cost of street lighting; but the consideration of the proposal discussed at the last meeting of the committees has been postponed pending the presentation of the first year's accounts.

AFGHANISTAN.—It is stated that the present Ameer is a man imbued with progressive ideas, and that he has recently decided to introduce the electric light into Cabul. Mr. R. Jamieson Browne, electrician to the British India Steam Navigation Company at Calcutta, has just been instructed to proceed to Cabul to fit up the installation there.

BACUP.—Mr. J. N. Shoolbred, electric lighting engineer to the Borough of Bradford, has sent in a report to the Bacup Town Council giving the results of the past five years' working of the electric light supplied by the Bradford Corporation.

BATH.—The application to the Board of Trade for a Provisional Order made by the Bath Electric Lighting Company is, we understand, to be opposed by the Urban Sanitary Authority on the recommendation of their Lighting Committee. As matters at present stand, the Municipality can purchase the Company's undertaking by valuation or arbitration in four years' time, but if the Order now applied for is granted the Company will continue in possession for 21 years. It is pointed out that the Corporation are in a favourable position for obtaining motive power from the water wheels at Bathwick, and are, therefore, in a position to deal, under favourable conditions with the electric lighting question.

BIRMINGHAM.—It is proposed to make considerable extensions at the Scarlet Fever Hospital in this city, and, from a report of the Health Committee of the City Council, it would appear that a large sum is to be spent upon electric lighting at the hospital at Winson Green. The work to be done is to include a telephone installation, lighting throughout by electricity, and the provision of electric bells. The total amount to be spent on the extension is £35,900.

BRIDLINGTON.—The North Cliff has just been lighted for the first time by electricity, arc lamps being used. The lighting extends from the north end of Prince's Parade to Trinity Cut. The result has been that the promenade has become exceedingly popular in the evenings. The plant used is the same as that in use for lighting the Prince's Parade, where there is still some reserve power for future small extensions.

BRISTOL.—The Electrical Committee of the Corporation are so far satisfied with the replies to the circulars recently issued in reference to the extending of the electric lighting mains to Clifton and Tyndall's Park that they have unanimously decided to extend the mains to Clifton forthwith. The local gas company has reduced the price of gas from 2s. 10d. to 2s. 8d. per 1,000 (a saving of £12,000 per annum to consumers), and has carried forward £10,000.

CHURCH LIGHTING.—The parish church of Leeds is undergoing alteration and redecoration, and is to be lighted throughout by electricity.

DENBIGH.—The Town Council of Denbigh discussed at their last meeting the singular proposal to enter into a contract with the local gas company for the supply of gas to the public lamps for a period of five years. There is, of course, nothing remarkable in such a proposal from the gas company's point of view; but that such a scheme should be seriously discussed in face of the fact of the almost general use of the electric light by municipal bodies is noteworthy. After discussion the question was referred back to the Lighting Committee for further consideration, with an instruction from the Council to consider the best steps to be taken to secure the early introduction of the electric light into the town. One member proposed that the Council should offer a prize for the best scheme for lighting Denbigh by electricity. North Wales was favourably situated in regard to water power, and in the near future every town in North Wales would be lighted electrically.

DERBY.—The Electric Lighting Committee of the Town Council have ordered 40 new motors at a cost of about £300, and extensions of the electric lighting mains have been ordered in several additional diitricts. The Committee report that the electric lighting exhibition in May last was well patronised by the public, and that the cost to the Corporation was less than was at first anticipated. Leaving out the item of current (£45) the expenses were £76. 17s. 11d.——At the County Police Court three lads were summoned for maliciously injuring telephone wires belonging to the National Telephone Company at Breadsall. Mr. W. A. Baxter, the local manager of the Company, said that in a section of 12 miles £50 had recently been spent in repairs owing to this malicious damage. Fines of 5s. and costs were inflicted.

DUNOON.—In times past the Dunoon Town Council were satisfied with a display of gas lighting in the handsome Castle gardens under their management, but this season the Roads Committee have obtained the sanction of the Council to illuminate the gardens by electricity; and last week, in the presence of more than 3,000 spectators, the formal ceremony of turning on the light was made the occasion of a popular demonstration. Dunoon is the first Scottish watering-place to instal the electric light, and from the satisfaction given by the contractors for the work, Messrs. Walter Dixon and Co., of Glasgow, it is likely that other places of popular resort in Scotland will speedily adopt the electric light. So popular was the demonstration at Dunoon that excursion trains were run on Saturday last to carry spectators to the second illumination of the gardens.

EDINBURGH.—The terms of the proposed new lease and the scheme for the proper working of the Edinburgh tramways were under consideration at the last meeting of the Tramway Committee of the Corporation. Various suggestions were made with the view of providing a working arrangement between the lessees, Messrs. Dick, Kerr and Co. and the Edinburgh Tramways Company, and it was stated that unless the terms were agreed upon an appeal will be made to the Board of Trade to settle the points in dispute. The matter is to come up again at the next meeting of the City Council on the 28th inst. The lease now held by the Company expires in December next.

ELECTRIC LIGHTING AT THE EAST AND WEST INDIA DOCKS.—At the general meeting of the proprietors of the East and West India Docks Company, Mr. J. H. Todd, the Chairman, in the course of his remarks, said that the Company had spent nearly £12,000 in their electric light installation at the Albert Docks, and that this outlay had proved of a very satisfactory and remunerative character, the saving during the past six months reaching the large sum of £1,000. The set of electric travellers at the wood wharf had also resulted in great economy, and it was the Directors' intention to introduce more of these travellers at an early date. New boilers and engines have been put in at the Victoria Docks, with a result favourable to economy and efficiency.

EMBEZZLEMENT.—George Wilson, 29, clerk, was charged at Marlborough Police Court, before Mr. Hannay, with having embezzled sums amounting to £10, which he had received from Messrs. Nelson Dadge and Co., of Cecil-court, Charing Cross-road, on behalf of his employers, the Electrical Accessories Company, of Charing Cross-road, London, W.C. Mr. Nelson Dadge said his firm was a customer of the plaintiff Company. On May 31st he paid the prisoner 15s. 4d., and received the receipt produced. On June 25th last he also paid the prisoner £3. 13s. 8d., and received

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a receipt. Mr. C. L. Schwind, Managing Director of the Electrical Accessories Company, said the firm had the books overhauled by an accountant, who had found a number of fictitious entries. On the 16th inst. the prisoner was taxed with the irregularities in the books, and acknowledged that he had appropriated the money to his own use, and agreed to make out a statement of his defalcations, which he said amounted to £16. 16s. 10d.; but further amounts of something like £80 had since been discovered. Mr. Hannay remanded the prisoner till Wednesday, when he was sentenced to six months' hard labour.

FAREHAM.—It is stated that the petition presented to the Board of Trade against the purchase by the Local Board of the undertaking of the Fareham Electric Light Company received 429 signatures, representing about one-third of the rateable value of the parish to the general district rate.

GAS MANAGERS' ASSOCIATION.—The thirty-third annual general meeting of the members of the North British Association of Gas Managers was held at Glasgow last week under the presidency of Mr. James M'Gilchrist, who, in his inaugural address, after pointing out the necessity for the gas companies keeping the price of gas at as low a figure as possible, made some references to the electric light. He said that since he last addressed them, in 1881, electric lighting had had a good trial, and were it not for its high cost it would become popular. It was, however, still the rich man's light, and, he feared, could never be anything else. Many and great improvements must be made in electrical plant before electricity could be taken seriously as a rival to gas in point of expense. The Corporation of Glasgow had spent thousands of pounds experimenting on electric street lighting, and only a few pounds experimenting with the Welsbach system of lighting by gas. Gas was being applied to new purposes every month of the year, and the consumption for purposes other than lighting continued to increase. Among the latest successful applications of the gas engine in this country was the Traction Syndicate's system of propelling street tramcars at Glasgow. The car was propelled by an 8-H.P. gas engine of the Otto type, and when charged would run for eight miles, taking heavy gradients and sharp curves with ease. The cost per mile for gas was about 1d. Horse haulage, on the other hand, was said to cost 6d. per car mile. Should the Glasgow Corporation prove these figures correct, an enormous saving would result when they propelled their cars with gas of their own manufacture.

GEELONG (VICTORIA).—As stated in our issue of the 13th ult., electric lighting matters are progressing in this district. The offer of the Crompton Electric Supply Company, of Australia, to give a complete installation for the district for the sum of £15,150, which offer was recommended for acceptance by the representatives of the Geelong Town Council and the Newton and Chilwell and Geelong West Borough Councils, has been adopted, and it now only remains for the districts concerned to give effect to the resolution.

HAMPSTEAD (LONDON, N.W.)—The Electric Lighting Committee of the Vestry have decided to purchase 50 meters, ranging from 5 to 80 amperes, at a cost of £265. 5s. Application is to be made to the London County Council to advance to the Vestry £24,400 for electric lighting purposes. An offer from Lloyd's Bank to advance money for two years at 3¼ per cent., was discussed, and the subject was adjourned to the next meeting of the Vestry in October.

HARROW.—Mr. R. E. H. Fisher, Clerk to the Harrow Local Board, sends us the following :—"Will you kindly correct a somewhat misleading statement in your issue of July 27th, where you say it was suggested to call in the services of Prof. Kennedy at a fee of 100 guineas. There is no proposition before the Board to that effect. Prof. Kennedy's name came to be mentioned in the following manner : One of the ratepayers at the meeting to which you refer had suggested that a second opinion might be taken, and one of the members of the Board asked at the meeting of the Board what Prof. Kennedy's fee would be. The Electric Lighting Committee did not report, but will probably do so at the meeting to be held on August 9th."

HOLYWELL (FLINTSHIRE).—The *County Herald*, in a recent issue, refers to the progress of electric lighting in North Wales, and to the necessity for its introduction into Flint. The occasion for its remarks was the sale of shares in the local gas company at Flint last week, where it was stated that "it was all nonsense to talk about electric light for the town ; gas was largely used for cooking, and for that purpose, as well as for lighting, there was nothing better. The electric lighting in parts of London had been discontinued." The *County Herald* thinks that the Cimmerian darkness of Flint at night will never be dispelled till electricity takes the place of gas.

HUDDERSFIELD.—The extensive installation of the electric light on the premises of the Huddersfield Industrial Society, was formally opened last week. Fourteen 2,000-c.p. arcs are used for outside lighting, and 34 1,500-c.p. arcs, and 270 16-c.p. incandescents for the interior. The generating plant consists of a tandem high-pressure compound engine by Messrs. T. Broadbent and Sons, Crompton dynamos, Babcock-Wilcox boilers, rope driven. The electrical work has been carried out by Mr. J. A. Edmondson.

KINGSTON-ON-THAMES.—By a clerical error in our last issue, the festivities in connection with the regatta held here were credited to Kingstown (Ireland). Messrs. New and Mayne inform us that the work carried out on the façade of the Town Hall building, which was brilliantly illuminated on the 25th inst., was done by them, and the illumination was repeated on the following Saturday evening at the request of the members of the Kingston-on-Thames Corporation.

LANCASTER. — The Electric Supply Committee of the Town Council have considered the question of keeping a stock of electric ovens and other cooking utensils for sale or letting out on hire. As a sign of the times this is distinctly interesting. Notwithstanding the fact that the Committee resolved not to entertain the suggestion for the present, a demonstration in cookery is to be held at the Storey Institute by Messrs. Crompton and Co., who are to provide all the apparatus, the Committee providing the room for holding the demonstration, the current, and the services of the electrical engineer. The price to be charged for current for cooking purposes is fixed at 7d. per unit. The committee, in their report, announce that they have resolved to obtain tenders for arc lamps for street lighting, and, having considered an application from Mr. A. S. Barnard, the electrical engineer, for an increase of salary, have made an increase from £120 to £156 per annum. The committee's report was adopted.

LEIPZIG.—It is stated that the Allgemeine Electricitäts Gesellschaft, of Berlin, has secured a contract for the construction of about 35 kilometres of electric tramway at Leipzig.

LIVERPOOL.—At the last meeting of the Mersey Docks and Harbour Board the Warehouse Committee recommended the establishment of a system of electric lighting at the Albert Dock warehouses, at an estimated cost of £2,850. Mr. R. Gladstone, in supporting the Committee's recommendation, said that for some time past they had been considering various methods by which the warehouses might be made more efficient and more productive of revenue. As a result of their considerations they unanimously recommended that electric lighting be adopted on all the floors except the vaults, one of the advantages claimed for the electric light being that the risk of fire was considerably minimised, and that work could be done on dark days and at night much more readily than now, when gas was used, and would generally permit of better work being done than was otherwise the case. The matter is to be again discussed at the next meeting of the Board.

MILL LIGHTING.—Crosse Hall Mill, Chorley, is being lighted throughout by electricity by Messrs. Bennett and Druce. The plant consists of a 12-kilowatt machine driven off the main mill engine. About 200 incandescents are distributed over the spinning department.

NEWCASTLE-ON-TYNE.—The dispute between the Corporation and the local gas company as to the liability of the Corporation to pay for gas lamps which, although not lighted, are not removed, came up for discussion at the last meeting of the Watch Committee, when it was stated that, having taken counsel's opinion on the subject, they had come to the conclusion that the Corporation were liable if they only extinguished, but did not remove the lamps. Another conference is to be held before a final decision is come to. The dispute is that, where the Corporation have discontinued the use of gas lamps in the immediate neighbourhood of electric lamps, the gas company insist upon the usual charge being paid for the gas lamps, and insist that they have legal powers to compel payment.

NEW GENERAL POST-OFFICE BUILDINGS (LONDON).—The extensive range of new buildings at St. Martin's-le-Grand is, during the current year, to be ready for the transfer of several of the telegraph departments. The clearing house, telegraph accounts, and telegraph message branches will be situated in the new block of buildings, which will provide accommodation for about 1,500 persons. The department's electrical staff is now engaged in fitting up the whole building for the electric light.

NORTHERN SOCIETY OF ELECTRICAL ENGINEERS.—A party of members of this Society have visited Belgium, and in addition to the exhibition have had an opportunity of visiting the central station of the Compagnie Hydro-Electrique Anversoise in the Rue du Chantier, and at Brussels were shown over the interesting central station in that city.

PENRITH.—Messrs. Hetherington and Co. have introduced the electric light into their new premises in the Corn Market, the work having been entrusted to Messrs. Dennison, Parmiter and Barber. The installation consists of 106 incandescents and four 1,500-c.p. arcs. The result of a preliminary trial has proved very satisfactory.

PRINTING BY ELECTRICITY.—The printing machines used in the production of the *Oxford Times* are now successfully driven by

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electricity from the mains of the Oxford Electric Lighting Company. The editor of the journal points with satisfaction to the results obtained, and states that electric power is preferable to gas or steam. In the machine room of the printing office it is very necessary that the power should be steady, quiet, and easily controlled, and, so far, this result appears to have been obtained wherever electric power has been used for driving printing machines.

PROVISIONAL ORDERS.—The Order promoted by the Harrow Local Board for power to supply current in the district has passed both Houses of Parliament.

REDFERN (N.S.W.).—During a discussion which took place in the Redfern City Council as to the cost of electric lamps, it was pointed out that many varying prices had been given for these lamps, and the Mayor, who was authorised at the meeting to purchase 2,500 lamps for street lighting at a cost not exceeding 5s. per lamp, was asked to communicate with the manufacturers in England to ascertain on what terms a regular supply could be secured. The Council has in the past paid as much as 8s. per lamp.

SHOREDITCH (LONDON).—The London County Council have agreed to loan the Vestry of Shoreditch the sum of £12,200 for the purchase of the site of a dust destructor and electric lighting station.

ST. HELEN'S.—The Corporation have appointed Mr. Robert Hammond to draw up a report and submit estimate of cost in connection with their electric lighting scheme.

SUNDERLAND.—The Corporation have decided to fix the price to be charged to consumers of electric current at 6d. per unit.

SUTTON (SURREY).—The Provisional Order obtained by the Local Board expires in June next, and the Clerk was instructed at the last meeting to communicate with the Board of Trade in order that sanction should not be given to any company or individual in the promotion of any scheme for lighting the town by electricity without first obtaining the sanction of the Local Board.

THEATRE LIGHTING.—Mr. Wilson Barrett has introduced the electric light at the Royal Court Theatre, Wigan, where the auditorium, which has been redecorated and reventilated, is to be installed throughout with the electric light.

TOWN AND COUNTRY HOUSE LIGHTING.—Eastwell Park has been taken by Lord Rosebery as a Kentish residence. Extensive alterations and improvements are being effected at the mansion, and the electric light is to be installed throughout.——Fawley Court, Henley-on-Thames, the residence of Mr. W. D. Mackenzie, and also the town residence of the same gentleman at 35, Park-street, W., is being fitted for the electric light by Messrs. Rashleigh Phipps and Co., as is also the town house of Mr. Anderson Critchett, the celebrated oculist, in Harley-street, W.

TUNBRIDGE WELLS.—The Local Government Board have given their sanction to the Town Council for borrowing £13,000 for electric lighting purposes, to be repaid in 25 years.

WEST HAM.—The Provisional Order obtained by the Town Council expires this year, and, on the application of the Council, the Board of Trade have agreed to consider the Order as in force for a further period of twelve months, at the same time intimating that the Board has no power to extend the time of the Order.

WEST HARTLEPOOL.—Mr. J. W. Brown, borough engineer and surveyor, has just issued his report for the year ended March 25th last. Amongst the points dealt with in the report is the sanction given by the Town Council to the local tramway company for running the tramcars by electricity on the overhead system, and the obtaining of a Provisional Order for supplying the district with electric light and power by the Corporation.

WHITECHAPEL.—A special meeting of the Lighting Committee of the Board of Works has been held this week for the purpose of considering a report regarding the lighting of the district by electricity.

WINCHESTER.—The General Purposes Joint Committee of the Town Council have, after a long discussion, decided to recommend the Council to apply for a Provisional Order to light the city by electricity. Application will also be made to the Local Government Board for power to borrow about £20,000 for the purposes of the electric lighting scheme.

WOKING.—Messrs. New and Mayne have secured the contract for lighting the streets of Woking by electricity. 25-c.p. incandescents are to be used, the first instalment consisting of 48 single-light and 13 double-light posts.

WOLVERHAMPTON.—Mr. F. Harman Lewis, borough electrical engineer, has issued a circular dealing with the advantages of electric light over gas, and calling attention to the fact that the central electric lighting station will be completed and in working order in September. The circular points out that the electric light is healthier, cooler, safer, and cleaner than any other artificial light, and when used judiciously, and with all advantages taken into account, is as cheap as gas. The Corporation charge for electric energy is fixed at 6d. per unit.

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

July 21, 1894.

14,069. CARL S. ENGLISH. London. Improvements in electrical governors for water-wheels. (Date applied for under Patents, &c., Act., 1883, Sec. 103, December 23, 1893, being date of application in U.S.A.)*

14,080. GEORGE FREDERICK REDFERN. London. Improvements in incandescent electric lamps. (Carl Schwabe, Germany.)

July 23, 1894.

14,113. ALFRED GEORGE COOPER. Lewisham. Improvements in electric energy and power-recording meters.

14,123. WILLIAM PAUL THEERMAN and G. C. ELLIOTT. Manchester. Improved method of fixing electric bells and telepones.

14,156. O. W. KETCHUM. London. Improvements in or connected with electric waggons.

July 24, 1894.

14,202. H. D. FITZ-PATRICK. Glasgow. Improvements in signalling by electric lamps.

14,240. WALTER WILKE. London. A new or improved electrical apparatus for calling or waking persons in different rooms at different determined times.*

14,246. CHAS. F. SCOTT. London. An improved system of electrical distribution by alternating currents. (Date applied for under Patents, &c., Act., 1883, Sec. 103, February 26th, 1894, being date of application in U.S.A.)

July 25, 1894.

14,290. G. BINSWANGER. London. Improvements in electrical lamp-holders and similar electrical fittings.*

14,303. CARL RAAB. Liverpool. An improved electricity motor meter.

14,312. JAMES THORNHILL ASHTON. London. Improvements in automatic switch devices for electric currents.

14,320. G. A. KINGDON. London. Improvements in dynamo electric machines and electromotors.

14,327. A. F. B. GOMESS. London. Improvements in the manufacture of aluminium and aluminium alloys, and the electro-deposition of the same.

July 26, 1894.

14,340. H. C. RISBOROUGH SHARMAN. Merton. An improved electro-massage roller appliance.

14,371. G. R. NEILSON and A. C. BROWN. London. Improvements in fire-alarm telegraphs.

14,394. H. G. DALE. London. Improvements in induction coil apparatus for electro-medical and other purposes.

July 27, 1894.

14,445. JAMES Y. JOHNSON. London. Improvements in or connected with electric railways and vehicles. (Malone Wheless, U.S.A.)*

14,455. E. TEMPLETON and H. P. SCHISCHKAR. London. An improvement in lightship connections for submarine cables.

14,488. J. JEFFREY and J. LEA. London. Improvements in or connected with electric arc lamps.

July 28, 1894.

14,492. A. G. ADAMSON. Glasgow. Improvements in the chamber or reflector for carrying the lamps used in photography by electric light.

14,493. A. G. ADAMSON. Glasgow. Improvements in apparatus for the use of electric light for photographic purposes.

14,509. H. V. KEESON. London. Improvements in electric current regulators.

14,511. R. HARTLEY and G. B. COCKS. Rochdale. An improvement in electric stop motion drawing frames.

14,518. A. WHALLEY. Helsby. Improvements in telephone switchboard apparatus.

14,533. J. A. FLEMING. London. Improvements in apparatus for transforming electric currents.

14,536. CHARLES F. PARKINSON and W. GATWOOD. Manchester. Improvements in apparatus for heating and welding by electricity.

14,545. THOMAS PARKER (LIMITED) and THOMAS PARKER. London. Improvements in the construction of dynamo-electric machines and electromotors.

14,546. SALLY DAVID. London. Electric contact by weight.

14,551. DAVID YOUNG. London. Improvements relating to the transmission of signals through submarine cables and other telegraph and telephone lines and to apparatus therefor. (John Mabry McMahon, U.S.A.)

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SPECIFICATIONS PUBLISHED.

NOTE.—All Specifications can now be obtained at the uniform price of 8d. each.

1893.

12,971. DAHL. Alternating current motors.
13,111. PEASE. Dynamos and electric motors.
13,133. MCLEAN. Electromagnetic switch.
14,664. KINGDON. Electromotors.
14,953. SHARP. Incandescent electric lamps.
16,017. GIBBS, H. W. and G. J. Electrically-actuated machine tools.
16,597. GEUTZSCH. Inspissated oil for electrical insulating purposes.
16,857. GEUTZSCH. Electrical insulating material.
17,310. SIEMENS BROS. AND CO., LIMITED (Siemens and Halske). Electric railways.

1894.

367. LONGSDORE (Hewett). Galvanic batteries
8,638. PITT (Blondel and others). Dynamo-electric machines.
9,215. DAVIS. Circuit control for electric machines.
10,186. NASHOLD. Cleats for electric wires.
10,590. EDISON and SWAN (United Electric Light Company, Limited, and Proctor). Switch and holder for electric glow lamps.
10,594. FRANK. Telephones.
10,660. GOLBZ (Neumann). Incandescent electric lamps.
10,853. JOHNSON (Société l'Accumulateur Fulmen). Electric accumulators.

COMPANIES' MEETINGS AND REPORTS.

Anglo-American Telegraph Company (Limited).

The ordinary general half-yearly meeting of the proprietors of this Company was held at the City Terminus Hotel, Cannon-street, on the 27th ult., under the presidency of the Most Hon. the Marquis of Tweeddale.

The SECRETARY (Mr. T. H. Wells) read the notice convening the meeting and the minutes of the last meeting. The report of the Directors was taken as read.

The CHAIRMAN: Gentlemen, the traffic receipts have proved extremely disappointing. They amounted for the past half-year to £130,094, showing a decrease of £16,791. Although very disappointing, I cannot suppose that this decrease has surprised any one who has any knowledge of the condition of commerce both in this country and the United States. That an improvement, sooner or later, may be hoped for and expected is, no doubt, the case, but so long as the tariff question in the United States remains unsettled, there is little or no prospect of any change. When, however, that matter is settled, we may look forward to a very substantial increase in our traffic receipts. The steamship "Minia" has happily come to our rescue financially, and earned £4,050 more than was earned this time last year; and again, our expenses have been reduced in a very substantial manner, the saving amounting to no less than £4,466. The principal items of this reduction are salaries and wages, which are £1,721 less, and in maintenance of our lines there has been a saving of £1,123. I hope the shareholders will observe that we have endeavoured to fulfil our promise to reduce expenses as far as possible, while at the same time maintaining the efficiency of our system. The net result is that after placing £12,000 to reserve we are able to recommend a dividend on the Ordinary Stock for the second quarter of the half-year of 10s. per cent. and of 1 per cent. on the Preferred Stock, carrying forward £1,173, or £670 more than last year. The condition of the cables is naturally a matter of great importance, and I am happy to be able to inform you that the 1874 cable has been repaired at last. You will remember that last year, owing to the extraordinary prevalence of bad weather the whole time the Telegraph Construction Company's ship was on the spot, we were unable to effect the repair; but this year Capt. Trott has accomplished the task most successfully. You all know that he is one of the most efficient telegraph captains in any service, and I am sure you will all congratulate him on the success of his efforts in restoring the 1874 cable. I am also happy to be able to add that our new cable has been laid successfully by the Telegraph Construction Company. The last splice was made a very short time ago—I believe within a few minutes; but, at any rate, it has been laid, and with the usual skill and success of the Telegraph Construction Company. The other two cables are in good working order, so that we have four cables across the Atlantic now in first-class order, and they are all duplexed. The fifth cable—the French cable—we have not attempted to repair this year. Having regard to the advanced state of the season, and the time the "Minia" would take in going out, I do not think there is any probability of that repair being undertaken this year. The expenses of the new cable and of the repair of the 1874 cable have made serious inroads into our renewal fund. The repairs last half-year cost £26,000, and this half-year they will cost about £20,000 more. The fund will, therefore, be reduced to a figure of something like £530,000. I need hardly repeat what I said at the last meeting, that the amount we propose to set apart to this fund—£12,000 each half-year and the interest of the fund—is a minimum figure. We should be only too glad to be able to add a larger sum, but in view of the fact that our cables are in such good order, and that we have a new one, which may be justly considered, for a few years at least, as part of our reserve, we believe that we shall be able to go on with that small sum added to our reserve—at any rate, for some time. We have just received a telegram from Valentia stating in regard to the new cable that the signallings are good. No doubt you have heard with considerable interest that judgment has at length been given in our favour in the proceedings with regard to the Pouyer-Quertier cable. The judgment proves, at any rate, that our contention was a correct one, that the French Company committed a serious breach of their agreement. So far that is established. Whether the result of that decision will be attended with any great financial benefit to the pool companies is doubtful, but it would be impossible to express an opinion as to what view the experts, who were to assess the damages, will take, and I shall not hazard one. We, however, strongly object to that part of the decision which limits the period of damages from December, 1886, to May, 1891, and we are considering whether it would not be wise and proper to appeal with respect to that part of the judgment. The opinion of the most eminent counsel in Paris is being taken at this moment, and upon their recommendation will depend the action of the pool companies. Gentlemen, I have no doubt that you have heard with some dismay of the possibility of one or two more cables being laid in the Atlantic. One is said to be contemplated by the French people and the other by the German Government. As I have often pointed out, the Atlantic is free to anyone, and there is no security against fresh cables being laid if only people are willing to subscribe sufficient money to lay them. So far as the French intentions are concerned we have no information whatever of a reliable character, but the case is different with respect to Germany, because we have reason to believe that the German Government does contemplate giving a concession for a new cable from Germany to America. It is not surprising either that the French people or the German Government should desire to have greater facilities than they possess at present; and, therefore, we need not wonder if the French people should at some time or other lay another cable, or if Germany should give a concession for a second means of communication with the United States. I believe the concession contains a subsidy—a grant of money to the concessionaire, and I believe that a cable may be expected to be laid, but certainly not sooner than 1897 or, probably, 1900, so we have a considerable time yet before any cable of that kind will be put down. As far as I aware, no concession has yet been granted. I said it was contemplated, and that is all I know about it in that respect. I think, however, you will agree with me that if a concession is granted by the German Government we may hope that it will fall into the hands of friends rather than of enemies—in the hands of those who, having large interests in the pool companies, both directly and indirectly, have strong inducements to deal more tenderly and in a more friendly spirit with any new company formed for the purpose of carrying out this cable than would be the case if the concession fell into the hands of enemies—that is to say, of hostile competitors. I do not think I need trouble you with many other remarks. There is, perhaps, one item in the general balance-sheet which requires explanation. Under the head of sundry creditors you will observe that there is a figure of £65,000 more entered than in the year 1893. This is due to the fact that £60,000 is owing to the Telegraph Construction Company for cable purchased for stock, repairs, &c. With your permission I now beg to propose—

"*That the report of the Directors and accompanying statement of accounts to June 30th, 1894, submitted to this meeting, be, and the same are hereby, received and adopted.*"

The DEPUTY CHAIRMAN (Mr. Francis A. Bevan) seconded the motion.

The CHAIRMAN expressed his readiness to hear any remarks that any shareholders might wish to make.

Mr. GOODSALL inquired what amount of cable was expended by the steamship "Minia" in effecting the last repair, and was it all used?

The CHAIRMAN: About 220 miles, and it was all used.

Mr. GOODSALL asked whether the condition of the 1874 cable had been reported. As far as he could make out, it had unfortunately been laid with too little slack.

The CHAIRMAN: I shall be in a position to give a much more satisfactory answer to that question when we get our information from Captain Trott; but I believe the cable is in very fair condition. He then put the resolution, and declared it carried unanimously. He added that that closed the business of the meeting, and he only hoped that they would have a better report to submit on another occasion.

Mr. JOHN NEWTON proposed a vote of thanks to the Chairman and Directors, remarking that their labours of late had undoubtedly been more arduous than at any previous time.

The motion was seconded and agreed to.

The CHAIRMAN, in returning thanks, assured them that the Directors were doing their best in the proprietors' interests, and very considerable labour was thus involved.

The meeting then separated.

Chili Telephone Company (Limited).

The annual general meeting of this Company was held yesterday at Winchester House, Mr. Thomas Greenwood (Chairman) presiding.

The SECRETARY (Mr. Edmund Petley) read the notice convening the meeting.

The CHAIRMAN: Gentlemen, I apprehend you will not deem it to be a profitable occupation of your time to take a discursive view of the accounts and report. If I may take that for granted, and if any shareholder requiring further information will be good enough to put his question, I will, without any detailed comment on the report and accounts, ask you to adopt them. But I think it may be agreeable to you that I should say a word or two about the position and prospects of the Company. There can be no doubt that the year, through which we have

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lately passed, has been the worst that the Company has seen, and I think I may fairly add it is the worst the Company is likely to see. There are three things requisite for the complete success of the undertaking. The first is doubtful, the second is probable, and the third cannot be estimated, being beyond the control of the Board. The first is as to the working expenses. It is only fair to say, on behalf of the officers on the other side and the Board, that from the outset every effort has been made to bring them down to as low a figure as possible. Every movement in that direction, however, has been practically cancelled by the reduction in the value of the dollar, so that, while endeavouring to save money in this direction, expenses which have been imperative have grown in amount, because, the salaries being payable in gold on the other side, we have to give away a greater number of dollars for the same services than we did when the dollar was worth more. At the same time it is not impossible that some further reduction will be made. The Board has a scheme before it with a view of making a part of the remuneration of our officers dependent upon the profits. That is a very desirable thing to do in any circumstances, and the effect of it will be that in bad times we shall have to pay less, while in good times we shall have, of course, to pay more. I think you will appreciate our object, and, I may add, that when we come to deal with the matter we shall do so in a generous spirit towards those on the other side, having due regard to the interest of the shareholders. The second point, which is probable, is the increase of our receipts. The Company have waited for years for a cash dividend, and had hoped for a rise in the exchange. Unfortunately, instead of rising, it had gone lower and lower year after year until it had touched the low figure of 10½d. per dollar. The Board, in these circumstances, had felt it necessary to increase the rates to their subscribers. We were very anxious to avoid doing so as long as possible. While our instructions were on the way to the other side the Manager there appeared to have taken the same view as ourselves, as he appeared to have issued a circular to the subscribers to the same effect practically as our own. There is no doubt that an increase of traffic may be expected, although the number of subscribers may be diminished, and I am pleased to see that during the three months which have elapsed since March 31st we have had an increase every month from our subscribers. In the first month, April, the receipts showed an increase of $1,153, in May $2,600, and in June $5,555, so that our income to the end of June was $515,000, against $505,000 to March 31st. The third item I wish to speak upon is the rate of exchange. I hold in my hand a diagram which has been sent over by the General Manager. It is a most interesting one, and there are in the centre 47 columns, representing the months of the years during which the Company has been in existence. On one side we have in a black line, starting at the left-hand corner, at the bottom, the revenue of the Company, gradually rising from $225,357 to $505,866. On the other hand the rate of exchange is depicted in a red line, commencing at the top left-hand column and ending at the bottom right-hand column, showing that we had for our dollars 26d. at the commencement of our working and that we left off at 13d., or just about half. That in itself is a complete explanation of how it is we have been so long without a dividend. At the same time I think there is a fair prospect of an improvement. You may ask what ground there is for that hope. The most knowing gentlemen we have connected with financial matters in the City have been wrong again and again, and it appears to be a difficult thing for anyone to come to a right conclusion. However, there are straws which show the way the wind is blowing. We find from the reports lately published by the Government of Chili that their position is very much better than it was, and that the amount of sterling money they have in hand ready for the redemption of currency amounts to millions. Our last advices from the other side were to the effect that the new Congress, which commenced its sittings on June 1st, had indicated a very large amount of talent, and a determination to work together rather than in a partisan spirit, with the object of doing the best they can for the nation as a whole. If the promises of the Government are fulfilled within two years we shall see our dollars worth 22d.—double what it is now—and if that be so the prospects of the Company will be very greatly improved. Indeed, any one of the three things I have mentioned will make a material difference in the aspect of affairs; but if this particular improvement takes place we may hope at an early date for dividends in cash. I now beg to move—

"*That the report of the Directors, with the statement of accounts to March 31, 1894, now presented to this meeting, be approved and adopted.*"

Hon. F. ERNEST ALLSOPP seconded the resolution, which was passed.

Mr. DEY then proposed—

"*That Mr. Thomas A. Welton be and he is hereby re-elected auditor of the Company.*"

Mr. BONNER seconded, and it was agreed to unanimously.

The CHAIRMAN: You will have noticed, gentlemen, in the report a reference to the retirement of Colonel Jackson. He was seriously ill at the time that it took place, but I am very pleased to say he is very much better now. By absenting himself from London, and residing in a more bracing atmosphere, he hopes to recover a large portion of his former strength. I thought the intelligence would be agreeable to you. The Board were very sorry to lose Colonel Jackson's services. He was a man of large commercial ability, and his knowledge of the telephone business was great. We considered Colonel Jackson an acquisition to the Board, and we regret his resignation very much. We may hope yet to see him again, and, if so, it will be announced in the usual way.

Mr. HENDERSON moved a vote of thanks to the Chairman and the Board, and in doing so said the shareholders felt, he believed, that although the report was not as satisfactory as they could wish, yet he firmly believed the Board had done their very best.

Mr. BAILLIE seconded the motion, which was carried.

The CHAIRMAN having acknowledged the vote of thanks, the proceedings terminated.

City and South London Railway Company.

The half-yearly ordinary general meeting of this Company was held at Winchester House on Wednesday, Mr. Charles Grey Mott presiding.

The SECRETARY (Mr. W. F. Knight) having read the notice convening the meeting,

The CHAIRMAN said: During the past half-year we have carried passengers numbering 236,493 more than in the corresponding period of last year, and our season ticket holders have increased by 49. This considerable increase of passengers has been carried with our usual perfect safety, and almost absolute punctuality. We have been able to get this increase in spite of the fact that during the first three months of the year the Oval remained closed for football matches, which undoubtedly deprived us of a considerable amount of traffic we should otherwise have had. But still, looking at the whole result of the half-year's working, I think you will agree with me that it is a fairly satisfactory one. We have now got this railway, in all its main details, into thorough working order, and of late your Directors have turned their attention to the question of how far they can, in the smaller details, improve the working of the line, so as to make it more convenient and more attractive to the travelling public. With that end in view we have improved very largely the station at King William-street, on the surfaces. Anyone who visits that station now, and compares it with what it was before will see that it presents a very different aspect from what it did in former days. I am happy to think that our expenditure at King William-street station is gradually likely, not only to be remunerative as the consequence of making the line more attractive, but also on account of the left luggage office, and other conveniences we have provided. The left luggage office, I think, will be of great service to our passengers as well as to the general public, because it is open and available to all persons either crossing or travelling in the vicinity of London Bridge. As this fact gets more widely known I believe it will be largely used, and bring us in a considerable revenue. We have also been trying to improve the trains, and we have now a new train on, which runs easier and with less noise, while the carriages themselves are of a much brighter and better description in many ways. As you will observe by the report, we have been considering carefully the question as to whether it would be possible to do away with the existing locomotives by substituting motors on the train itself. This, I may tell you, is the idea we started with originally, but we adopted the separate locomotives in deference to the views of the Board of Trade, and for other special and weighty reasons at the time. We have, however, now got this line into such working order that we think it may be possible to revert to our original intention of putting motors on the carriages instead of having separate locomotives. This would give us the necessary room at King William-street station to add to the trains another coach. Unfortunately we do not yet know whether we shall be able to carry our idea out. We are making experiments, but the difficulties arising from the smallness of the tunnels, and other matters, render it at present somewhat dubious whether the proposal will be practicable. I believe we shall find means of effecting the improvement, and, if so, as I have already remarked, we shall be able to accommodate a larger number of passengers by each train. Turning now to the accounts, you will notice, as regards the capital account, that we have paid off £8,200 of our Five per Cent. Terminable Mortgage Debenture Bonds, and re-issued them as Debenture Stock or Preference shares. We have received on capital account during the half-year £33,100—£2,000 from the issue of Preference shares and £31,100 from Debenture Stock, making in all £33,100. We have received in premiums on shares and debenture stock £2,580, making the total amount received £35,680. Out of this we have paid £21,000 off the loan I told you of at the last meeting; £8,200 have been applied, as I have mentioned, to the paying off of Terminable Mortgage Debenture Bonds; and we have expended on capital account £3,765. We have, further, reduced our general outstanding accounts by £1,440, which accounts for a total of £34,405 out of the £35,680 received. The small balance remaining has gone to increase the balance at our bankers and other accounts. The loan that I spoke of was originally £22,000, of which we have paid £21,000 according to these accounts, but I may add that the remaining £1,000 has been paid since these accounts were made up, so that our liabilities are now discharged, and we are free to consider the future. As regards the revenue account, the receipts from passengers show an increase of £1,106, parcels £16, transfer fees, £7, and sundry receipts £18. There is a decrease in the rents of £12, leaving a net increase of £1,135. On the other side of the account you will find that the expenditure on maintenance of way shows an increase of £110, and the locomotive department an increase of £17. There has been a decrease in carriage repairs of £89, in traffic expenses of £45, in general charges of £19, in passenger duty of £19, in law charges of £38, and in compensation of £17. But there has unfortunately been an increase of £124 in rates and taxes, which leaves us, notwithstanding the various decreases I have mentioned, with a net increase in the expenses of £26, reducing the sum of £1,135 to £1,109. After paying 5 per cent. on the Preference shares it allows us to pay 1 per cent. on the Ordinary stock, and enables us to carry forward £1,335, against £898 last year. The total working expenses for the half-year are now reduced to 61·7, against 64·61 at this time last year. If you take away all the expenses connected with the lifts, which, as I have said on previous occasions, do not properly belong to the working of a railway, it reduces our percentage of working expenses to about 52 per cent., which is lower considerably than that of many of the large railways in England. Of course, that percentage of working expenses I hope to see largely reduced in the future; but it all depends upon the increase of our traffic. It has so far gone steadily down from a very much higher figure. The receipts per train mile have been 2s. 1½d., the same as in the corresponding period of last year, because we have run an

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increased mileage. The receipts per passenger work out at 1·62d., practically the same as last year, when it was 1·61d. The locomotive expenses per train mile have been 6·21d. against 6·48d. at this time last year. Deducting from these figures the cost of the carriage of coal, which is not paid for by other companies, our locomotive expenses are reduced, in comparison with them, to about 5d. per train mile. We have run during the half-year 72,179 trains, which is no inconsiderable number. I think that, as a whole, although our dividend is not as large as we should like to see it, we are making steady, if not very rapid, progress. I am afraid I cannot hold out to you any prospect of more rapid advancement as the line now stands, because, as you know, our appliances are very limited, and until some extension of the line takes place I fear we must be content with a steady and somewhat slow movement upwards; but the Board are doing their best to accelerate that movement with the materials that we possess. With these remarks, I beg to move—

"*That the report and statement of accounts for the half-year ended June 30, 1894, now presented to the meeting, be received and adopted.*"

Mr. SAMPSON HANBURY seconded the motion.

Mr. DRAKE said they were all pleased with the increase, small though it might be, in the dividend. It had unquestionably been demonstrated that electricity as a motive power was a practical thing, which was a great point. It had also been demonstrated that their line was a wonderful convenience to the enormous population of South London, through which it ran. The remaining thing they wanted demonstrated—and he was sure the Board were devoting themselves carefully, vigilantly, and perseveringly to the point—was that the line should also yield a fair return to the shareholders who had invested their money in the undertaking. They had an excellent Board and an efficient staff, capable, he believed, of managing a line three or four times its present length. They were now throttled at King William-street, and he hoped that before long the Directors would be able to find some solution for dealing with the growing traffic on the line.

Mr. SAMUEL GURNEY SHEPPARD, speaking as one who had as large, or nearly as large, an interest in the Company as any individual, advocated the extension of the line as far as Moorgate-street.

Mr. COURT, who said he represented shareholders having £100,000 in the Company, alleged that the expenses of management were too heavy, and gave notice that at the next meeting he should move a resolution for reducing the Directors' fees to £750 per annum.

Mr. MIDDLETON contended that unnecessary delay had taken place in the experiments to find out whether motors in the carriages could be substituted for the separate locomotives, and added that until the shareholders received 2 per cent. dividend he would oppose any extension.

The CHAIRMAN, in reply, said: I am afraid it is hopeless to try and satisfy Mr. Middleton. The larger the dividend the more does he say we have mismanaged the affairs of the Company. I think it is unfortunate he is not better acquainted with the working of a railway of this kind. If he were he would appreciate the difficulties which beset us, and the extreme amount of care and the constant attention which is required to carry it on in the way it has been. He deals with it entirely from an outside point of view, and says we should do this and the other without at all knowing the obstacles in the way. He referred to the motor question as if it was something he had suggested, whereas it is the very thing of all others dearest to my heart from the beginning. The whole plans were arranged for having motors on the carriages, and they were only altered at the last moment in deference to the Board of Trade. I cannot control the Board of Trade. If Mr. Middleton can, let him do so. I venture to say we have lost no time in the matter. As I have told you, it is a very difficult thing, and it is very doubtful if we shall, after all, be able to carry out our idea. So anxious are we that we have not been satisfied in giving the necessary orders to carry out the experiments to one firm, but we have given them to two, so as to expedite the matter as much as possible. I can only say that the remarks of Mr. Middleton are not encouraging to the Directors after the labour and trouble they have given to the Company's affairs. As regards the question of extensions, we have not brought that before you. I told you we should not until we had a plan we could thoroughly recommend to you. So far from Mr. Middleton's idea, that you are going to suffer in your dividends through it, being correct, I may say that, as far as we can see—and we have most careful figures before us, that can hardly go astray to any large extent—the completion of the line to Moorgate-street, after paying every possible preference charge that can be, will result in the increase of your dividend almost immediately to 5 per cent. I thank Mr. Drake for his observations, and I was glad to hear the views of Mr. Sheppard, who represents, perhaps, as large an amount of capital as anyone in this room. In view of what he has said, we shall give this question of the extension still more careful consideration. I do not suppose Mr. Middleton will support any scheme for that purpose, because he has always consistently been opposed to any extension. I will merely thank those gentlemen who have spoken kindly of the way in which we have managed the Company. It is an encouragement to us, and will stimulate us, if possible, to do more in the interests of the shareholders.

The motion was then adopted.

The CHAIRMAN then moved—

"*That the full dividend of 5 per cent. per annum be paid on the Perpetual Preference shares for the half-year ended June 30th, 1894.*"

Mr. EDWIN TATE seconded the motion, which was agreed to.

The CHAIRMAN next moved:—

"*That a dividend at the rate of 1 per cent. per annum be paid on the Consolidated Ordinary Stock for the half-year ended June 30, 1894.*"

Mr. GREATHEAD seconded the motion, which was carried.

On the proposition of Mr. COURT, seconded by Mr. DRAKE, a vote of thanks was passed to the Chairman and the other Directors.

The CHAIRMAN having acknowledged the vote, the proceedings terminated.

Globe Telegraph and Trust Company (Limited).

The twenty-first ordinary general meeting of this Company was held on the 27th ult., at Winchester House, Old Broad-street, under the presidency of Sir John Pender, G.C.M.G., M.P.

The SECRETARY (Mr. Sidney Collett) having read the notice convening the meeting and the minutes of the last general meeting, which were confirmed, the report of the Directors was taken as read.

The CHAIRMAN: Before asking you to approve the report, I will, as usual, go over some of the details of last year's working, and give you such information as I think may interest you. The receipts for the year ended the 18th inst., after paying all expenses, amounted to £185,057, as against £188,931 in the previous year, or a decrease of £3,874. This decrease is due principally to the reduced dividends which we have received from the Anglo-American Telegraph Company, in which, as you know, we have a very large interest. The object, however, of the Globe Company was, and still is, to equalise the dividends paid by the various telegraph companies in which we hold investments, and this object to a very large extent has been attained; because, while we have smaller returns from the Anglo Company, on the other hand the Telegraph Construction and Maintenance Company have given us a larger return than we had from them last year, so that we are able to recommend to-day the payment of a dividend on the Ordinary shares of 4½ per cent. for the year, against 4⅝ per cent. in the previous year. But this decrease is by no means a large one, and I may add that the dividend we are paying this year is still above the average, and that taking our Preference and Ordinary shares in like quantities they show a return of £5. 5s. per cent. Of course, gentlemen, we cannot pass through such hard times as have been existing not only in this country, but also, I may say, in every part of the world, without being affected. The decline in our dividend is, however, small and incidental, and I think that in view of the times we have been passing through we ought to congratulate ourselves that the dividend is not worse than it is. It is only ⅛ per cent. less, although every ⅛ per cent. makes up. I will, as usual, give you some information in running over the various figures which show fluctuations compared with last year's receipts. The Anglo-American Telegraph Company has paid us £4,207 less than we received from them last year, but this reduction needs a little explanation. The dividends we received last year were increased by the fact that the interest on their investments, instead of being placed to reserve fund, as formerly, were applied to the dividend, which was consequently increased by that amount; while this year not only has this interest not been distributed in dividend, but in accordance with the arrangement made at the time in connection with the laying of their new cable, which had become a necessity, certain moneys, which would otherwise have been distributed in dividends, have been placed to the reserve fund, with a view of building up that fund as soon as possible. We have also received £994 less from the Direct United States Company than the amount they paid us last year; but the remarks I have just addressed to you in reference to the stagnation in business between America and here refer to this Company in the same way as they do to the Anglo Company. However, the return this year on our investment in the Direct Company is £5. 5s. 5d. per cent. You will also have noticed that the accounts show that we received from the Submarine Cables Trust last year £1,083 more than we have received from them this year; but this difference, I may say, gentlemen, is more apparent than real, the larger dividend in the previous year being due to the fact that the Submarine Cables Trust paid the balance of the April, 1892, coupon at the commencement of our financial year, which ended July, 1893, and this amounted to £1,098, which you will at once see explains this difference. The coupons on those certificates are fixed at the rate of 6 per cent.; but for some years past they have been a little behind in their payments, and this is why the amounts they pay in one year may not exactly correspond with the amounts they pay in any other given year. With regard to the Telegraph Construction and Maintenance Company, you will remember that last year they paid us at the rate of 15 per cent., instead of, as formerly, 20 per cent., and you will also remember, gentlemen, that when I addressed you at our annual meeting last year I did not hold out much hope of a return to the high rate of 20 per cent., at least for some little time. Happily, however, it has proved otherwise, and that Company has once more reverted to its 20 per cent. dividend. This is very satisfactory to us, being large shareholders in that Company, as it means an increase in our receipts of £2,188, and we can only hope that this handsome return will be maintained. The return for this year on our investment in that Company is £6. 13s. per cent. You will have observed from the report that the Direct Spanish Company's Six per Cent. Debentures, which were held entirely by this Company, amounting to £62,000, matured on May 1st last and were paid off; £16,989 of this amount has been reinvested as follows: 300 shares in the Western Union Telegraph Company, 250 shares in the American Cable Company, 22 certificates in the Submarine Cables Trust, 354 Ordinary shares in the Direct Spanish Telegraph Company, 346 Preference shares in the Direct Spanish Telegraph Company, and the remainder will be reinvested (I may say it is already reinvested temporarily) as soon as suitable investments can be found by us. You are aware of the difficulty of getting suitable investments at the present moment. We have money in the bank, and cannot get more than 1 per cent. for it, and we are therefore obliged to fall back upon Consols for investments, and there is not a very large return from that. However, rather than leave the money unemployed, or only earning 1 per cent. at the bank, we have invested it temporarily in Egyptian Three per Cent. Guaranteed Loan and in Two and Three-Quarter per Cent. Consols. These are, at all events, safe, and will not run away from us. They are well guaranteed, and although the rate is not a high one, still we can keep the money invested in this way until we find something more in accordance with our views as to investments. The returns on the investments in other companies are practically the same as they were last year, and there-

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fore call for no special remark; but it is satisfactory to note that from most of the companies in which we hold important investments we get very good returns in the way of dividends. I may mention the companies in question. From the Brazilian Submarine Company we get £6. 10s. per cent., from the Eastern Telegraph Company £6. 7s. 2d., from the Eastern Extension Company £6. 16s. 5d. per cent., from the Indo-European Company £11. 3s. 8d. per cent., from the London Platino-Brazilian Company £5. 16s. 6d. per cent., and from the Western Union Company £6s. 5s. 6d. per cent. Besides these investments we have the Direct United States Company, which yields us £5. 5s. 5d. per cent., and the Telegraph Construction Company, £6. 13s. per cent. With respect to the West African Company, I should just like to mention that, while we are not receiving any dividend from them this year, the Directors of that Company have taken every possible precaution to obviate the necessity of those heavy expenses which have had to be incurred on account of the frequent interruptions to their cables. In addition to removing the cable from its former position, as I reported to you last year they had decided to do, a small repairing vessel, specially adapted for work in those waters, has been equipped and sent out to the coast with the view of repairing any breaks which may occur with as little delay and at as small a cost as possible. This vessel has been equipped and sent out to the spot, and is at the present moment doing work continuously. I therefore hope that when I stand before you next year, if I am spared to do so, I may be able to report that we have received some return on our money invested in that company. It may be possible also for us to get some return on our West Coast of America shares now that the Transandine line is completed. As you are aware, we have now a connection with the lines across the Andes, and I may tell you that the other night we had a message from Lima to London and an answer to it in the short space of two minutes forty seconds. Probably that has never been equalled before, and at all events it shows that our connection is one which is capable of doing good work, and if good work will bring traffic, the traffic will come to us. I am hopeful that by that means this West Coast of America Company, which has been rather in the background for the last two or three years, will come forward again and pay us something for our investment, which we have continued to hold in the belief that it was certain to give us a return. Now, gentlemen, before closing these remarks I would like to mention what no doubt many of you who have read our reports from year to year must have noticed—that while the capital of this Company is over £3,500,000 and the work in our transfer office is ever on the increase, for we have 9,000 shareholders—the cost of working the Company is kept at a very low figure. Shares are being continually transferred, large holdings are split up into smaller holdings, and by this means the number of our shareholders is continually increasing. As you may imagine, this gives our small staff a very great deal of work to attend to, but nevertheless you will notice that our total working expenses amount to the small figure of 2s. 6d. per cent.—in other words, ⅛ per cent. only on the capital. I do not think there is much to beat that in the way of economy of management. At present the price of our shares will yield a return of £5. 5s. 10d. per cent. on the Ordinary and £3. 17s. 5d. per cent. on the Preference shares. The amount of the capital paid up is £3,602,690, while the present value of our securities is £3,920,536, showing a surplus balance of £317,846, or over £20,000 better than at this time last year. That leads me to refer to a gentleman who took the trouble, no doubt for some exchange operation, to endeavour to discredit us before the public. With that object he issued a circular, which I hold in my hand—it was in November last—in which he alleged that we were in a state of bankruptcy. We made a reply to his statements and our answer showed that we were in a very satisfactory and flourishing state indeed. The figures at that time were as follows: paid-up capital £3,602,690, while the value of our investments was £3,896,118, or a surplus of £293,428, whereas to-day, as I have said, we have a surplus balance of £317,846, taking our securities at the price we paid for them. There is an improvement in the market price of our securities of £20,418 over last year. That must be very satisfactory to you to hear, and I may state that the gentleman who wrote this circular was very ignorant of what he was writing about, and I think he will consider twice before making a statement again which he dared not repeat after we had met him. His circular caused a little feeling among some of the shareholders at the time, but our answer was so complete—and it is so much more complete to-day—that I am satisfied you will be pleased with it. I think that that finishes what I have to say respecting our own affairs, but I may add that telegraphs as a rule are now more or less influenced by the depression in trade throughout the country. They are also influenced to some extent by the laying down of new cables, and there are a great many rumours about other new cables being laid. Some of these rumours, I daresay, are true, or may become true; but whatever the result of the new cables may be to those who lay them, from a financial point of view, they will, at all events, secure a thoroughly efficient system of telegraphing for the general public. I only hope that the demand for the increased facilities thus afforded will to a large extent recoup any reduction of revenue which may be sustained by existing companies through the increased competition. I hope also that it may be more or less met by good management and good common sense on the part of the different Directions, and that they will not run into competition unduly, but will try and husband their resources, and promote to the best of their ability the interests with which they are entrusted. I now beg to move—

"*That the printed report and accounts for the year ended July 18, 1894, submitted to this meeting, be, and the same are hereby received and adopted, and that a dividend be now declared, payable on and after this day, of 3s. per share on the Preference shares, less income tax, and of 3s. 9d. per share on the Ordinary shares (income tax having already been deducted), making with previous payments a total dividend for the year of 6 per cent. on the Preference shares, less income tax, and of 4½ per cent. net on the Ordinary shares of the Company.*"

The MARQUIS of TWEEDDALE seconded the motion.

The CHAIRMAN: If anyone wishes to ask me any question now I shall be very glad to answer it. No one rising to address the meeting he put the motion and declared it carried unanimously. Continuing, he said: The next resolution that I have to propose is—

"*That Lord Sackville A. Cecil, who now retires, be, and he is hereby re-elected a Director of the Company.*"

Mr. JAMES PENDER seconded the motion, which was carried unanimously.

The CHAIRMAN then moved—

"*That the Marquis of Tweeddale, who now retires, be, and he is hereby re-elected a Director of the Company.*"

The Hon. ST. JOHN BRODRICK, M.P., seconded the resolution, which was carried unanimously.

On the motion of the Rev. C. F. BOOKER, Messrs. Deloitte, Dever, Griffiths and Co. and Mr. William Griffith, B.A., were elected auditors for the current year.

Mr. BOWES said he thought that the shareholders ought to be informed of the name of the gentleman or firm that made the attack on them to which the Chairman had referred. He would, however, be the last to press this point if the Directors had any reason for not mentioning the name.

The CHAIRMAN stated that the circular was anonymous, being signed "Scrutator." If the writer had had the courage to put his name to the circular the Directors would probably have dealt with him in a different way instead of "killing him" by their reply to his allegations.

A cordial vote of thanks was then proposed to the Chairman and Directors for their able administration of the Company's affairs, and carried unanimously.

Liverpool Overhead Railway Company.

The following is the report of the Directors to the twelfth ordinary half-yearly general meeting to be held at the Law Association Rooms, 14, Cook-street, Liverpool, on Tuesday, the 14th inst., at noon:—

The gross revenue receipts to June 30th amount to £20,044. 7s. 6d.

The number of passengers carried since the opening of the railway are as follows:—

	From March 6 to June 30, 1893.		Half-year ending Dec. 31, 1893.		Half-year ending June 30, '94.
First class	235,487	...	260,221	...	277,653
Second class	956,922	...	1,293,840	...	1,246.975
Workmen (special return tickets)	178,333	...	921,578	...	1,336,809
Total	1,370,742	...	2,475,639	...	2,861,437

During the past half-year 50,483 trains have been run, and 96 per cent. have been punctual.

The northern extension was opened on April 30th, and the traffic at the Seaforth Sands station has been very satisfactory. An arrangement has been made with the Liverpool Tramway and Omnibus Company to run omnibuses to this station, connecting it with the surrounding districts, and generally to act as feeders to the railway.

Two new stations have been opened at points where experience has shown it to be desirable to provide further accommodation, viz., at Nelson and Huskisson Docks, and a third will shortly be opened at Langton Dock.

Revenue Account.

	£	s.	d.
The gross receipts from traffic amount to	£19,658	13	11
Miscellaneous receipts	385	13	7
	£20,044	7	6
Less working expenses	14,947	5	6
	£5,097	2	0
From which deduct Interest on debentures and calls paid in advance...	2,639	7	7
	£2,457	14	5
Add balance brought forward from last year	2,598	7	1
Leaving available for dividend, the sum of	£5,056	1	6

Out of this balance your Directors recommend the declaration of dividends at the following rates (less income tax) payable on and after August 17th, viz.:—

5 per cent. per annum on Preference shares...	£2,170 13 8			
1 " " Ordinary shares ...	1,875 0 0			
		£4,045	13	8

leaving a balance of £1,010. 7s. 10d. to be carried forward to next half-year.

Manchester Edison-Swan Electric Light Company (Limited).

The twelfth ordinary general meeting of this Company was held on Monday last, at the Memorial Hall, Manchester, Mr. V. K. Armitage presiding. The Directors' report, which was taken as read, was as follows:—"The net profit, including last year's balance, amounts to £1,508. 17s. 5d., which it is proposed to appropriate as follows: To writing off balance of loss on Williamson Electrical Engineering Company, £940. 0s. 1d.; to special depreciation owing to change of showrooms, £256. 5s. 6d.; to special depreciation on stock of lamps on expiration of

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patents, and to reduction in value of cables, £306. 11s. 5d.; balance to be carried forward, £6. 0s. 5d. The Directors view the result of the year's trading as satisfactory, considering the depressed state of trade during the last twelve months, and the fact that the Company's monopoly of the lamp trade has now ceased. They propose to write off the whole of the loss made on the Williamson Electrical Engineering Company (Limited), and the special depreciation shown above this year, and accordingly do not recommend the payment of a dividend."

The CHAIRMAN, in moving the adoption of this report, referred to the work that had been undertaken by the Company at Altrincham and Bowdon, and said he thought that from that installation the shareholders were justified in expecting a satisfactory financial result. He believed that in that and in other directions the future of the Company was hopeful.

Mr. F. B. ROSS seconded the motion, which was adopted.

Mr. F. B. Ross and Mr. W. P. James Fawcus were re-elected Directors.

A vote of thanks and £150 as remuneration for the past year was voted to the Directors, and the proceedings terminated.

Hong Kong Electric Company (Limited).

The report of the Board of Directors to the fifth ordinary yearly meeting of shareholders, held at the Company's offices, Hong Kong, on Monday, June 25th, expressed their satisfaction at being able to point to a steady progress in the Company's business, the working account showing a credit balance of $6,310. 94c., which, transferred to profit and loss account, left a balance to the credit side of $7,248. 47c.; while the amount overdrawn at the Company's bankers has, during the year, been reduced from $12,267. 17c. to $6,339. 97c. Although there had not been that rapid extension of the Company's operations which the Directors had hoped for, there was a steady increase in the amount of house lighting, and the benefit from the installations now being fitted would soon be showing itself in the earnings. It was not intended to fill the vacancy on the Board caused by the death of Mr. J. S. Lapraik.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1894, pages 274-300, *&c., &c.*]

CROPPER, CHARLTON AND COMPANY (LIMITED).—This Company was registered on July 28th with a capital of £2,000 in £1 shares, to carry on the business of (amongst others) machinists, mechanical, electrical and gas engineers, &c.

HARVEY CONTINENTAL STEEL COMPANY (LIMITED).—This Company was registered, on July 24th, to carry into effect certain agreements with the Harvey Steel Company, of New Jersey and New York, and to carry on the business of manufacturers of and dealers in armour and other plates, iron and brass founders, smelters, metal workers, boiler makers, machinists, metallurgists, engineers, manufacturing chemists, &c.

ROBERTS AND COMPANY (LIMITED).—This Company was registered on July 28th with a capital of £6,000 in £10 shares, to carry on the business of mechanical engineers, metal workers, boiler makers, machinists, electrical engineers, &c.

J. E. H. ANDREW AND CO. (LIMITED).—The annual return of this Company, made up to June 11th, has been filed. The nominal capital is £40,000 in £20 shares, of which 1,465 have been taken up, 300 shares have been considered as fully paid, and the full amount has been called on the remainder, resulting in the total payment of £24,000, which includes a sum of £700 received in respect of 35 forfeited shares.

KEIGHLEY ELECTRICAL ENGINEERING COMPANY (LIMITED).—The annual return of this Company, made up to March 17th, was recently filed. The concern has a nominal capital of £10,000 in £1 shares, of which 4,083 have been taken up, and 3,300 issued as fully paid. The full amount has been called and paid on 728 shares, while no calls have as yet been made upon the remaining 55 shares.

LONDON HEALTH ELECTRICAL INSTITUTE (LIMITED.)—The annual return of this Company, made up to April 29, was recently filed, when 6,007 shares, out of a capital of £10,000 in £1 shares, were taken up. Of these 6,000 were issued as fully paid to the vendors, and the full amount has been called and paid on the remaining seven shares.

NEW ZEALAND ELECTRICAL SYNDICATE (LIMITED).—The annual return of this Company, made up to December 31, 1893, was recently filed. No general meeting was held in 1893, owing to the non-receipt of the complete accounts from New Zealand. These have since been received. Out of a nominal capital of £30,000, in £10 shares, 2,955 have been taken up, and 2,000 have been issued as fully-paid to the Gulcher (New) Electric Light and Power Company (Limited). The full amount has been called on the remaining 955 shares, resulting in the payment of £8,040, and leaving £1.510 unpaid.

NORWICH ELECTRICITY COMPANY (LIMITED).—The annual return of this Company, made up to May 9th, has been filed. The concern has a nominal capital of £50,000, in £10 shares, and of these 2,382 have been subscribed for and allotted. The full amount has been called on each of these shares, resulting in the payment of £23,752. 10s., leaving £67. 10s. as yet in arrears.

OSWESTRY ELECTRIC LIGHTING COMPANY (LIMITED).—The annual returns of this Company, made up to July 15, 1893, and June 29, 1894, were both recently filed. Out of a nominal capital of £10,000, in £1 shares, 14 shares have been taken up, and upon these no calls have as yet been made.

J. H. PICKUP AND CO. (LIMITED).—The annual return of this Company, made up to June 14th, was recently filed, when the whole nominal capital of £15,000 in £5 shares were taken up. Of these 800 were issued as fully paid, and a call of £3 per share has been made on the remainder, resulting in the receipt of £6,600.

REUTER'S TELEGRAM COMPANY (LIMITED).—The annual return of this Company, made up to July 11th, has been filed. Out of a nominal capital of £100,000 in £8 shares, 11,839 have been taken up, the full amount called, and £94,712 paid.

ST. LUKE'S, CHELSEA, ELECTRIC LIGHTING COMPANY (LIMITED)—The secretary of the Chelsea Electricity Supply Company (Limited) notifies the Registrar that all the shares in the St. Luke's Company have been transferred to the members in the Chelsea Company, and that the name of the former should be struck off the register. It will be remembered that the Company was registered in 1890 with a capital of £1,000 in £10 shares, as the New Cadogan and Belgrave Electric Supply Company (Limited), as a reconstruction of the Cadogan Electric Light Company (Limited). The name was changed to the present title in 1892, the capital being raised to £30,000 in £10 shares, but only the seven signatories' shares were taken up.

J. G. STATTER AND CO. (LIMITED).—The statutory return of this Company, made up to May 4th, and recently filed, shows that 607 Ordinary and 340 Preference shares have been taken up out of a nominal capital of £20,000, in £10 shares. Of these 600 Ordinary and all the Preference shares were issued as fully paid. The full amount has been called on the remaining seven Ordinary shares, resulting in the payment of £10, and leaving £60 in arrears. The vendors, John G. Statter, Henry Foote, and Leonard Milne, hold all the shares, except four Ordinary and five Preference.

CITY NOTES.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended July 29th were £858 as against £824 in the corresponding period of 1893, being an increase of £34. The total receipts for the half-year amount to £3,458, as against £3,433 for the corresponding period of 1893, an increase of £25.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the month of July amounted to £2,800, as compared with £2,933 in the corresponding month of last year.

EASTERN TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of July amounted to £56,753, as against £62,317 in the corresponding period of 1893.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of July amounted to £42,873, and to £45,376 in the corresponding period of 1893.

KENSINGTON AND KNIGHTSBRIDGE ELECTRIC LIGHTING COMPANY (LIMITED).—The Directors of this Company have declared an interim dividend at the rate of 5 per cent. per annum on the Ordinary shares for the half-year ended June 30th last.

STOCK EXCHANGE NOTICES.—Application has been made to the Stock Exchange Committee to allow £100,000 Five per Cent. Debenture Stock of the City of London Electric Lighting Company (Limited) to be quoted in the Official List in lieu of the scrip.

UNITED ALKALI COMPANY (LIMITED).—The Directors have declared an interim dividend of 7s. per share on the Preference shares for the half-year to June 30th. There is no distribution on the Ordinary.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended July 27th (after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited), were £2,162.

WESTERN UNION TELEGRAPH COMPANY.—This Company has purchased the American Rapid Telegraph Company's undertaking, and has increased its capital stock by 5,000 shares. The Rapid Company defaulted in its interest and the property passed into the hands of a Receiver, who leased it to the Western Union at a rental of 60,000 dollars a year. The property was sold under foreclosure on March 11, 1891, to a committee of bondholders. The purchase of the Rapid Company's lines ensures economy to the Western Union Company in their operations, as compared with the terms of the lease.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share	Last Dividend.	Name.	Previous Week's Price, July 25.		Price Wednesday, Aug. 1.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Aug. 1.	
			TELEGRAPHS					£ s. d.		Highest	Lowest
£1,012,880	Stock	10 0	Anglo-American ... xd	37	40	37	40	6 4 6	Jan., Apr., July, Oct.	..	..
£2,933,560	Stock	20 0	Do. Preferred ... xd	71	73	70	72	6 5 0	" "	71¾	70
£2,933,560	Stock	5/0	Do. Deferred	6¼	6¾	6¼	6¾	..	..	..	..
£184,500	100	4%	African Direct Teleg. 4% Deb. (Reg. & Bearer)	101	104	101	104	3 16 11	January and July	..	..
130,000	£10	3/0	Brazilian Submarine	12	12½	12	12½	5 4 0	Mar., June, Oct., Dec.	12 7/16	..
£18,700	£100	5%	Do. 5 per Cent. Bonds ... xd	101	104	..		..	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	107	111	107	111	3 16 11	June and December	..	..
10,000,000	$100	$1¾	Commercial Cable Capital Stock	139	143	139	143	4 17 11	Jan., Apr., July, Oct.	..	—
16,000	10	8/0	Cuba Submarine	12½	13½	12½	13½	5 18 6	February and August	..	..
6,000	10	10%	Do. Preference 10 per Cent.	19½	20½	19½	20½	4 17 7	" "	..	..
12,931	5	1/7½	Direct Spanish (£4 paid)	4	4½	4	4½	4 8 11	April and October	..	—
6,000	5	10%	Do. Preference 10 per Cent.	9½	9¾	9½	9¾	5 2 7	" "	9¾	—
£30,000	Stock	4½%	Do. 4½% Debentures of £50 each	103%	106%	103%	106%	4 4 11	..	..	..
60,710	20	2/0	Direct United States Cable, 1877 ... xd	8	9	8	9	6 13 4	Jan., Apr., July, Oct.	8 11/16	8¾
400,000	10	5/6	Eastern ... xd Bonus	15¾	16	15½	15¾	4 2 6	" "	16¼	15½
70,000	10	6%	Do. 6 per Cent. Preference ... xd	16½	16¾	16	16½	3 12 8	" "	16 7/16	16¼
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	116	119	114	119	3 7 3	May and November	116½	..
£192,100	100	5%	Do. 5 per Cent. Debentures, 1899 ... xd	108	111	105	109	4 11 9	February & August	..	..
250,000	10	2/6	Eastern Extension	15½	15¾	15⅝	15¾	4 8 2	Jan., Apr., July, Oct.	15¾	15⅝
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock ... xd	116	119	114	117	3 8 5	February & August	..	..
£32,700	100	5%	Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900	103	106	103	106	3 17 3	January and July	..	..
£95,100	100	5%	Eastern and S. African 5 p. Cent. Mor. Deb., 1900	103	106	103	106	3 17 8	" "	..	..
£300,000	100	4%	Do. 4% Mortgage Debentures, 1909 (regd.) xd	105	108	103	106	3 15 6	February & August	..	—
£200,000	£25	4%	Do. 4% Mauritius Sub. Debs.	107%	110%	107%	110%	3 12 9	May and November	..	—
180,227	10	2 6	Globe Telegraph and Trust	8¾	8⅞	8¼	8½	5 5 11	Jan., Apr., July, Oct.	8½	8⅝
180,012	10	6%	Do. 6 per Cent. Preference	15¾	15⅞	15¾	15⅞	3 16 10	" "	15⅞	15⅝
150,000	10	5 0	Great Northern	20½	20¾	20	20½	4 3 9	Jan., April, and July	..	..
£190,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	105	108	105	108	4 12 7	March & September	..	..
17,000	25	37/6	Indo-European	44	46	44	46	5 8 8	May and November	45½	44¾
37,548	10	5/0	London Platino-Brazilian	5	7	5	7	..	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	108	111	108	111	5 8 1	March & September	..	..
£100,000	£100	4%	Pacific European Tel. 4% Guar. Debs. "Red" 1942	102	105	102	105	3 16 2	..	..	—
11,839	8	4/0	Reuter's	5	6	4½	5½	..	April and October	..	..
3,381	£100 Cert.	25/0	Submarine Cables Trust 6 per Cent.*	108	113	108	113	5 6 2	" "	..	..
15,609	10	5/0	West African Telegraph	3	5	3	5	..	January and July	..	..
£240,900	100	5%	Do. 5 per Cent. Debentures	102	105	102	105	4 15 3	March & September	103	..
30,000	10	2/0	West Coast of America	2½	3	2½	3	..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	98	101	98	101	7 18 5	June and December	..	..
88,321	10	9d.	West India and Panama	1	1¼	1	1¼	..	..	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10	10½	10	10½	5 14 3	May and November	..	..
4,669	10	6%	Do. 6 per Cent. 2nd Preference	9	10	9	10	6 0 0	" "	..	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	107	110	107	110	4 5 7	June and December	..	—
64,242	15	7/6	Western and Brazilian	6¾	7¼	6¾	7¼	..	May and November	..	..
33,129	7½	7/6	Do. 5 per Cent. Cumulative Preferred	5¾	6¼	5¾	6¼	..	..	6	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	1¾	2¼	1¾	2¼	..	..	..	..
£171,900	100	6%	Do. 6 per Cent. Debs., Series "A" 1910 ... xd	108	111	105	108	5 11 1	February & August	..	..
£244,800	100	6%	Do. 6% Mort. Debs., Series "B" 1910 ... xd	108	111	105	108	5 11 1	" "	..	..
$,211,000	$1,000	7%	Western Union 7% 1st Mort. (Building) Bonds	115	120	115	120	5 16 8	May and November	..	..
£166,900	£100	6%	Do. 6 per Cent. Sterling Bonds	100	104	100	104	5 15 5	March & September	..	..
			TELEPHONES.								
44,000	5	10/0	Chili Telephone (fully paid)	1	2	1	2	..	..	..	..
224,850	10/0	2¾d.	Consolidated Telephone Const. & Maintenance	¼	½	¼	½	..	May and November	..	..
171,504	£1	6d.	Oriental Telephone and Electric (fully paid)	¼	⅜	¼	⅜	..	Yearly	¼	..
484,597	5	3/4	National*	4¾	5¼	4¾	5	5 0 0	June and December	4 13/16	4¾
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.*	14½	15½	14	15	4 0 0	" "	14½	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)*	14	15	3½	14½	4 2 9	" "	..	..
119,234	5	3/4	Do. 5% Non-Cumulative 3rd Pref.*	5½	5¾	5⅜	5⅝	4 8 11	..	5½	5½
1,000,000	Stock	4½%	Do. Debenture Stock, 4½%	109	112	109	112	4 10 0	January and July	..	..
58,000	5	1/0	United River Plate	1	2	1	2	..	" "	..	..
£146,733	Stock	5%	Do. 5 per Cent. Debenture Stock	90	100	85	95	5 5 3	" "	..	—
			ELECTRICITY SUPPLY COMPANIES.								
40,000	£10	..	City of London Electric Lighting (fully paid)	12½	13	12½	13½	..	..	13½	..
40,000	10	6,0	Do. 6% Cumulative Pref. (fully paid) ... xd	14	14½	14	14½	4 2 9	..	14 7/16	14½
19,900	£5	..	Electricity Supply Co. for Spain					..	..	..	..
£30,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	4½	5½	4½	5½	..	..	..	..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	..		..		—	..	..	..
8,322	£5	..	House-to-House Electric	..		..		..	..	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	..		..		—	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..		..		—	..	..	..
45,000	£5	2/6	Liverpool Electric Supply (fully paid)	6½	6¾	6½	6¾	—	January and July	..	..
111,000	5	..	London Electric Supply	¾	⅞	¾	⅞	—	..	..	—
49,900	£10	5/0	Metropolitan Electric Supply (fully paid)	8½	9	8¼	9	2 15 7	..	8¾	..
£150,000	Stock	4½%	Do. 4½% Debs. (Bonds of £10, £20, and £40)	..					..	..	..
6,452	£10	..	Notting Hill Electric			3	5 pm	4 11 9	June and December	..	..
15,950	£5	2 0	St. James and Pall Mall ... xd	4½	5½	4½	5½	—	..	..	..
20,000	£5	7%	Do. 7 per Cent. Preference ... xd	7	7½	7	7½	..	..	—	—
59,900	5	2/0	Westminster Electric Supply (fully paid) ... xd	8½	9	8½	8¾	4 0 0	..	..	..
				6¼	6¾	6	6½	3 9 3	—	6¼	6 7/16
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
90,000	3	1/6	Brush Electrical Engineering	2¾	3	2¾	3	6 0 0	..	..	..
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	2¼	2½	2¼	2½	4 16 0	..	2 5/16	2 5/16
£125,000	Stock	4½%	Do. 4½ per Cent Debentures	110	113	110	113	3 19 8	March & September	..	..
20,000	5	2/6	Crompton and Co., 7 per Cent. Cumulative Pref.	2½	3	2½	3	..	January and July	..	..
12,130	5	..	Edison and Swan United	—		—		..	..	—	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	..		..		..	..	—	..
120,000	2	..	Electric Construction	¾	¾	¾	¾	..	—	—	—
12,845	2	..	Do. 7 per Cent. Cumulative Pref.	1¼	1¾	1¼	1½	..	—	—	—
91,195	2	10/0	Elmore's Patent Copper Depositing	1	1¼	1	1¼	..	..	..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	½	1½	½	1½	..	..	..	..
50,000	10	10/0	India Rubber, Gutta Percha, &c., Works	23	24	23	24	5 4 2	February & August	23¾	23
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103	105	103	105	4 5 9	March & September	..	..
15,995	£10	6/4	International Okonite Ordinary	..		..		..	..	..	..
15,000	£10	..	Do. 8 per Cent. Preference	..		..		—	December and June	—	—
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid)	—	½	—	½	..	..	—	—
78,949	5	3/6	Swan United (£3 10s. paid)	..		..		..	May and November	—	..
37,350	12	12/0	Telegraph Construction and Maintenance ... xd	40	42	40	42	5 14 3	March and July	41½	40
£150,000	100	5%	Do. 5 per Cent. Bonds	102	105	102	105	4 13 6	January and July	..	..
37,514	£5	..	Woodhouse and Rawson Ordinary (£3 15s. paid)	..		..		..	..	—	..
41,098	£5	..	Do. Preference (fully paid)	—		..		..	..	—	..
£63,570	10	10/0	W. T. Henley's Telegraph Works Ordinary	..		..		..	..	..	..
£30,000	10	..	Do. Preference	..		7	8	6 5 0	..	..	..
			RAILWAYS AND TRAMWAYS.								
£630,000	Stock	1%	City and South London Railway	33	33	36	38	1 16 2	May and November	37	..
7,000	10	5%	Do. 5% Perpetual Preference	12¾	13½	12¾	13½	3 15 6	May and November	..	..
£67,130	Stock	4%	Do. 4% Perpetual Debenture	119	121	120	122	..	..	..	..
37,500	£10	1%	Liverpool Overhead Railway	8¾	8½	8¾	8½	..	..	..	..
6,295	10	5%	Do. 5% Preference	12¾	13½	13	13½	3 14 1	..	..	..
£125,000	Stock	4%	Do. 4% Debenture	111	113	111	113	3 10 10	January and July ..	..	..

* Ex 8 months dividend

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NOTES.

The destiny which led the British Association to Oxford this year, there to find as Chancellor of the University one of the few of our statesmen who have given serious attention to science, left no choice in the selection of a President. This destiny, a hard destiny in Lord Salisbury's opinion, has happily resulted in a notable address, which a less stern necessity might have failed to elicit. The serving-up by specialists of a palatable dish of tit-bits of their own particular science can be enjoyed at any meeting by the omnivorous *habitués* of the British Association. Sometimes, as at Nottingham last year, the public is allowed a glimpse of a burning controversy, or, as at Edinburgh, the artistic use of a scientific imagination will grant a vision of a prehistoric scene. But this year there is no labouring with minutiæ by a conscientious monographist, no graceful trivialities of a dilettante, but a broad survey of modern science and of its limitations. It is reserved for one who can stand at a distance, to obtain a true perspective view of the small, bright oasis of knowledge, and to discern the boundaries of the vast unexplored desert which still remains to be cultivated, and to be won. A shallow man taking this position might have tickled the fancies of his audience by trying to forecast the discoveries of the future; a dull one, to recount what has been done. Lord Salisbury chose to examine one or two instances of the obscurity that still hangs over some of the most important problems, and did not shirk the difficulties which he met. A bold man must be he who can stand up between Lord Kelvin and Prof. Huxley and call the ether a *modus vivendi*, and evolution "a comfortable word"; and bolder still is he who can to-day claim the attention of a British Association audience, even though sheltered behind the judgment of the greatest living master of natural science, for the argument of design.

The fact that we are under no obligations to find a theory, if the facts will not provide a sound one, cannot too often be insisted upon, and Lord Salisbury clearly drew a distinction between the necessity with which, as a politician, he was well acquainted, of taking some definite course, and the freedom of the man of science to wait for further developments. No Paper, or even preliminary note, on a new research is, as a rule, published without some attempt to supply a theory. A man may be a skilful experimentalist, and may have made some very useful contribution to the store of facts from which science is evolved; but he may be quite unfitted for discovering a theory. Many a careful worker and ingenious investigator has marred an otherwise valuable communication by thinking it to be his duty to append to the account of his experiments some hypothesis by which to account for his results. His discoveries, so far as they are new and accurately observed, are of some value, either now or in the future, but his theory may be perfectly useless. And here lies the great danger of which Lord Salisbury utters so clear a warning,—the acceptance of mere conjecture in the name and place of knowledge. How useful would it be if every writer on scientific research were compelled to distinguish his facts from his conjectures, making, say, the former his text and the latter his footnotes; and how delightful would it be sometimes to run through the one to see if they were new and interesting, and to leave the other until they could command attention.

The abstract of the researches of Elster and Geitel on the relation between atmospheric potential and solar radiation brings to a close a series of articles which have been translated by, or at the suggestion of, Dr. Oliver Lodge, in connection with the interesting experiment shown by him at the Royal Institution, namely, the dissipation of a negative charge on a piece of zinc by the action of ultra-violet radiation. Feeble as are the usual phenomena of atmospheric electrification, the aggregate result is probably much more important than is generally supposed. An occasional thunderstorm reminds us that the equilibrium has been disturbed; but we know, at present, but little of what is going on while that equilibrium is maintained. We could do without hurricanes, but not without wind. Thunderstorms are highly objectionable, but should we suffer if the annual and daily cycles of potential gradient were suppressed? The kindred subject of earth currents is still inexplicable, and even the comparatively tame and harmless variations of terrestrial magnetism have, in Prof. Rücker's opinion, received but little attention, except for the utilitarian purposes of geography and navigation. It is possible that these three, atmospheric electrification, earth currents, and terrestrial magnetism, are bound up together, and, so far from being a simple periodic flux like the tide, are connected by far more complicated forces than that of gravitation with both visible and invisible radiations of the sun, or if the sun is too small to account for them, to some grand external influence of which absolutely nothing is known.

The news that the business of the London Electric Supply Corporation has passed into the hands of a receiver appointed

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by Lord WANTAGE will come as a blow to all electrical engineers who have followed the vicissitudes of this bold undertaking with interest and sympathy. It is but one more instance of the futility in commercial and engineering affairs of splendid courage unless supported by something more prosaic. Fortune, it must, however, be admitted, has been peculiarly unkind to the sanguine backers of Mr. FERRANTI; burn-outs and break-downs, most of them at particularly inopportune moments, have marked the history and hopelessly retarded the development of this concern; and, except to the *ex post facto* wisdom of the well-known "I told you so" type, the majority of these mishaps were distinctly beyond control.

THE *immediate* commercial success of the enterprise financially fathered by Lord CRAWFORD, Lord WANTAGE, and Sir COUTTS LINDSAY was entirely dependent upon the success of a fine piece of strategy, which at the time it was conceived appeared to have every chance in its favour. At a date when most of the companies now at work in London were in a very embryonic stage of development, without capital, business, experience, or powers, the London Electric Supply Corporation possessed three out of these four requisites, and, had it been able to maintain its lead in this respect, and arrive first in the field, the £850,000 which has been sunk in this plucky endeavour to capture the electric-lighting business of the metropolis would now have been reaping an adequate reward. As it is, there is nothing to be done but to hope that the undertaking will *ultimately* realise the anticipations of its promoters, and to offer our sympathies to the unfortunate shareholders, who, at any rate, have not experienced the added misfortune of being kept in the dark until the ship was right on the rocks.

SOME two years ago Lord WANTAGE, whose ordinary and preferential stake in the concern amounts to the respectable sum of something like a quarter of a million sterling, lent the Company £50,000, secured on the whole of its undertaking, and it was the inability of the Company to repay this loan that obliged Lord WANTAGE to take the step he has, those with the next largest holdings being quite satisfied that there was nothing else to be done under the circumstances. The concern will go on as before, with the difference that it will be possible for Lord WANTAGE alone to effect economies in the working, which it would perhaps be difficult for a Board to do. He has shown his anxiety to study all interests by appointing Mr. BAIN as his receiver and manager, and, as this gentleman is still Secretary to the Company, there are no conflicting interests, as might have been the case had the matter been handed over to a member of a firm of actuaries. It may be of interest to state that there are some 860 Ordinary and 210 Preference shareholders; Lord WANTAGE, Sir COUTTS LINDSAY, Mr. HENRY OPPENHEIM, Lord CRAWFORD, and Mr. CHARLES MORRISON holding between them over £300,000 of Ordinary shares.

FOR the modest sum of one halfpenny the constituent items of the great British public may procure for themselves a Return to an Order of the Honourable The House of Commons, showing the number of telegraphists in the service of the Post Office in London and the provinces, together with their wages and conditions of employment in 1891 as compared with 1872. In 1872 the Postal telegraphists numbered in all some 5,200; to-day they number nearly 9,600 of both sexes; an argument, if one be needed, that service conditions are not altogether so intolerable as some would have the public believe. But what are these conditions? First-class telegraphists, it would seem, now receive in London an average salary of £135, with a maximum of £160, and the general body of employés an average salary of £76, with a maximum of £110; the average of the former being some 15 per cent. and that of the latter some 24 per cent. higher than was the case two-and-twenty years ago. When with this, by no means inadequate, remuneration, are coupled such considerations as permanent employment, pension, regular holidays, payment during sickness (full pay for first six months, half pay for next six), free medical attendance, overtime pay for Sunday labour, tolerable hours, &c., we are at a loss to discover just where these grievances, about which we hear so much, come in. The average members of the electrical profession, and indeed of the general public, may well envy the average lot of the average postal telegraphist.

IN the early days of electric lighting it was a common practice to use "banks" of glow lamps for testing dynamos, and for other experimental purposes. These gave place to resistances of iron or other wire as soon as ammeters could be bought, but the reduction in the price of lamps makes lamp rheostats again practicable, and this very simple and convenient form of resistance is to be found in nearly every laboratory. Many ingenious switches have been designed for connecting resistances in series or in parallel, and most of these aim at putting the whole in parallel, the whole in series, together with many intermediate combinations. A convenient arrangement is described in a recent number of the *Electrical World* of New York, in which ten lamps are used, each of sixty ohms resistance. One, two, or three can be put in series, and of the remaining seven, any number can be put in parallel. This gives a range of from 180 to 7·5 ohms, and gives 24 combinations.

THE American daily papers are sometimes disposed to take the romances of science too seriously, and to think that the speculations of enthusiasts are redeemable at par on demand. They are therefore unable to understand that the predictions of future illumination by Teslaic processes are not affected by any such sordid considerations as mere time limitations, but must be taken as promissory notes to a future generation. One of these newspapers recently presented its readers with a number of illustrations, designed to show what things will be like when we "have light, not lights." Light, we are told, "will well impalpably out of walls," or will shine on us like "a century plant in unending bloom, of which the petals are sheafs of light." An illustration shows one of these flora planted on a footpath in front of someone's doorsteps, and it bears a striking resemblance to a cocoanut palm over which several buckets of whitewash have been thrown. Another

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illustration shows a ballroom, the walls of which are welling —not impalpably—with spiky streaks of something intended to be light, but which has the appearance of an anti-burglar frise. We notice that this form of illumination casts deep shadows!—but perhaps that is the fault of the artist.

Cable Interruption and Repair:—

	Date of Interruption.	Date of Repair.
Para-Maranham	July 23, 1894.	August 3, 1894.

British Association at Oxford.—The number of tickets taken up to 6 o'clock on Tuesday evening last was 1,472, compared with 1,114 at the corresponding period last year. The tickets taken by the time the meeting commenced on Wednesday, amounted to 2,134.

"Electric Power."—Mr. Horatio A. Foster, who is now associated with Prof. George Forbes as his representative in America, has become the editor of *Electric Power*. Mr. Foster was one of the staff on electrical work of the last United States Census, and has long made a close study of electrical technics and statistics.

Gas and Electricity in London.—At the last meeting of the Gas Light and Coke Company the Governor, in defending his Company against the South Metropolitan Company, pointed out that his Company had had the electric light to contend with, "which had stopped their increase, though it had not caused them to have a decrease."

Automatic Railway Ticket Machines.—Railways worked on the single fare or zone system can very easily dispense with booking clerks, for whom the automatic penny-in-the-slot machine may be substituted. The North London Railway Company has recently adopted the automatic method for distributing tickets for the workmen's trains.

Electric Traction in Madrid.—The shareholders of the Madrid Tramways Company have unanimously decided to adopt electric traction on their system. A Brussels concern will equip the tramway according to the provisions of a scheme drawn up by the Allgemeine Elektricitäts Gesellschaft, and will work the line at so much per car-kilometre.

Meter Rentals.—At the last meeting of the Gas Light and Coke Company Colonel Makins announced that his Company was prepared to abolish meter rentals if only the South Metropolitan and Commercial Companies would do likewise. Meter rents bring in an annual income of £58,000 to the Gas Light and Coke Company, notwithstanding that no rents are charged within the City area.

Geneva.—The Town Council of Geneva has decided to place three two-phased alternators at the new hydraulic power station, which is situated five miles below Geneva. These machines are being manufactured by the Compagnie de l'Industrie Électrique, of Geneva, and they will be direct-coupled to the turbines. The output of each machine will be 1,200 H.P., at a speed of 80 revolutions per minute.

A New Use for Magnetism.—"Ballistic" circles have been much exercised of late by the new Russian "secret" armour piercing projectile. The opinion of experts is that the secret consists in the projectiles having false points or caps fixed on their apices. As they have been called magnetic shot it is suggested that magnetism may have been employed to hold the cap to the smooth apex of the shot.

The Pacific Cable Question.—According to a Reuter telegram, dated Ottawa, August 6th, the Canadian Government, under the authority given it by the recent Inter-Colonial Conference, is inviting tenders from cable manufacturers for the laying and maintenance in an efficient condition of a cable across the Pacific from Canada to the Australasian colonies. Offers will be received to November 1st next.

Fire at an Electric Works.—The gutta-percha coating of a quantity of telegraphic wires stored in the cellars of the electrical works at 226, Rue Saint-Denis, Paris, caught fire last Saturday afternoon, and the flames were spreading forth when the danger was discovered by a workman. He succeeded in extinguishing the fire, but had a narrow escape of being suffocated by the fumes of the burning gutta-percha.

Obituary.—Miss Ellen Webb, the last surviving sister of Mr. F. H. Webb, Secretary of the Institution of Electrical Engineers, and Mr. F. C. Webb, expired at her Hove residence last Saturday. Miss Webb was well known and much respected in temperance circles, and was an enthusiastic supporter of the Salvation Army and its leader. She was known in the Hove and Brighton districts as a generous donor to numerous local and other charities. Her death was quite unexpected.

Wiring Charts.—With reference to the chart published as a supplement to our issue of July 20th, Mr. W. M. Mordey reminds us of a very convenient scale which he showed us some months ago, and which resembles Mr. Sanders' scale in several particulars. We have been reminded also that Mr. A. H. Howard has constructed an elaborate chart of wire gauges, &c. These are, of course, all independent productions.

The Telephone in Birmingham.—We have always understood that outside London the telephone service was all that could be desired; evidently we have been long labouring under an erroneous impression. The *Birmingham Post* has lately been filled with the wailings of the local telephone exchange subscribers. The following is a sample letter:—

Sir,—Your correspondent "Disappointed" puts his complaint in a most mild form. I consider the telephone management in Birmingham is disgraceful. You are either told, as "Disappointed" states, that the firm you require is "engaged," or the line is engaged, or the instrument is out of order; and frequently when you do get through you are talking with two or three voices mingling with your own. You ask for an explanation, and you are told it is "induction." DISGUSTED.

The Wear of Tramway Rails.—In a Paper read before the Tramway Institute, by Mr. T. Arnall, of Birmingham, the author states that trouble has been experienced with girder rails on the tram-lines of that city, owing to the uneven wear of the head and the projecting flange of the groove. Owing to this the flange of the groove projected above the rest of the rail, and became a nuisance to the ordinary street traffic. This trouble does not arise on horse lines where the traffic is not so great, as the wear of the groove flange is then not much less than the rail head; but with the heavy traffic of the steam lines it had become necessary, for the reasons stated, to remove rails long before they were actually worn out. To avoid this trouble in future, Mr. Arnall suggests the use of a girder rail with a central groove.

Copper.—The explanation of the low price of copper, which is only a shade over £38 per ton, is, says *The Statist*: 1. The necessities of producers in the United States to realise cash, and selling largely to Europe. 2. The small consumption in the United States consequent on the depression in trade. 3. The indisposition of consumers to buy at a time when the market has been declining. 4. The working off during the last four or five years of the great accumulations that occurred when copper was carried up to an abnormally high level, and invisible supplies of old copper were accumulated to the extent of, perhaps, not far short of 50,000 tons beyond the large accumulations brought about by mines being put into work when prices were at a high level. In the opinion of our financial contemporary the time is at hand when a turn in the tide is likely to be witnessed.

The Steam Jacket.—A paper was read at the recent meeting of the American Society of Mechanical Engineers by Prof. R. H. Thurston on the theory of the steam jacket. The paper described the method of action of steam jackets and the sources and limits of the efficiency. Prof. Thurston at one point states that "the final result of experience up to date may be summed up in the statement that when a jacket is properly designed, constructed, and attached, and when it is properly manipulated, it may always be expected to give good economic results in simple engines, and large returns on the investment, with all classes except, possibly, the high-speed engines." The author believed that it was still a question whether the unsatisfactory reports from its use on fast-running engines may not be attributable to defects in jacketing rather than to limitation of the system to slow-speed engines.

A Forecast.—Mr. R. J. Jack, the Government Geologist of Queensland, in reporting upon the Ipswich coalfield of that

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country, has been giving free play to his imagination. "I can see the time," says Mr. Jack, "when the fuel will no longer be roughly handled, and at a great unnecessary cost in its transport to the city and to the distant ports, whence it has to be distributed to where it is wanted for the various purposes of human industry. I can see the coal shot into furnaces at the mouth of the pit, smelting the iron ores of the district, required for a host of native manufactures, and transmitting power and light, and the vehicles of locomotion, by means of electric cables, to other industrial centres. I can see, further, that the extension of the use of electric cables, not only from Ipswich, but from other at present impracticable coalfields, will make copper mines no more a drug in the market, but eagerly sought after."

Telephonic Marvels.—A correspondent of the *Dundee Advertiser*, writing from Broughty Ferry last Wednesday week says:—"I had an interesting experience this afternoon. A friend rang me up by telephone at my house in Broughty Ferry from the Highland Show yard in Aberdeen, and whilst he was speaking to me he said—'Wait a minute; I can't hear what you are saying for a pipe band which is presently passing the telephone booth.' I instantly replied—'I was just hoping you would stop for a minute, as I wanted to hear the band.' The wire was fortunately in very good order to-day, and not only did I hear the pipe music, but I distinctly heard the tramp of the men as they walked past. The tune they were playing was The Barren Rocks of Aden, and it was a most interesting experience to hear pipe music and 'the tramp of armed men' over 150 miles of wire. I have repeatedly before heard by telephone a common eight-day clock striking and piano music at a distance of over 100 miles, and have heard a watch ticking at a distance of about a mile, but I have never until to-day had the pleasure of hearing over the telephone music played in the open air at a distance of considerably over 100 miles."

The Cottrell Telephone Transmitter.—In our issue of January 8, 1892, we described at length an ingenious telephone transmitter devised by Mr. Charles Cuttriss, in which the motions of the microphone diaphragm alternately elongated and compressed a delicate spiral of springy carbon, the complete rupture of the circuit at any moment being in this way rendered impossible. A telephone transmitter on the same principle has recently been brought out by Mr. Herbert Cottrell, of Newark, New Jersey. A thin strip of carbon, from which project knobs or points that are but lightly, if at all, in contact with each other when the strip is straight, is bent into an arch between the telephone diaphragm and the back of the instrument. The backward and forward motion of the diaphragm successively stretches the strip straight and bends it into a bow, the knobs successively separating and coming into contact. No movement of the diaphragm can possibly rupture the circuit, since that is always complete through the base of the carbon strip, along which the variable contact shunting projections are arranged. Obviously the resistance will be greatest when the circuit is completed only through the base. The resistance of the projections is preferably made considerably smaller than the resistance of the base along which they are set.

Power Transmission in California.—In a recent issue the *Electrical Engineer* of New York gives an account of a proposed Californian power-transmission scheme. The first project is one of transmitting power electrically from Clear Lake to San Francisco, a distance of 75 miles. It is proposed to run three lines of steel pipe of 5ft. average diameter a distance of 40,800ft. to the generating house, where the water delivered under 151ft. head at the Pelton wheels will furnish a total of 28,950 H.P. At 72 per cent. loss, this would net 20,845 H.P. in San Francisco. It is proposed to employ 1,000 H.P. generating units and 25,000 volts pressure on the line; and two overhead lines, each carrying 10 circuits. The total cost is estimated at £800,000 in round figures. Fuel is costly in San Francisco, and power costs £2 per horse-power per month. The Clear Lake Company intend to sell it at £1 per month. It is stated that San Francisco, with its 300,000 population, is now ninth in the Union in manufactures despite the high cost of fuel. Its power plants aggregate 60,000 H.P. The conditions are favourable, therefore, for a large utilisation of cheap water-power from a distance, and, as the climatic conditions are also good, there is no reason, on the surface, why the Clear Lake transmission should not prove quite feasible.

Lightning.—During the past few days lighting has been doing more than its normal amount of damage. Last Sunday morning it struck the 90ft. high tower of the village church of Norton-sub-Hamdon, in Somerset. The sacred edifice is not protected by any lightning conductor. On the roof is a flag-staff, with a pulley and metallic chain attached. The lightning struck this, evidently mistaking it for a regular conductor. It must then have gone through the roof to the brass-work of the clock, and thence to the floor of the chamber. This floor had been cased with deal, and here the fire originated, which got complete mastery of the tower.—Early in the week, during a wedding at Thanington Church, which is about a mile from Canterbury, a cabdriver named Joseph Bennett was killed by lightning. During the storm Bennett took refuge under an elm tree on the other side of the road, holding the horse's head. Both he and the horse were struck by lightning and instantly killed.—During a thunder-storm at Potsdam on Tuesday, the New Palace was struck by lightning shortly after four o'clock. The current followed the telegraph wires and set the fire alarm apparatus in motion, causing the firemen at the Palace and the town engines to turn out. No damage was done to the building.—From Ssenkowo (Russia) comes the story of an extraordinary case of a man being struck by lightning during a storm which was taking place at a distance of 107 versts, or 71 miles, from the spot where he was working. The workman was engaged in putting up a wire on a telegraph post, when he suddenly feel down dead. There were 13 burns discovered on his body. At the moment of the man's death the sky over the town was quite clear and bright, and there was no trace of a thunderstorm, but at the same time in Wladimir, 107 versts from Ssenkowo, a very heavy storm was raging.

The Blackpool Tramway.—An extraordinary statement was made at the meeting of the Blackpool Town Council on Tuesday by Mr. Councillor Pearson anent the state in which the electric tramways had been found. They found, he said, that the main difficulty was in the station itself. The difficulties they had encountered were not electrical but mechanical—difficulties that ought never to have arisen, inasmuch as they were due to want of attention. In company with Mr. Holroyd Smith, the Committee examined the shed, and found a state of things that was positively disgraceful, and for which somebody was greatly to blame. The tubes of the boilers were so choked with dirt and filth that it took two men six days to clear them out. The dynamos were in a similar condition; the foundations and frame-work were rotten; in fact, the whole plant was giving way for want of attention and proper repair. The armatures were in a bad condition, and the fire-boxes of the boilers were ten inches deep in thick mud. The cylinders themselves were in a similar condition, and the steam-pipes were so thickly coated with oil-paste that they could not possibly have been cleaned out for twelve months! The dampers were all stuck fast and rusted up, and the main shafting was badly worn, and not to be depended upon. Those things had now been remedied. Four practically new cars had been placed on the track, with motors fitted with Mr. Holroyd Smith's worm-gearing, and they had ordered two new bogey-cars. Mr. Pearson then went on to say that it was to their certain knowledge that they had had enemies on their track almost the whole of the time they had been trying to remedy these defects; someone with a knowledge of electrical matters had tried to interfere, not only with the tram lines but with the electric lighting. Only the previous day he had brought to him a chain which had been placed round the copper rod (in a scientific way), which conducted the current entirely to earth. That was not the first time they had discovered such interferences. They had a multitude of evidence in the shape of spades, nails, small pieces of iron and copper, which had been laid in a proper manner by people who knew what they were doing. It was their intention to ask the Watch Committee, along with the Chief Constable, to try and detect those malicious persons.

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HEINRICH HERTZ.

The portrait presented to the reader to-day is that of the man with whom science at the commencement of this year buried its best and richest hopes. Hertz was in our midst but 37 years. The 20 years of earnest labour claimed by Faraday as necessary to the full development of the philosopher's mind were barely allotted to him, and yet we know his works rank with the highest achievements attainable by a human mind. And now that we have begun to know and fully appreciate him, we have already lost him, and with him all that so rich a mind holds latent, and all that it would have disclosed, both of itself and by its influence upon others. His works lie open before us from the first research to the great electrical investigations, and from these, again, to the "Principles of Mechanics." He will add no more to these.

If, to estimate our loss fully, we cast a glance into the Past, and search for men who with similar masterly insight have penetrated the complexity of the Known, have selected elevated standpoints from whence to perceive the great landmarks in the dim and distant Unknown, who as surely reached them, and who have succeeded in doing all this at an equally early period of life, we meet with the most consecrated names written in the history of science. It was the same philosophical spirit that, once in Newton, revealed a hidden world by means of a simple prism of glass, now in the person of our genial fellow-worker, performed the same by means of feeble sparks. The same power of abstraction, the same keen insight produced formerly the method of fluxions, now that system of ideas to which the "Mechanics" owes its mathematical form. The same mental power viewed Nature as a whole and summed up its operations aforetime in three laws, now in one single law of simple meaning.

The external life of Hertz was as simple and straightforward as himself. He was born at Hamburg on February 22, 1857, being the eldest son of Dr. G. F. Hertz, who was at that time a lawyer, and is now a Senator, and at the head of the legal administration of the Hanse Town. His mother came from Frankfort-on-Main. From his father he seemed to have his noble pride and his practical turn of mind; from his mother his amiable disposition. The great talent which he early displayed, and the deep sense of duty which distinguished him even as a boy, made him the especial favourite of his parents, who bestowed every care upon his education. He received his first school training at a private school in his native city, which he attended until the fifteenth year of his age. He did not, as is usual in Germany, pursue the course of classical study at the gymnasium; but he read the ancient classics with zeal and pleasure at home, and so thoroughly mastered them within two years that he was admitted to the final course at the Hamburg Gymnasium known as the "Johanneum." A year later, at the age of eighteen, he left this school with a certificate testifying to his fitness for university studies. In addition to his school tasks he practised mechanical work at home. His favourite occupation was working at the carpenter's bench. He constructed wheels for himself to convert his bench into a lathe, and he made many kinds of physical apparatus as he wished to have them, in order to observe this or that phenomenon. He was likewise fond of drawing and painting. Scientific books he eagerly seized upon, and he used every spare moment to study them until he could tell his parents "I have now mastered that book," and this invariably proved to be true. He successfully ventured upon the study of the most difficult branches of mathematics during his school days.

When at length the time came for Hertz to choose a profession, he determined to become an engineer. The choice disappointed all his teachers. He, too, greatly desired to pursue the study of pure science; but his natural modesty led him to doubt the possibility of his ever making any satisfactory progress towards those ideals of science which his striving mind had in view. He preferred to rely on his taste for mechanical work. Consequently, he worked for a year in the municipal engineering office at Frankfort-on-Main, where the great bridge over the Main was then in process of construction. Many designs, executed with admirable care, testify to the zeal and earnestness with which he devoted himself at this time to his chosen calling. He then went to the Polytechnic in Dresden, where he remained, however, only half a year, being then called upon to fulfil his term of military service. In the autumn of 1877 he went to Munich, intending to continue his studies at the Polytechnicum of that city. But, as he read over the syllabus of the classes and realised, more clearly than before, the nature of the work which was to occupy him now and probably throughout his life, he began to feel dissatisfied. He had attended lectures on the steam-engine in Dresden; they aroused his intense interest, inasmuch as they revealed to him the secrets of the mechanical theory of heat; the technical details, on the other hand, were unable to offer any interest to him. These details proved burdensome to a mind striving to reach the summit of perfection, and the load now began to be intolerable. He therefore resolved to go over to the university. The resolution was for him no easy one. It caused him to rely entirely upon those faculties he so longed to set at work, but on which as yet, in their unproved state, he had little reliance. He was strengthened, however, in his resolve by the assent of his parents. After studying for a year at the University of Munich he went to Berlin, and became the pupil of Von Helmholtz and Kirchhoff. It was Von Helmholtz in particular who exercised the greatest influence upon the whole course of his thoughts and views. Hertz therefore retained throughout his life an especial attachment for him, and a characteristic childlike gratitude towards him. After only one year's work in the laboratory of Von Helmholtz he completed his first original investigation, in which he seeks to answer the question whether electricity in motion possesses inertia. Tendered with words of rare praise from the lips of Von Helmholtz and Kirchhoff, the work gained the gold medal offered by the Philosophical Faculty for the solution of the problem. It happened also about that time that Von Helmholtz drew the attention of the 22-year-old student to the prize problem of the Royal Academy of Sciences of Berlin, referring to the proof of Maxwell's theory, and offered him the assistance of the Institute in case he decided to carry out the research. Hertz himself tells us in his work "On Electric Waves" that he thought over the subject, and finally gave up the attempt, realising that the methods then known were inadequate. But he retained in his mind for eight years the deep impression made upon him by this request of Von Helmholtz, until the discovery of new methods enabled him to achieve success in his famous electrical researches.

Soon after this first work Hertz obtained the Doctorate, with a theoretical dissertation, in which he solved the problem of Foucault currents with a generality including all previous solutions as particular cases. He was appointed assistant to Von Helmholtz, a post which he held three years. During this time he produced an excellent series of researches, both experimental and theoretical in character. Their number, twelve, testifies to the enormous capacity for work their author possessed, while we see in their contents with astonishment how wonderfully he mastered, even at that time, theory as well as experiment. It is indeed difficult to find any difference between these early researches and his later famous investigations, unless it be in the smaller influence which the early works have exercised on the progress of science. Nevertheless they by no means treat entirely of out-of-the-way subjects. In one of them, for instance, along with the solution of most difficult problems in the theory of elasticity, he has given for the first time clear insight into the nature of a universally known property of bodies, which had nevertheless been only dimly and vaguely comprehended, namely, that of hardness. Or, again, from another communication, "On the Pressure of Mercury Vapour," we learn by Hertz's characteristic combination of theory and experiment that this constantly-occurring pressure at ordinary temperatures is nearly one hundred times smaller than usually assumed. A peculiar charm of these, as well as of all his writings, is due to the clearness and profundity of thought, but none the less to the simple and yet striking manner of representation. His works reflect his own character, which was as simple and straightforward, as true and steadfast, as the operations of Nature herself.

In the year 1883 Hertz left Berlin, and, following the advice of Von Helmholtz, settled down as Privat-Docent at the Univer-

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sity of Kiel, where he received a teaching appointment from the Prussian Minister. During his stay of two years he was occupied exclusively with theoretical investigations, there being no laboratory at his disposal. Although always conscientious in the employment of his time, he used to enjoy occasional pleasure parties by steamer or yacht in the harbour of Kiel. Perhaps it was these trips that led his thoughts to the study of atmospheric phenomena, which formed the subject of one of his investigations at that time. But he ever liked to come back to the subject of his first work, electro-magnetics, upon which two very important communications were published by him about this time. Ere long he was to harvest the well-deserved fruits of his persevering activity on this field of research.

Hertz was now twenty-eight years of age. Held in high esteem by all his fellow workers, by a few already recognised as the rising sun of a new epoch, he received almost simultaneously three calls to professorships, in Greifswald, in Kiel itself, and in Karlsruhe. He accepted Karlsruhe, being well pleased with the laboratory. There, in the capital of Baden, he became acquainted with Elizabeth, daughter of his colleague Dr. Doll; he won her heart and soon afterwards made her his wife.

Then began the happiest period of his life. He observed the small sparks at the ends of a Riess spiral used by him in a lecture, and the very fact which so many had previously passed over became for him the starting point of those researches, the impression of which is still fresh in our memory. New properties of the ether have been revealed. Electric phenomena have ceased to stand isolated as if they were exceptional conditions artificially produced; they exist everywhere—light is an electrical phenomenon. A supposed action-at-a-distance is proved to require time for its propagation. The rambling old building of electro-magnetic theory, already shaken by Faraday and Maxwell, collapsed and totally disappeared; in its place the new building stands firm and shapely.

The recognition of such work was not wanting; it is now consoling to know that it came so quickly. Hertz was soon invited to become the successor either of Kirchhoff in Berlin or of Clausius in Bonn. He preferred the latter, and went to the Rhenish town in the spring of 1889. England, also, was not backward in doing honour to his success. The Rumford Medal was awarded to him; the Literary and Philosophical Society of Manchester and the Cambridge Philosophical Society each elected him as an honorary member, and the London Mathematical Society conferred the same distinction upon him. The latter especially pleased Hertz, as being a particular recognition of the mathematical merits of his researches. He became a member of almost all the chief Continental Academies; various great prizes were awarded to him. But let us not linger over the enumeration of his honours, it would only divert us from the image of this ever modest man, still present in our memory and still retaining its old magic charm over the hearts of those who knew him. To describe fully this noble character would be beyond my feeble powers. Let me only attempt to recall some of its many lovable traits. Great modesty was the main feature; it permeated his whole being, and led him to keep his personality in the background in the presence of old and young alike. This modesty was accompanied by an anxious desire to spare the feelings of others. He displayed unvarying kindness to all those who came within the range of his influence, and most especially to those in the laboratory who were associated with him in his capacity as Director. His was an intensely sympathetic nature. To cheer and encourage others was for him a delight. It was to his charming manner and amiable disposition, no less than to the exceeding greatness of his merit, that he owed the singular good fortune never to encounter petty jealousies or animosities. He was ever ready to fully acknowledge the merits of others, and give honour where honour was due, and nothing roused him so much as to see such merits undervalued or slighted. His tender, unassuming nature, his great modesty, could not, however, conceal the mighty power of his intellect. The striking and forcible thoughts he could produce at any moment gave him the superiority in discussion, and they lost none of their impressive power by the unassuming form in which they were uttered. To be, however, considered as an authority in his science, even by the youngest beginner, was a thought which never entered his mind. In daily life he quickly perceived the comic side of things, and used to season his narratives with such rich and sparkling humour, that it was a positive treat to listen to him. He liked to attack in a playful way such thoughts as were wanting in clearness. But it was only in his later years, that this humorous disposition developed, in his earlier life his reticence and reserve, the outcome of a deep and earnest nature, preponderated.

Hertz made but few demands upon the equipment of the laboratories of which he was Director. Indeed, almost all his results were obtained with the simplest contrivances and with external means known long before. He also liked to set up his own apparatus, using such materials as he could find near at hand, and with the simple tools which he had possessed from his youth. He thus accomplished his purpose with an astonishingly small expenditure of time and material. By all sorts of ingenious devices he knew how to make use of the properties of the commonest substances. Yet he did not set any value upon his devices, sometimes even forgetting them entirely, to rediscover them later on. They were secondary matters; it was the great ends that he had in his mind. He liked to work alone; the presence of an assistant seemed to distract his thoughts. In his later years he read but few scientific works; indeed, in most cases a glance between the pages was apparently sufficient to enable him to gather the essentials of the contents.

For three years and a-half Hertz thus lived happily in Bonn, perfectly content in his sphere of activity. Then, in the autumn of 1892, a malady began to show itself; apparently insignificant at first, but slowly and continuously undermining his health, which until then had been excellent. The seat of the illness seemed to lie in the cavities of the nose. In the following winter an operation behind the right ear was necessary to remove the danger threatening his life. It was successfully performed, and every hope of his recovery was entertained. He resumed his lectures in the spring of 1893, continuing them until early in December, though at the end with evident effort, as the symptoms of the malady returned in an increased degree. From this time the course of the disease was rapid, and ended in blood-poisoning. On the afternoon of New Year's day this year death released him from unspeakable suffering, borne with heroic fortitude. His remains are interred at Hamburg.

In the last three years of his life Hertz completed a work on "The Principles of Mechanics." He left it to science as a legacy. It was given to the world only a few days ago. In this magnificent work he shows us the universe from a new point of view, to the deep satisfaction of the mind convinced of the simplicity of Nature, existing, but hidden from the narrow standpoint of our five senses. For a long time past natural philophers have agreed that all natural phenomena are to be traced to the simple laws of mechanics; but which these simple laws may be, this is not agreed upon. It is not certain which definite combination of mechanical principles is necessary and sufficient to embrace all known processes of Nature, and at the same time to exclude every process the occurrence of which is already excluded by experience. The combination usually used is formed by Newton's three laws, together with D'Alembert's principle. But are the forces of which Newton's laws speak of a simple nature? And, in order to have the laws assert neither too little nor too much, which properties should be ascribed to these forces? and of what nature are we to assume the connections between the parts of natural systems, entering into D'Alembert's principle? In the two latter questions are expressed the uncertainties of this first combination of mechanical laws, and, moreover, the idea of "force" introduced here into the fundamental principles loads them with inner contradictions. The second known possible combination of mechanical laws is formed by the principle of the conservation of energy, and by one of the integral principles—for instance, Hamilton's principle. Here it seems doubtful from the beginning whether this combination is really sufficient to account for all natural processes. Again arises the question as to the real range of the mechanical principles. Which phenomena do they embrace, which not? And what is the real inner meaning of laws as complicated in

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form as those integral principles? Moreover, is the idea of "energy" with its twofold nature at all fit to be introduced into the fundamental principles? All these uncertainties and doubts must have been felt by all whose wish it was to grasp the deeper meaning of mechanics, of the existence of which the mind is convinced; and the inner contradictions are painful even to the beginner in this science.

Hertz deals with all these questions in the introduction to his work; he brings to light the existent inner contradictions with words of impressive simplicity. In the contents of the work itself he gives a solution of the questions, completely removing the contradictions. He gives a thoroughly definite combination of mechanical laws, which is neither too narrow nor too wide. And he gives it in the form of one single Fundamental Law of the greatest simplicity and lucidity. This Fundamental Law speaks of spaces, times, and masses only. The ideas of force and energy with their difficulties are removed from the foundation. He shows us all the known general laws and principles of dynamics as fragments of this single Fundamental Law or as applications of it to particular cases. The range and the inner meaning of each law and principle is revealed thereby with wonderful clearness and precision, a clearness and precision attainable only by such keen logical reasoning as was peculiar to Hertz. Ordinary mechanics now appears as a special case of Hertz's new system of mechanics, inasmuch as ordinary mechanics deals with the motions of masses directly perceptible by the senses. If we consider these masses by themselves we are always confronted by complex and unintelligible laws. But if we add to these masses the intangible masses of the existence of which physical science is now fully convinced, and if we ascribe to these masses properties and motions possible in every way, and for all we know probable, then we obtain a connected Universal system based on the one Fundamental Law. The law states that "Every independent system of Nature moves with uniform velocity along one of its straightest paths." The possibility of expressing this universal law by such simple words is due to the use of a new system of kinematical ideas, such as "velocity of a system," "straightest path of a system," adapted to Nature, the discovery of which excites our highest admiration. To the construction of this system of ideas the "First book" of "Mechanics" is devoted, whilst the "Second book" gives the development of the known contents of mechanics, in a wide sense, from the Fundamental Law.

The system of Hertz's mechanics is, strictly speaking, only a hypothesis, which is not contradicted by any known experience, but which asserts more than can be proved as yet by positive experience. Standing there, however, in unique and marvellous beauty and perfection, like Nature, the system bears already in itself the character of the utmost probability. And the very fact that in its statements it goes beyond the limits of present experience makes it appear all the more adapted to become a guiding star for future discoveries of new general truths. On Hertz's Mechanics hang now all hopes of ever getting essentially nearer the goal towards which for ages the human mind has striven: tracing back Natural Phenomena to simple, general laws. A firm basis to further progress is now given. The greater the difficulties still to be overcome may appear at present, the further a creative mind has gone beyond us here: the deeper will be the influence of that mind upon all further development of man's knowledge of Nature.

P. L.

PROF. RUCKER'S PRESIDENTIAL ADDRESS TO SECTION A.

It is impossible for a body of English scientific men to meet in one of our ancient university towns without contrasting the old ideal of the pursuit of learning for its own sake with the modern conception of the organisation of science as part of a pushing business concern.

We are, as a nation, convinced that education is essential to national success. Our modern universities are within earshot of the whirr of the cotton mill or the roar of Piccadilly. Oxford and Cambridge themselves are not content to be centres of attraction to which scholars gravitate. They have devised schemes by which their influence is directly exerted on every market town and almost on every village in the country. University extension is but a part of the extraordinary multiplication of the machinery of education which is going on all around us. The British Association, which was once regarded as bringing light into dark places, is now welcomed in every large provincial town by a group of well-known men of science; and we find ready for the meetings of our sections not only the chapels and concert-rooms which have so often and so kindly been placed at our disposal, but all the appliances of well-designed lecture-rooms and laboratories.

I do not propose, however, to detain you this morning with a discourse on the spread of scientific education; but you will forgive me if I illustrate its progress by two facts, not perhaps the most striking which could be selected, but especially appropriate to our place of meeting. It is little more than thirty years since the two branches of science with which our Section deals, Mathematics and Physics, have been generally recognised as wide enough to require more than one teacher to cope with them in an educational institution of high pretensions and achievement. In 1860 the authorities of the Owens College, Manchester, debated whether it was desirable to create a Professorship of Natural Philosophy in addition to, and independent of, the Chair of Mathematics. It was thought necessary to obtain external support for the opinions of those who advocated this step. An appeal was made to Profs. De Morgan and Stokes. The former reported that a "course of experimental physics is in itself desirable;" the latter, that "there would be work enough in a large institution for a mathematician and a physicist."

In the end the Chair of Natural Philosophy was established, and the fact that our host of to-day, Prof. Clifton, was its first occupant reminds us how little we have advanced in time and how far in educational development from the days when propositions such as those I have cited were only accepted on the authority of the names of Stokes and De Morgan.

The other fact to which I would refer is that the Clarendon Laboratory, in which the meetings of Section A are to be held, though erected barely a quarter of a century ago, was the first laboratory in this country which was specially built and designed for the study of experimental physics. It has served as a type. Clerk Maxwell visited it while planning the Cavendish Laboratory, and traces of Prof. Clifton's designs can be detected in several of our university colleges.

But though our surroundings remind us of the improvement which has been effected in the equipment of our science, it would not be difficult to indicate weak points which should forthwith be strengthened. On these, in so far as they affect education, I will not dwell—and that for two reasons. In the first place, we meet to-day not as teachers, but as students; and, secondly, I think that whereas we have as a nation awoke—though late in the day—to the importance of education, we are not yet fully awake to the importance of learning. Our attitude in such matters was exactly expressed by one of the most eminent of the witnesses who gave evidence before the "Gresham Commission." In his opinion the advancement of knowledge must in a university in London be secondary to the higher instruction of the youth of London. If this be so—and I will not now dispute it—we shall surely all agree that somewhere or other, in London or out of it, included in our universities or separate from them, there ought to be institutions in which the advancement of knowledge is regarded as of primary and fundamental interest, and not as a mere secondary bye-product thrown off in the course of more important operations.

It is not essential that in such an institution research should be the only task. Investigation may be combined with the routine work of an observatory, with teaching, with the care of standards, or with other similar duties. It is, however, essential that, if the advancement of knowledge is seriously regarded as an end worth attaining, it shall not be relegated to a secondary place.

Time and opportunity must be found for investigation, as time and opportunity are found for other tasks. It is not enough to refer to research in a prospectus, and then to leave it to be accomplished at odd times and in spare moments not claimed by more urgent demands. Those to whom the future of the higher learning in England is dear must plan and scheme to promote the lifelong studies of men, as in the last quarter of a century they have struggled, with marked success, to promote the preparatory studies of boys and girls. That the assignment of a secondary position to research is the more popular view, and that the necessity for encouraging it has as yet hardly been grasped by many of those who control our modern educational movements is, I fear, too true. It is therefore a matter for congratulation that within the last year Oxford has established a research degree, and has thus taken an important step towards gathering within her fold workers of mature years who are able and willing, not merely to gain knowledge, but to add to it.

We may also note, with pleasure and gratitude, that recently the stream of private munificence has been in part directed to the advancement of learning. Sir Henry Thompson has generously offered a sum of £5,000 to provide a large photographic telescope

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for the National Observatory at Greenwich. The new instrument is to be of 26in. aperture and 22ft. 6in. focal length, or exactly double the linear dimensions of that which has been previously employed. Mr. Ludwig Mond, too, has added to his noble gifts to science by the new research laboratories which he is about to establish in connection with the Royal Institution. Albemarle-street is thronged with memories of great discoveries. The researches of Lord Rayleigh and the remarkable results of Prof. Dewar's studies of matter at low temperatures are maintaining the great reputation which the Royal Institution has gained in the past, and all English physicists will rejoice that prospects of new and extended usefulness are opening before it.

Another hopeful, though very embarrassing, fact is that the increase in the number of scientific workers makes it increasingly difficult to find the funds which are necessary for the publication of their work. Up to the present the author of a Paper has had to submit it to criticism, but when it has been approved by competent judges, it has been published without ado and without expense to himself. This is as it should be. It is right that due care should be exercised to prune away all unnecessary matter, to reduce as far as may be the necessary cost. It will, however, be a great misfortune if judgment as to what curtailment is necessary is in future passed, not with the object of removing what is really superfluous, but in obedience to the iron rule of poverty. Apart from all other disadvantages, such a course would add to the barriers which are dividing the students of different sciences. A few lines and a rough diagram may suffice to show to experts what has been attempted and what achieved, but there is no Paper so difficult to master as that which assumes that the reader starts from the point of vantage which months or years of study have enabled the author to attain, undue pruning will not make the tree of knowledge more fruitful, and will certainly make it harder to climb.

Connected also with the increase in scientific literature is a growing necessity for the publication of volumes of abstracts, in which the main results of recent investigations are presented in a concentrated form. English chemists have long been supplied with these by the Chemical Society. The Physical Society, though far less wealthy than its elder sister, has determined to undertake a similar task. We are compelled to begin cautiously, but in January next the first number of a monthly pamphlet will be issued containing abstracts of all the Papers which appear in the principal foreign journals of physics. In this venture the society will incur grave responsibilities, and I avail myself of this opportunity to appeal to all English physicists to support us in a work, the scope of which will be rapidly extended if our first efforts succeed.

From this brief glance at what has been or is about to be done to promote the study of physics, I must now turn to the discussion of narrower but more definite problems, and I presume that I shall be most likely to deserve your attention if I select a subject in which I am myself especially interested.

During the last ten years my friend Dr. Thorpe and I have been engaged upon a minute magnetic survey of the United Kingdom. The main conclusions at which we have arrived are about to be published, and I do not propose to recount them now. It is, however, impossible to give so long a time to a single research without having one's attention drawn to a number of points which require further investigation, and I shall perhaps be making the best use of this opportunity if I bring to your notice some matters in the practical and theoretical study of terrestrial magnetism which deserve a fuller consideration than has yet been given to them. In the first place, then, there is little doubt that the instruments at present used for measuring the declination and horizontal force are affected with errors far greater than the error of observation.

We employed four magnetometers by Elliott Brothers, which were frequently compared with the standard instrument at Kew. These measurements proved that the instrumental differences which affect the accuracy of the declination and horizontal force measurements are from five to ten times as great as the error of a single field observation. The dip circle, which two generations ago was so untrustworthy, is, in our experience, the most satisfactory of the absolute instruments. In most cases these comparisons extended over several days; but the Astronomer Royal has described, in his recent report, observations made at Greenwich for two years and a-half with two horizontal force instruments. These differ between themselves, and the discrepancy is of the same order of magnitude as those we have detected. If such differences exist between instruments of the Kew pattern, it is probable that they will be still greater when the magnetometers under investigation are of different types. This point has been investigated by Dr. Van Rijckevorsel, who five years ago visited Kew, Parc St. Maur, Wilhelmshaven, and Utrecht, and using his own instruments at each place, compared the values of the magnetic elements determined by himself with those deduced from the self-registering apparatus of the observatory. The discrepancies between the so-called standards, which were thus brought to light, were quite startling, and prove the necessity for an investigation as to their causes.

Magneticians had long been aware that the instruments used by travellers should be compared at the beginning and end of a journey with those at some fixed observatory, to make sure that the comparatively rough usage to which they are subjected has not affected their indications. But Dr. Van Rijckevorsel's expedition first drew general attention to the fact that there are serious differences between the standard observatory instruments themselves. The importance of a careful comparison between them was at once recognised. The Magnetic Sub-Committee of the International Meteorological Conference, held at Munich in the autumn of 1891, resolved that it is "necessary that the instruments employed for absolute measurements at the different observatories should be compared with each other and the results published." As far as I am aware nothing has been done to give effect to this resolution, but the necessity for such an international comparison is urgent. The last few years have been a period of unexampled activity in the conduct of local magnetic surveys. To cite instances from the north-west of Europe only, observations have recently been made on a more or less extended scale in the United Kingdom, France, Holland, North Germany, and Denmark. It will be absurd if these surveys cannot be collated and welded into a homogeneous whole, because we are in doubt whether the indications of our standard instruments for the measurement of declination and dip differ by five or six minutes of arc. If, however, an official international comparison of the magnetic standards in use in different countries is instituted it is probable that only one observatory in each country will take part in it.

It may fairly be left to each nation to determine for itself the relations between the results of measurements made in its own institutions. Apart, therefore, from all other reasons, we in England would only be able to make the best use of an international comparison if we had beforehand set our own house in order, and were able at once to extend the results of experiments made at Kew or Greenwich to Stonyhurst, Valentia, and Falmouth. This we are not at the present moment in a position to do. As far as I know, nobody has ever carried a magnetometer backwards and forwards between Kew and Greenwich to test the concordance of the published results. During the recent survey single or double sets of observations have been made at Stonyhurst, Falmouth, and Valentia, with instruments which have been compared with Kew; but these measurements, though amply sufficient for the purposes of our research, were not numerous enough to serve as a firm basis for determining the discrepancies between the various standards, so that the exact relations between these important sets of apparatus are still unknown.

The first point, therefore, to which I wish to draw the attention of the Section is the necessity for a full primary comparison between the standard magnetic instruments in use at our different observatories. But, if this were satisfactorily accomplished, the question would arise as to whether it should be repeated at regular intervals. We have at present only a presumption in favour of the view that the standards which we know are discordant are nevertheless constant. A single instance may suffice to show how necessary it may be—at all events in the case of outlying and isolated observatories—to put this belief to the test.

In the most recent account of the work of the observatory of the Bombay Government at Colába the dips are discussed for the period of twenty years between 1872 and 1892. During this interval the adjustment of the agate plates upon which the dip needle rolls has thrice been modified. In 1877 the plates were renewed. In 1881 and 1887 the dip circle was taken to pieces and rebuilt. In the intervals the dip, as determined by several needles, but always with this circle, remained approximately constant; but after each overhauling it suddenly altered, increasing by 12′ on the first occasion, by 23′ on the second, and by 20′ on the third. Mr. Chambers states that he "can give no satisfactory account of this behaviour of the instrument," but suggests that "the needle gradually hollows out a depression in the agate plates on which it rolls, and that this characteristic of the dip circle" has not before been discovered owing to the reluctance of magnetic observers to interfere with the adjustments of instruments which are apparently working well.

I do not think this explanation will suffice. Dr. Thorpe and I employed a new dip circle in the earliest part of our survey work, which has remained in accord with Kew for 10 years. During that time the dip has been measured some 700 times with it. This corresponds, I believe, to more than the amount of work done with the circle at Colába in six years, which, in turn, is longer than some of the intervals in which the Colába instruments gave results erroneous to the extent of 20′. I feel, therefore, quite sure that the difficulties which have been experienced at Bombay are not due to any "characteristic [defect] of the dip circle." But, whatever the cause may have been, surely the lesson is that, if such things can happen in so well-known an institution, it is desirable that we should take the moderate pains required to assure ourselves whether smaller—but, possibly, not unimportant—errors are gradually affecting the results at any of our observatories.

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This brings me to my next point, namely, that if we are to draw conclusions from the minor differences between measurements of secular or diurnal change made in the observatories, it is not only necessary that we should know whether the instruments are strictly comparable and constant, but the observations must be reduced by precisely the same methods. In 1886 the late Mr. Whipple drew the attention of the British Association to the fact that there was a systematic difference between the diurnal ranges of declination at Greenwich and Kew. His results were based on the three years 1870-72. In 1890 two of my students, Messrs. Robson and S. W. J. Smith, extended the comparison to three more recent years (1883-6-7), and obtained results in complete accord with those of Mr. Whipple. It is well known that the average daily oscillation of the magnet is affected by the magnetic weather. Sabine showed that magnetic storms do not merely buffet the needle now in this direction and now in that—they affect its average behaviour, so that the mean swing east and west is different according as we deduce it only from days of magnetic calm, or include those of storm.

Mr. Whipple reduced the Kew observations by two methods,* one of which depended on the calmest days only, while the other included those which were moderately disturbed. Neither agreed exactly with the method in use at Greenwich, but the difference between the results deduced from them was so small when compared with the difference between either and that obtained at Greenwich, that it seemed possible that the diurnal variations, even at these closely neighbouring places, might differ appreciably. The question whether this is so has now been answered. In 1890, at the request of the Kew Committee, the Astronomer Royal undertook to select early in each year five quiet days in each of the preceding twelve months. It was also agreed that, whether they adopted other methods or not, the chief English magnetic observatories should determine the diurnal variations from these days alone. The Greenwich† and Kew observations for 1880 have, therefore, been worked up in exactly the same way, with the result that the discrepancy, which had persisted for 20 years, has entirely disappeared, and that the two diurnal ranges at the two observatories are in as close accord as could be expected. If, therefore, we may judge from a single year, the cause of the difference lay in the choice of days. Greenwich will in future give us two diurnal variations—one obtained from the most quiet days only, the other from all days except those of violent storm, and in these we shall have most valuable data for studying the mean effect of disturbances on the diurnal variation.

To this satisfactory conclusion I have only one suggestion to add. The Astronomer Royal and M. Mascart now publish for the same stormy days the photographic traces by which the history of a magnetic storm is mapped. Is it possible for Greenwich and Paris also to agree in their choice of calm days for the calculation of the diurnal variation, so that a precise similarity of method may obtain not only between the English observatories, but between England and France?

The importance of co-operation between institutions engaged on the same tasks having been illustrated, I am glad to be able to announce that another step is about to be taken in the same direction. For some years, in spite, I believe, of great financial difficulties, the Cornwall Royal Polytechnic Society has maintained a magnetic observatory at Falmouth. The results of the observations have hitherto been printed in the *Journal* of the Society only, but the Royal Society has now consented to publish them in the *Proceedings*. Before long, therefore, the Kew and Falmouth records, which are already worked up in the same way, will be given to the world side by side. Is it too much to hope that this may be the first step towards the production of a "British Magnetic Year Book," in which observations whose chief interest lies in their comparison may be so published as to be easily compared?

We owe to private enterprise another advance of the same kind. The managers of the new journal *Science Progress* have made arrangements with the Kew Committee for the yearly publication of a table showing the mean annual values of the magnetic elements as determined at the various magnetic observatories of the world. It will, therefore, in future be possible to get a general idea of the rate of secular change in different localities without searching through a number of reports in different languages, which can only be consulted in the rooms of the few societies or institutions to which they are annually sent. The present state of our knowledge of the secular change in the magnetic elements affords, indeed, very strong support to the arguments I have already adduced in favour of a comparison between the instruments of our magnetic observatories.

The whole question of the cause of this phenomem has entered on a new stage. It has long been recognised that the earth is not a simple magnet, but that there are in each hemisphere one pole or point at which the dip needle is vertical, and two foci of maximum intensity. A comparison of earlier with later magnetic observations led to the conclusion that one or both of the foci in each hemisphere is in motion, and that to this motion—however caused—the secular change in the values of the magnetic elements is due. Thus the late Prof. Balfour Stewart, writing in 1883, says: "While there is no well-established evidence to show that either the pole of verticity or the centre of force to the North of America has perceptibly changed its place, there is, on the other hand, very strong evidence to show that we have a change of place on the part of the Siberian focus."* The facts in favour of this conclusion are there discussed. The arguments are based, not on the results of any actual observations near to the focus in question, but on the behaviour of the magnet at points far distant from it in Europe and Asia. The westerly march of the declination needle, which lasted in England up to 1818, and the easterly movement which has since replaced it, are connected with a supposed easterly motion of the Siberian focus, which, it is added, "there is some reason to believe . . . . has recently been reversed." In opposition, therefore, to the idea of the rotation of a magnetic focus round the geographical poles, which the earlier magneticians adopted, Stewart seems to have regarded the motion of the Siberian focus as oscillatory.

A very different aspect is put upon the matter by a comparison of the magnetic maps of the world prepared by Sabine and Creak for the epochs of 1840 and 1880 respectively. Capt. Creak, having undertaken to report on the magnetic observations made during the voyage of the "Challenger," supplemented them with the unrivalled wealth of recorded facts at the disposal of the Hydrographic Department of the Admiralty. He was thus able, by a comparison with Sabine's map, to trace the general course of the secular changes all over the world for 40 years. The negative results may be shortly stated. There is no evidence of any motion either of magnetic pole or focus. The positive conclusions are still more curious. There are certain lines on the surface of the earth towards which in the interval under consideration the north pole of the needle was attracted. From each side the compass veered or backed towards them. Above them the north pole of dip needle moved steadily down. There are other lines from which, as tested by compass and dip circle, a north pole was in like manner repelled. The two principal points of increasing attraction are in China and near Cape Horn; the chief points of growing repulsion are in the North of Canada and the Gulf of Guinea. I am sure that my friend Captain Creak would be the first to urge that we should not generalise too hastily from this mode of presenting the facts, but there can be no doubt that they cannot be explained by any simple theory of a rotating or oscillating pair of poles. *Primâ facie* they suggest that the secular change is due not so much to changes at the principal magnetic points, as to the waxing and waning of the forces apparently exerted by secondary lines or points of attraction or repulsion.

All down the west coast of America, close—be it noted—to one of the great lines of volcanic activity, north hemisphere magnetism has since 1840 been growing in relative importance. Near Cape Horn a weak embryonic pole is developing of the same kind as the well-known pole at the other end of the continent near Hudson's Bay. Along a line which joins Newfoundland to the Cape of Good Hope precisely the reverse effects have been experienced, while in the Gulf of Guinea a south hemisphere pole is growing within the tropics. Of course I do not suggest that these secondary systems can ever determine the principal phenomena of terrestrial magnetism, or reverse the magnetic states of the hemispheres in which they occur. These are no doubt fixed by the rotation of the earth. I do, however, wish to emphasise the fact that they show that either secular change is due to the conjoint action of local causes, or that if some single agent, such as a current system within the earth, or a change of magnetic conditions outside it, be the primary cause, the effects of this cause are modified and complicated by local peculiarities.

Mr. Henry Wilde has succeeded in representing with approximate accuracy the secular change at many points on the surface of the earth by placing two systems of currents within a globe, and imparting to the axis of one of them a motion of rotation about the polar axis of the earth. But he has had to supplement this comparatively simple arrangement by local features. He has coated the seas with thin sheet-iron. The ratio between the two currents which serves to depict the secular change near the meridian of Greenwich fails in the West Indies. Thus this ingenious attempt to imitate the secular change by a simple rotation of the magnetic pole supports the view that local peculiarities play a powerful part in modifying the action of a simple first cause, if such exist. I need hardly say that I think the proper attitude of mind on this difficult subject is that of suspended judgment; but there is no doubt that recent investigation has, at all events, definitely raised the question how far secular change

* Sabine's and Wild's.

† The Greenwich observations for subsequent years have not yet been published.

* *Encyclopædia Brit.*, 9th edition. Art. "Meteorology, Terrestrial Magnetism."

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is either due to or modified by special magnetic features of different parts of the earth.

It is possible that light may be thrown upon this point by observations on a smaller scale. Assuming for the moment that the difference in the secular changes on opposite sides of the Atlantic is due to a difference of local causes, it is conceivable that similar causes, though less powerful and acting through smaller ranges, might produce similar, though less obvious, differences between places only a few miles apart. For testing this Greenwich and Kew are in many respects most favourably situated. Nowhere else are two first-class observatories so near together. Differences in the methods of publishing the results have made it somewhat difficult to compare them, but the late Mr. Whipple furnished me with figures for several years which made comparison easy. Without entering into details, it may be sufficient to say that the declination needles at the two places do not from year to year run parallel courses. Between 1880-82 Kew outstripped its rival, between 1885 and 1889 it lost, so that the gain was rather more than compensated. The difference of the declination of the two places appears to increase and diminish through a range of five minutes of arc.

This evidence can be supplemented by other equally significant examples. No fact connected with terrestrial magnetism is more certain than that at present the rate of secular change of declination in this part of Europe increases as we *go* north. This is shown by a comparison of our survey with those of our predecessors fifty and thirty years ago, by M. Moureaux's results in France, and by Captain Creak's collation of previous observations. Yet, in spite of this, Stonyhurst, which is some 200 miles north of Greenwich and Kew, and should therefore outrun them, sometimes lags behind and then makes up for lost time by prodigious bounds. Between 1882 and 1886 the total secular change of declination at Stonyhurst was about 3'·5 less than that at Greenwich and Kew, whereas in the two years 1890-92 it reached at Stonyhurst the enormous amount of 28', just doubling the corresponding alteration registered in the same time at Kew. If these fluctuations are caused by the instruments or methods of reduction my argument in favour of frequent comparisons and uniform treatment would be much strengthened; but, apart from the inherent improbability of such large differences being due to the methods of observation, the probability of their physical reality is increased by the work of the magnetic survey.

The large number of observations at our disposal has enabled us to calculate the secular change in a new way, by taking the means of observations made about five years apart at numerous though not identical stations scattered over districts about 150 miles square. The result thus obtained should be free from mere local variations; but, as calculated for the south-east of England for the five years 1886-91, it differs by nearly 5' from the change actually observed at Kew.

We have also determined the secular change at 25 stations by double sets of observations made as nearly as possible on the same spot at intervals of several years. The results must be interpreted with caution. In districts such as Scotland, where strong local disturbances are frequent, a change of a few yards in the position of the observer might introduce errors far larger than the fluctuations of secular change. But when all such cases are eliminated, when all allowance is made for the possible inaccuracy of field observations, there are outstanding variations which can hardly be due to anything but a real difference in the rate of change of the magnetic elements. A single example will suffice. St. Leonards and Tunbridge Wells are about 30 miles apart. Both are situated on the Hastings sand formation, and on good non-magnetic observing ground. At them, as at the stations immediately around them—Lewes, Eastbourne, Appledore, Etchingham, Heathfield, and Maidstone—the local disturbing forces are very small. All these places lie within a district about 40 miles square, at no point of which has the magnet been found to deviate by 5' from the true magnetic meridian. No region could be more favourably situated for the determination of the secular change, yet according to our observations the alteration in the declination of St. Leonards in six years was practically equal to that at Tunbridge Wells in five. It is difficult to assign so great a variation to an accumulation of errors, and this is only one amongst several instances of the same kind which might be quoted.

We find, then, when we consider the earth as a whole, grave reason to question the old idea of a secular change caused by a magnetic pole or focus pursuing an orderly orbit around the geographical axis of the earth, or oscillating in some regular period in its neighbourhood. It would, of course, be absurd to admit the possibility of change in the tropics and to deny that possibility in the arctic circle; but the new facts lead us to look upon the earth not as magnetically inert, but as itself—at the equator as well as at the pole—producing or profoundly modifying the influences which give rise to secular change. And then, when we push our inquiry further, accumulating experience tells the same tale. The earth seems, as it were, alive with magnetic forces, be they due to electric currents or to variations in the state of magnetised matter. We need not now consider the sudden jerks which disturb the diurnal sweep of the magnet, which are simultaneous at places far apart, and probably originate in causes outside our globe. But the slower secular change, of which the small part that has been observed has taken centuries to accomplish, is apparently also interfered with by some slower agency, the action of which is confined within narrow limits of space. Between Kew, Greenwich, and Stonyhurst, between St. Leonards and Tunbridge Wells, and, I may add, between Mablethorpe and Lincoln, Enniskillen and Sligo, Charleville and Bantry, the measured differences of secular variation are so large as to suggest that we are dealing not with an unruffled tide of change, which, unaltered by its passage over continent or ocean, sweeps slowly round the earth; but with a current fed by local springs or impeded by local obstacles, furrowed on the surface by billows and eddies, from which the magnetician, if he will but study them, may learn much as to the position and meaning of the deeps and the shallows below. But if this is the view which the facts I have quoted suggest, much remains to be done before it can be finally accepted; and, in the first place—to come back to the point from which I started—we want, for some years, at all events, a systematic and repeated comparison of the standard instruments in use at the different observatories. That they are not in accord is certain; whether the relations between them are constant or variable is doubtful. If constant, the suggestions I have outlined are probably correct; if variable, then the whole or part of the apparent fluctuations of secular change may be nothing more than the irregular shiftings of inconstant standards. I cannot myself believe that this is the true explanation, but in any case it is important that the doubt should be set at rest, and that if the apparent fluctuations of secular change are not merely instrumental, the inquiry as to their cause should be undertaken in good earnest.

The question is interesting from another point of view. It is now fully established that even where the surface soil is non-magnetic, and even where geologists have every reason to believe that it lies upon non-magnetic strata of great thickness, there are clearly-defined lines and centres towards which the north-seeking pole of a magnet is attracted, or from which it is repelled. To the magnetic surveyor fluctuations in secular changes would appear as variations in the positions of these lines, or as changes in the forces in play in their neighbourhood.

Greenwich and Kew are both under the influence of a widespread local disturbance which culminates near Reading. At both places the needle is deviated to the west of the normal magnetic meridian, and if the westerly declination diminishes sometimes faster and sometimes more slowly at one observatory than at the other, this must be, or, at all events, would in the first instance appear to be, due to local changes in the regional disturbing forces. The question of the nature of the variations of secular change and of the causes of local disturbances are therefore intermingled; and information gained on these points may in turn be useful in solving the more difficult problem of world-wide secular variations.

Two causes of regional and local disturbances have been suggested, viz., earth currents, and the presence of visible or concealed magnetic rocks. The two theories are not mutually exclusive. Both causes of the observed effects may, and probably do, coexist. I have, however, elsewhere explained my reasons for believing that the presence of magnetic matter, magnetised by induction in the earth's field, is the principal cause of the existence of the magnetic ridge-lines and foci of attraction which for so many years we have been carefully tracing. I will only now mention what appears to me to be the final and conclusive argument, which, since it was first enunciated, has been strengthened by the results of our more recent work. We find that every great mass of basic rock, by which the needle is affected at considerable distances, attracts the north-seeking pole. Captain Creak some years ago showed that the same statement is true of those islands in the northern hemisphere which disturb the lines of equal declination, while islands in the southern hemisphere repel the north pole and attract the south. In other words, these disturbances are immediately explained if we suppose that they are due to magnetic matter magnetised by induction. The theory of earth currents would, on the other hand, require that round the masses of visible basalt, and round the island investigated by Captain Creak, currents, or eddies in currents, should circulate in directions which are always the same in the same hemisphere, and always opposed on opposite sides of the equator. For this supposition no satisfactory explanation is forthcoming, and therefore, with all reserves and a full consciousness that in such matters hypothesis differs but little from speculation, it appears to me that the theory of induced rock magnetism, as the main cause of the disturbance, has the greater weight of evidence in its favour.

If this be granted, it is evident that the positions of the main lines and centres of attraction would be approximately constant, and, so far as it is possible to form an opinion, these conditions seem to be satisfied. There has certainly been no noticeable change in the chief loci of attraction in the five years which have elapsed

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between the epochs of our two surveys. Mr. Welsh's observations made in Scotland in 1857 8 fit in well with our own. Such evidence is not, however, inconsistent with minor changes, and it is certain that as the directions and magnitude of the inducing forces alter, the disturbing induced forces must alter also. But this change would be slow, and as the horizontal force is in these latitudes comparatively weak, the change in the disturbing forces would also be small, unless the vertical force altered greatly. It is at all events impossible to attribute to this cause oscillations which occupy at most eight or ten years. It is possible so suggest other changes in the state of the concealed magnetic manner—alterations of pressure, temperature, and the like—to which the oscillations of secular change might be due, but probably there will be a general consensus of opinion that if the slowly changing terms in the disturbance function are due to magnetic matter, the more rapid fluctuations of a few years' period are more likely to be connected with earth currents. It becomes, therefore, a matter of interest to disentangle the two constituents of local disturbances ; and there is one question to which I think an answer might be obtained without a greater expenditure than the importance of the investigation warrants. Are the local variations in secular change waves which move from place to place, or are they stationary fluctuations, each of which is confined to a limited area beyond which it never travels? Thus, if the annual decrease in the declination is at one time more rapid at Greenwich than at Kew, and five years afterwards more rapid at Kew than at Greenwich, has the maximum of rapidity passed in the interval through all intervening places, or has there been a dividing line of no change which has separated two districts which have perhaps been the scenes of independent variations? The answer to this question is, I take it, outside the range of our knowledge now ; but if the declination could be determined several times annually at each of a limited number of stations in the neighbourhood of London—to this inquiry, at all events—a definite answer would soon be furnished. There are two other lines of investigation which I hope will be taken up sooner or later, for one of which it is doubtful whether the United Kingdom is the best site, while the other is of uncertain issue.

If, however, it be granted that the principal cause of local and regional magnetic disturbances is the magnetisation by the earth's field of magnetic matter concealed below its surface, the question as to the nature of this material still remains to be solved. Is it virgin iron or pure magnetite, or is it merely a magnetic rock of the same nature and properties as the basalts which are found in Skye and Mull? There is, of course, no *a priori* reason why all these different materials should not be active, some in one place and some in another.

As regards the United Kingdom I have, both in a Paper on the Permeability of Magnetic Rocks and in the description of the recent survey, made calculations which tend to prove that, if we suppose that the temperature of the interior of the earth is, at a depth of twelve miles, such as to deprive matter of its magnetic properties, and if we further make the unfavourable assumption that down to that limit the susceptibility is constant, the forces which are observed on the surface are of the same order of magnitude as those which could be produced by large masses of the ordinary basalt or gabbro. It would not, however, be wise to generalise this result, and to assume that in all places regional disturbances are due to basic rocks alone.

We know that local effects are produced by iron ore, for the Swedish miners seek for iron with the aid of the magnet, and in some other cases magnetic disturbances of considerable range are so intense as to suggest that material of very high magnetic permeability must be present. If the concealed magnetic matter were iron, and if it were present in large quantity, it is evident that the results of experiments with the magnetometer and dip circle might be supplemented by observations made with the plumbline or pendulum. In such a case the region of magnetic disturbance would also be a region of abnormal gravitational attraction. An account of a suggested connection between anomalies of these two kinds occurring in the same district has lately been published by Dr. Fritsche.*

Observations made about 30 years ago by a former director of the Astronomical Observatory in Moscow led to the conclusion that throughout two large districts to the north and south of that city the plumbline is deviated in opposite directions. The deflections from the vertical are very considerable, and indicate a relative defect in the attraction exerted by the rocks in the neighbourhood of Moscow itself, and the suggestion has been made that there is either a huge cavity—a bubble in the earth-crust—under the town, or that the matter beneath it is less dense than that which underlies the surface strata on either side at a distance of 10 or 12 miles.

As long ago as 1853 Capt. Meyen made magnetic observations in order to determine whether the same district is also the seat of any magnetic irregularity. His stations were hardly sufficiently numerous to lead to decisive results, but the magnetic elements have recently been measured by Dr. Fritsche at 31 places within 50 miles of Moscow. The experiments were all made within 11 days, so that no correction for secular change is required. They indicate a locus of magnetic attraction running through Moscow itself. South of the town the disturbance again changes in direction so as to show either that repulsive forces are in play, or that there is another magnetic ridge line still further to the south. Dr. Fritsche thinks that these observations explain the gravitational anomalies without recourse to the somewhat forced hypothesis of a vast subterranean cave. He assumes that there is a concealed mass of iron which approaches near to the surface at Moscow, and also along two loci to the south and north of the city. He attributes the magnetic irregularities to the attraction of the central iron hill, the deflections of the plumbline to the flanking masses. It is, perhaps, not inconceivable that such results might follow in a special case, but without the support of calculation it certainly appears that the magnetic experiments point to the existence of the principal attracting mass under the town. This is, in fact, the arrangement shown in the figure with which Dr. Fritsche illustrates his hypothesis. If this is so, the theory would *primâ facie* seem to require that the bob of a plumbline should be attracted towards and not—as is actually the case—away from the centre of the magnetic disturbance. On the whole, then, though the coexistence of large magnetic and gravitational disturbances in the same place is suggestive, I do not think that they have as yet been proved to be different effects of the same hidden mass of magnetic matter.

In a few weeks an International Geodetic Conference will meet at Innsbruck, at which the Royal Society will be represented. It is, I believe, intended to extend the detailed investigation of the relations between the nature of the earth's crust and the gravitational and magnetic forces to which it gives rise. We may, therefore, hope that special attention will before long be given to localities where both may combine to give information as to facts outside the range of the ordinary methods of geology.

The second phenomenon on which more light is desirable is the permanent magnetisation of magnetic rocks. It is known that fragments of these are strongly but irregularly magnetised, but that the effect of very large masses at a distance appears to be due to induced rather than to permanent magnetism. There are three questions to which I should like an answer. Are underground masses of magnetite ever permanently magnetised? Are large areas of surface masses, say a few hundred square yards in extent, ever permanently and approximately uniformly magnised in the same sense? Is there any relation between the geological age and the direction of the permanent magnetism of magnetic rocks?

Inquiries such as these can only be taken up by individual workers, but I venture to think that the comparison of the observatory instruments, and the fluctuations of secular change outside the observatories, could best be investigated under the auspices of a great scientific society. The co-operation of the authorities of the observatories will no doubt be secured, but it is most important that the comparisons should in all cases be made with one set of instruments, and by the same methods. Whether the British Association, which for so long managed a magnetic observatory, may think that it could usefully inaugurate the work, it would be improper for me in a Presidential Address to forecast. Who does it is of less importance than that it should be done ; and I cannot but hope that the arguments and instances which I have to-day adduced may help to bring about not only the doing of the work, but the doing of it quickly.

* "Die magnetischen Localabweichungen bei Moskau und ihre Beziehungen zur dortigen Local-Attraction," *Bulletin de la Société Impér. des Naturalistes de Moscou*, 1894, No. IV.

Priming Tests.—In a letter to the *Engineering Record*, Prof. R. C. Carpenter, of the Sibley College, Cornell, states that in testing the quality of steam as regards priming by the calorimeter method, erroneous results will be obtained if the calorimeter supply is drawn from a horizontal pipe. Experiments made at Cornell showed that when flowing through such a horizontal pipe the steam at the bottom of the pipe contains much more water than at the top of the pipe. When the moisture exceeds 1 per cent. it collects in the form of drops on the sides of the pipe, and when more than 2 per cent. is present it can, with suitable arrangements, be seen flowing along the bottom of the pipe in a separate stream, the main body of the steam being clear and transparent, until the amount of moisture present was still further increased, when it became hazy and foggy. The best place from which to draw off steam for a calorimeter determination is from a vertical pipe, at a distance below a bend or elbow equal to about three diameters of the pipe.

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TITLES.

Some few weeks since an esteemed engineering contemporary lifted up its voice against what it was bold enough to call the "ignoble" style of latter-day technical literature, and announced its readiness "to sacrifice some little brevity for the sake of a little more grace." In this, as in other matters, an ounce of practice is worth a pound of precept; but up to the time of going to press the increased lucidity and added grace of our contemporary's editorial columns have eluded our most careful observation. However, let that pass. The phenomenon of a staid engineering publication devoted to the interests of the "practician" vigorously pleading for a certain amount of style in engineering books is at once so unusual and so encouraging that anything approaching banter is not to be thought of. For our own part we should be content to forego style—in the strict literary sense of the word—if only we could obtain the twin blessings of clearness and conciseness in text-books, treatises, and technical papers, though we cannot go so far as a certain paradoxist who obstinately defended the position that it matters little what a man has to say so long as he makes his meaning clear, and that within the limits of the C.G.S. unit of area. Style is a most useful ancillary in the case of scientific writings intended to be understanded of the people; indeed, it is there perhaps the prime consideration; but literary gems would seem a little out of place in "An Experimental Investigation of the Circumstances under which a Change of the Velocity in the Propagation of the Ignition of an Explosive Gaseous Mixture takes place in Closed and Open Vessels." Mere brevity and lucidity would satisfy us here.

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Closely allied to this question of style is the choice of suitable titles for our scientific lucubrations. A contempt for titles is generally taken as evidence of a superior mind, and it is this consideration very possibly that gives us such stupendous superscriptions as the one just quoted. It should, however, be borne in mind that "small matters win great commendation," and a title which arrests attention, indicates the purport of the Paper, and last but not least admits of easy indexing, has its value and is worth a little thought. To make a scientific discovery requires apparatus, skill, training, good luck; to make it known requires pen, paper and perspicuity; and to hand it down to posterity, after intrinsic worth, nothing avails better than a felicitous label; "in fame of learning, the flight will be slow without some feathers of ostentation."

There is fashion in titles as in all things else. In the dawn of modern physical science there was a charming directness and freshness about the titles of scientific papers. Dip for a moment into HAUKSBEE's "Physico-Mechanical Experiments," which he dedicated in 1709 to "my Lord Sommers"; "The Attrition of Glass on Oyster-Shells"; "Concerning some very uncommon effects of the Effluvia of Sealing Wax"; "An Account of an Experiment concerning the quantity of Air produced from a certain quantity of Gun Powder fired in Common Air," are the quaint and expressive finger-posts that catch the eye. The *Philosophical Transactions* for the same period exhibit almost the same characteristics in this matter of titles, though here and there one is pulled up suddenly by a strikingly modern superscription such as the "Infinitely-infinite Fractions" of a certain Dr. J. WALLIS, for which amends is promptly made by ANTHONY LEEUWENHOCK, who, in 1722, investigated the painful case of the "Magnetism acquired by Iron standing long in the same position." In October, 1748, we may remark in passing, "some gentlemen of the R. S." made many curious experiments in order to measure the absolute velocity of electricity. They stretched on dry sticks a line of iron wire of a total length of 2¼ miles 6 chains, or 12,276ft. Into this circuit they brought an "electrified phial" and "two gentlemen of the R.S.," one being at the "phial" end of the line, and the other at the earth end. On the "phial" being discharged, the other gentlemen of the R. S. endeavoured to measure the interval of time between the jump of the gentleman at the near and that of the gentleman at the distant end of the circuit. Obvious conclusion: "velocity of Electricity is instantaneous up to a distance of 12,276ft."

Coming to papers of a more recent date one might classify their titles under the headings of the picturesque, the vaguely mysterious, the dubious, the synoptical. We must confess to have had a slight *penchant* for the picturesque type of title until the danger of using "unmeaning catch words" was writ large in the columns of the *Glasgow Herald* a few days after the reading before the Physical Society of London of a Paper entitled "Electric Splashes," which interesting little discourse on Lichtenberg figures was considered across the border to "furnish powerful arguments in favour of the fluid theory of electricity." And when "Electric Splashes" were followed by "Electrical Evaporation" we straightway purged ourselves of our heretical leanings, lest we should be treated to a naval memoir dubbed "Side Lights on Search Lights." The vaguely mysterious type of title, on the other hand, possesses an undoubted advantage; it rouses curiosity. Anything, or nothing, may be wrapped up in contributions to contemporary science labelled "The Nature of Depolarisers," "A New Photometer," "A New Phenomenon," "A Sensitive Cell." The dubious style of title, however, is scarcely less effective from this point of view. "A Note on the Antecedents of Clerk-Maxwell's Electro-dynamical Wave Equations" seems to denote a grave scandal of some sort; and in "Matrices which represent Vectors" we obviously ought to have concrete representations of vectors in three dimensions, neatly moulded in plaster of Paris. Science and mathematics are at all times the bane of the typographer; but it is not until he is by way of being an artistic typographer, and encounters a sample of the synoptical variety of title that he yearns for fresh fields and pastures new. The author of one of the most interesting Papers read of late years before the Institution of Electrical Engineers endeavoured—misguided man—to sum up his investigations in his title; hence came "On the Prevention and Control of Sparking; Continuous-Current Dynamos without Winding on the Field Magnets and Constant-Pressure Dynamos without Series Winding," a portentous result only surpassed by that of a Colonel COOK, who just 150 years before read a Paper to the Royal Society, which he was good enough to christen "A Proposal for warming Rooms by the Steam of boiling Water conveyed in Pipes along the Walls: And a Method of Preventing Ships from leaking whose bottoms are eaten by the Worms."

No classification of titles, however, would be complete without a specimen—a single specimen is all our founts permit of—of the kind of title often adopted by those who "when they know within themselves they speak of that they do not well know, would nevertheless seem to others to know of that which they may not well speak," at any rate such it seems to us must be the origin of—Tetramethyldiamidotriphenoylmethane-ortho-carbonate of methyl—which afforded—well, food for thought—in a recent number of the *Comptes Rendus.*

MOTIVE POWER AND GEARING.*

BY E. TREMLETT CARTER.

(Continued from page 352.)

The Performance of Boilers.

Performance during Full Load Trials.—The information which is obtained through systematic boiler trials affords data which may be of considerable use to the engineer. At the same time, there is a great deal of misplaced confidence in such information; and it is only where the conditions of trial have been carefully specified, and the trials have been conducted by an unbiassed engineer competent to carry them out, that any great reliance can be placed upon the results. We have previously remarked the discrepancy which may arise between the conditions of a careful full-load trial and the actual conditions of working, a discrepancy which is often sufficient to render the conclusions derived from the former inapplicable to the latter case. Still, in order to have exact knowledge of the suitability of any given boiler, fired with any given class of fuel, it is necessary to know what the boiler can do (1) on full load, (2) on fractional loads, (3) when forced above full load, (4) when standing-by, and (5) when being got under steam. Unfortunately, the attention of expert engineers has been much more directed to the determination of the first point than to the remaining points; and our knowledge as to these latter is as meagre as that of the former is, perhaps, too abundant. During a full-load trial the conditions of firing and steaming are kept as steady as possible, and the engineer is constantly on the alert to prevent loss of fuel or heat at any place. The results are, therefore, generally superior to those which can be obtained in practice, even where the boiler is, in practice, always maintained at full load.

Miscellaneous Boiler Trials.—As it is not necessary to enter into full particulars of trials of electric power

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station boilers, the author has compiled the following Table of the principal results of a number of miscellaneous trials. It is to be regretted that it has been found impossible always to give results of full-load trials in actual electric power stations, in the case of these boilers; but the conditions are sufficiently similar to render the table of some value, at any rate :—

Miscellaneous Boiler Trials.

Type of boiler.	Class of coal.	Pounds of coal per sq. ft. of grate per hour.	Evaporation from and at 212°F. per lb. of coal.
Galloway	Steam coal.	18	12·15
Ditto.	Ditto.	19·7	10·75
Lancs. with Galloway tubes	Welsh.	15·9	12·02
Ditto.	Newcastle.	19·8	10·27
Ditto.	Durham.	18·3	9·81
Ditto.	Bituminous slack.	18·8	9·10
Ditto.	Ditto.	20·2	8·40
Ditto.*	Wigan slack.	24·1	10·13
Ditto.†	Seaborne, rough, small.	20·3	10·59
Marine.	Welsh.	18·4	12·00
Ditto.	Newcastle.	16·4	9·85
Ditto.	Ditto.	18·8	8·56
Locomotive.‡	Welsh.	11·21	12·96
Ditto.‡	Ditto.	20·90	10·14
Ditto.§	Steam coal.	68·00	12·00
Ditto.§	Ditto.	90·00	10·19
Ditto.§	Ditto.	76·00	10·12

Reduced Loads.—There are no exact data of the economy of boilers when working at a given fraction of full load; and it is very important that this question should be systematically threshed out by competent engineers, by means of a series of careful trials. It is probable that there is a certain load, which ought to be the normal load, at which the evaporative efficiency is highest, and that there would be a steady fall in efficiency as this load was more and more departed from; and it is probable that this would be the case whether the departure was due to a fall below or a rise above the best load. There are certain losses in the boiler, such as those due to radiation and conduction, which may be considered to be fairly constant at all loads. Other losses, such as priming and the loss of heat up the chimney, increase rapidly as the load is raised. The loss due to the heating of diluent air in the furnace probably, in most cases, falls as the load rises, because less air is required per pound of coal where the consumption is more vigorous. Again, it is certainly more difficult, where the stoking is done by hand, to regulate the furnace economically at very low loads; and this difficulty varies with the character of the fuel. Most human stokers look after a furnace more economically with dry fuel than with smoky fuel, where the load is very low. This difficulty does not occur with mechanical stokers. The two principal elements which determine whether a furnace is doing its best, at any load, are (1) the amount of opening given to the dampers, and (2) the thickness and uniformity of the fuel on the grate. Directly a boiler is to be put on reduced load the dampers should be lowered and the fire evenly thickened, the damper being finally adjusted so as just not to give rise to smoke. If the draught is produced by a blower the force of the blower should be reduced; but the fire must be increased in thickness and the damper lowered as well, or the combustion will be uneconomical. The increase in the thickness of fuel on the grate, and the amount of lowering of the dampers, must vary directly with the fall in the steaming rate of the boiler.

Absolute Efficiency of Steam Generators.—The steam boiler has the credit of being considered by engineers to be a very efficient appliance; but it requires only a little investigation on scientific lines to reveal the fact that this credit is entirely misplaced, and that the steam boiler is a most inefficient and wasteful adjunct to power plant. Indeed, a very large proportion of the loss in steam plant takes place in the boiler or, to be more correct, between the boiler and the furnace. The praise which has been lavished upon boilers has taken its authority in the large percentage of the heat of the fuel which is imparted to the steam raised by that fuel. We may rightly assume that a good boiler, working at full load, will raise 10lb. of steam for every pound of good coal burned on the grate; the feed water being supplied to the heaters at 60°F. and evaporated at 200lb. pressure (388°F.), and the total thermal value of 1lb. of the coal being assumed to be 14,500 B.T.U. On this basis, we see that as much as 11,720 B.T.U. is imparted to the 10lb. of feed water in generating the steam; a figure which represents about 80 per cent. of the total heat of the fuel. Only 20 per cent., or 2,780 B.T.U., is wasted in radiation and other losses, and in developing the draught. Accordingly, it has been said that the thermal efficiency of a good boiler may be as high as 80 per cent. !

The argument is specious, but utterly wrong. Of what use is it that the boiler should turn out 80 per cent. of the total heat of the fuel, when it turns it out in such a form that only a very small fraction of this percentage can possibly be utilised for doing work? The mere fact that 80 per cent. of the heat passes through the heating surfaces into the water, and passes with the steam along the pipes to the engine, is not an adequate performance. In order to have a true efficiency of this value the boiler should serve up the heat in such a form that 80 per cent. of the total heat is really available for doing work in an engine. Let us see what the real efficiency of a steam generator amounts to.

We have said that, of the 14,500 B.T.U. in one pound of coal, some 11,720 enters the steam. Now, the temperature of the steam (at 200lb.) is 388°F.; and the thermal energy of the steam is only available from this temperature down to (say) 60°F. Therefore, the total available heat in 10lb. of steam is, by equation (67),

$$11{,}720 \times \left(\frac{388-60}{388+460}\right) = 4{,}524 \text{ B.T.U.}$$

But 4,524 B.T.U. is only 31 per cent. of the total heat of combustion of the pound of coal. Instead of 80 per cent., therefore, only 31 per cent. of the heat is available from the coal, when we employ a steam boiler to utilise it. It is interesting to note that 4,524 B.T.U. is the total heat of combustion of about five ounces of good coal.

We may localise the source of this tremendous loss of efficiency, a loss amounting to 69 per cent. In the furnace there may be a temperature of some 3,000°F., in the boiler the temperature is but 388°F.; consequently, about 12,324 B.T.U., or 85 per cent., is available in the furnace, whereas only 4,524 B.T.U., or 31 per cent., is available in the boiler. The passage of the heat through the fraction of an inch which represents the thickness of the useful heating surface is sufficient to cause a drop in the efficiency from 85 down to 31 per cent.!

We ask: How shall this unhappy state of affairs be remedied; how shall we obtain a steam generator which will yield us a very much higher percentage of heat in an available form? Since it is improbable that we can improve the efficiency of a good boiler by the process of getting more heat into the steam—because there is already as much imparted to the steam as we may expect to impart—the only way to raise the efficiency is to develop the *availability* of the heat, *i.e.*, to generate the steam at a higher temperature. To do this, we must either develop a much higher steam pressure, or else we must superheat the steam with the furnace heat. Both these methods are open to practical objection, so that probably we must be content with an efficiency never exceeding, and often very far inferior to, 31 per cent.

Some writers have attributed the great inefficiency of steam plant to the engine, not to the boiler. That the boiler and not the engine is principally the culprit is evident from the fact that if we wish to cause a considerable rise of efficiency, we must improve the boiler; there is not so much need to improve the engine.

As we shall presently see, the engine in steam plant is by no means as perfect as it might be made; but, at the same

* The fuel was mechanically stoked with Vicars' stokers. This trial was conducted at Warrington, by Dr. Markel.

† Vicars' stokers were used. This trial was conducted at Falcon Wharf hydraulic-power station, by Mr. E. B. Ellington, M.I.C.E.

‡ These trials were made by the Royal Agricultural Society.

§ These boilers were under forced draught from a steam-blast.

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time, any radical improvement in the thermodynamic efficiency of the whole plant can only be made by means of radical improvements in the boiler and furnace.

It must not be forgotten that boiler plant is usually far from evaporating 10lb. of water for every 14,500 B.T.U. developed in the furnace; also that steam is often raised at lower temperatures than 388°F. Consequently, when the average performance throughout a day or a year is considered, the thermal efficiency of steam raising is always below 31 per cent.—sometimes as low as 5 per cent. At this last figure, the available units of heat amount to 72·5 B.T.U. per pound of coal; which is approximately the heat of combustion of one-twelfth of an ounce of good coal. Hence, although there is little hope of improving the present best, there is plenty of room for possible improvement in the present average performance of boilers. It is in this fact that the hope of higher economy in steam-driven electric power stations must chiefly rest. There is, as Prof. Kennedy has pointed out, far more difference between the present best and the present average performance, than there is between the present best and the best possible. In a lesser degree, these remarks apply also to the engines.

(To be continued.)

ON IMPULSIVE CURRENT-RUSHES IN INDUCTIVE CIRCUITS.

BY ALFRED HAY, B.SC. (EDIN.).

(Concluded from page 394.)

§ 21. From the experiments described in the preceding paragraphs it will be seen that the phenomenon of impulsive current-rushes is a very frequent and general one, and that the cases in which there is no distortion of the initial current-waves are the exception rather than the rule. In circuits of constant permeability these current-rushes never reach any very high value, the greatest value of the abnormal current being always less than twice the maximum value of the normal current. In the case of circuits containing iron, on the other hand, we may have enormous rushes; even when the iron is worked at a very low magnetic induction, the maximum value not exceeding 500 C.G.S. lines per sq. cm., the current rush is much greater than could occur in a circuit of constant permeability. As the normal maximum of magnetic induction increases, the current-rush increases very rapidly, so that with the older types of transformers, in which the normal maximum frequently exceeded 6,000 C.G.S. lines per sq. cm., we should expect some very extraordinary rushes. With *very low* degrees of magnetic induction, the initial state of the iron does not very seriously affect the current-rush. But with moderately high degrees (say, from 2,000 C.G.S. lines per sq. cm. upwards), such as are used in transformers of modern construction, the initial state of the iron very materially influences the amount of the "rush."

§ 22. With regard to the effect of varying the periodicity, it has been stated by some experimenters that current-rushes do not occur at high periodicities. The periodicity used in the experiments described above was rather high—122 ∿ per second—and we see that very large current-rushes may occur at this periodicity. It has also been pointed out in § 11 that in the case of circuits of constant permeability, a change of periodicity, so far as it has any appreciable effect at all, tends to *increase* the current-rush. *Statistical* experiments have been described which seem to show that *under ordinary conditions, with a more or less slow-acting switch*, current-rushes may be to a large extent reduced by increasing the periodicity. In the writer's opinion, this effect is due, not to a change in the periodicity directly, but to the simple fact that, with an ordinary switch, the point of making contact becomes more and more indefinite as the periodicity increases; and, unless contact is made at a definite point of the E.M.F. wave, no large current-rush need be expected.

§ 23. We shall now give a description of the special switching arrangement by means of which the results described above have been obtained. As already mentioned, the alternator used was one of the old Ferranti pattern, with two driving pulleys, one at each end of the armature spindle. One of these pulleys was removed, and the length of spindle exposed was sufficient for carrying the switching and contact-making apparatus. A diagram of the connections of the switching apparatus is given in Fig. 13. G S is a graduated scale, which is insulated and supported by wrought-iron standards attached to the frame of the alternator. This scale carries two sliders, S and S_1, to which are attached the brushes B and B_1; each slider is provided with a terminal and a clamping-screw. The actual arrangement used is shown in Figs. 14 and 15 (where all unnecessary detail is omitted, so as to show

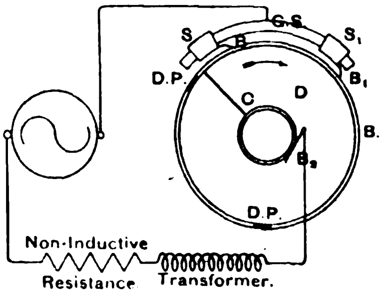

FIG. 13.

the essential parts more clearly). A wooden disc, D, is keyed to the alternator spindle, and is provided with a brass rim, B R, which consists of two unequal portions separated from each other by distance-pieces, D P (Fig. 13) of vulcanite. The larger portion of the rim is the active one, the other being attached merely for the sake of true running. A small cylinder of hard wood carries the collar, C, which is in metallic connection with the active portion of the brass rim, B R of the disc. A brush, B_2, bears on this collar; the remainder of the connections are easily made out from the diagram, Fig. 13. It will at once be seen that when one or both of the brushes B and B_1 bear on the active portion of the rim, the circuit is

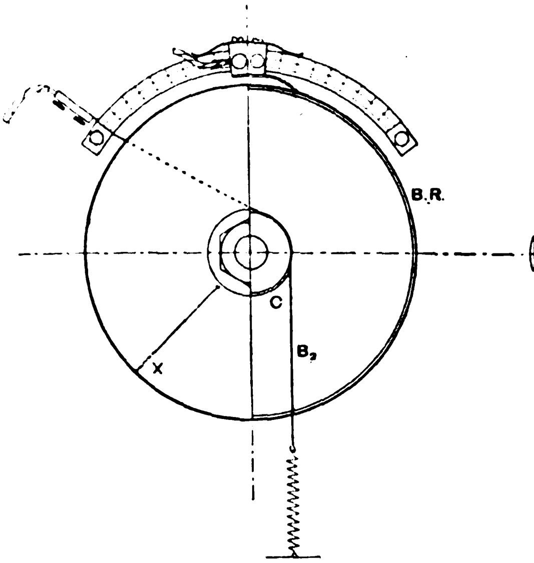

FIG. 14.

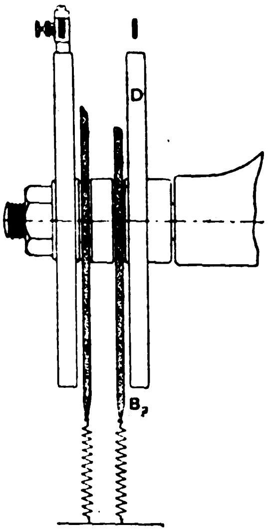

FIG. 15.

completed; but if both of them rest on the dummy portion the circuit is open. Again, as the disc revolves, the brush B is the first to *make* contact, so that by sliding B along the scale the instant at which the circuit is closed may be varied; the brush, B_1, on the other hand, is the last to *break* contact, and by sliding it along the scale the switching-off point may be controlled independently. The brushes marked B and B_1 consisted of several thicknesses of copper foil, while the brush marked B_2 was in the form of a long braided conductor of fine copper wires, which passed round the collar C, and was kept taut by means of a fine spiral spring. This is shown clearly in Figs. 14 and 15. Of the two discs there shown, the inner one is the switching disc; while the outer one, which has no

metallic rim, but merely a thin strip of brass, X (Fig. 14), let into it radially and connected to a collar, acts (after the manner first used by Joubert) as an instantaneous contact-maker, and may be used for obtaining the shape of the E.M.F. and current curves, in accordance with the method described in § 2.

When the switching disc is in action, the current is switched on and off cnce in every revolution. Hence, if there are any abnormal waves of current, they will be reproduced once in every revolution of the disc. A state of forced vibration is thus kept up, the abnormal waves being periodically started and arrested. These abnormal waves can, however, be only allowed to run through a limited number of periods—the greatest number possible with the arrangement of apparatus described being about 6½ periods. The number of periods during which the current may be kept on obviously depends on the number of poles in the alternator.

The switching arrangement just described may be applied to the study of the abnormal waves which make their appearance in inductive circuits possessing capacity as well as self-induction. It is the writer's intention so to use the arrangement, and to supplement the experiments described in these articles by others in which the iron is pushed to a much higher magnetic induction; also, to investigate the effect of varying the periodicity. In the meantime, the above sketch of the apparatus used and results obtained must suffice.

In concluding the present series of articles, I desire to express my obligations to Professors Robinson and Heaton for encouragement in the work, and every facility afforded for carrying out the experiments.

PREPARATION OF SOLUTION FOR ACCUMULATORS.

BY H. M. SAYERS.

In erecting a battery of accumulators abroad the writer had to face the question of preparing the electrolyte on the spot, as shipping it was impracticable. There are obviously some difficulties in making a large quantity of acid solution, and distributing it to the cells; and as it is injurious to the plates to be in the acid for more than a very few hours before charging is commenced, it is necessary to make the whole quantity needed and have means of distributing it at once. In this case about 600 gallons of solution of a density of 1215 was needed.

Slate, being cheap in the neighbourhood, was selected for the mixing-tank, which was made of sufficient size to contain about 25 per cent. excess of liquid. It was made in the usual way, the bottom being grooved to receive the four slabs forming the walls, and the two longer of these slabs being grooved to receive the ends of the others, the whole held together by iron bolts and nuts passing through the overlapping ends of the two longer walls. As the tank was put together the grooves were all painted thickly with anti-sulphuric enamel, and caulked with red lead putty inside and out. The whole innner surface was then painted with two coats of anti-sulphuric enamel and received two pretty thick coats of asphalte, as used for waterproofing walls, put on hot, the angles being all rounded. The tank has given no trouble by leaking. The discharge cock is of ebonite, and put in 6in. above the tank bottom to avoid taking off any sediment. The tank stands on a strong wooden framing, sufficiently raised from the floor of the battery room for the acid to flow by gravitation into the cells, with the tank nearly empty to the cock level. The solution was distributed to the cells by means of a strong rubber hose and some ebonite tubing of 1¼in. diameter, and a bib-cock on the end of the hose. Filling 60 cells with 10 gallons each of fluid took about six hours, and there was an entire absence of slopping on the floor, connections, &c.

The tank had about 4·096 cubic metres, or 144·77 cubic feet capacity, being 1·60m. (5ft. 3in.) cube inside. Taking the mean of two or three tables, acid of 1215 specific gravity at 15°C. has 29·6 per cent. of monohydric sulphuric acid, this last having 1842 specific gravity at the same temperature. Calculations gave the result that on this basis the tank should be filled to a height of 1·27m. (3ft. 11⅛in.) with water, to which should be added 1,367 kilos (3,007lb.) of the strong acid, which should give about 3·810 cubic metres of solution. The 600 gallons for the cells being equal to 2·73 cubic metres, the difference made up the space from the bottom to the tap level, and 20 per cent. extra for stock.

The acid used was from the St. Gobain works in France, and was purchased on the spot. As railway and steamship people impose troublesome regulations about transport of acid, which make the freight for small quantities very expensive, it was not practicable to order it specially. The acid marked 1,840 special gravity was of very good colour, and fairly pure. As it was slightly under the 1842 of monohydric acid about 1,375 kilos. were used. The special gravity of the resultant solution at 15°C. was very exactly 1215.

The tank was filled with water to the calculated height, and the carboys emptied into it one at a time, slowly and at intervals. Two days were allowed for this mixing, half the acid being put in each day, to avoid excessive heating. The temperature was checked by a thermometer, and thus never rose above 40°C. The tank took three days to cool down to the air temperature. A test of the solution showed that it contained a distinct amount of metals of the "arsenic and copper groups," mostly arsenic apparently, but no detailed analysis was made. Iron was also present, but is not considered prejudicial to cells as far as the writer knows. It was thought advisable to get rid of the arsenic, &c. To precipitate these metals by the passage of sulphuretted hydrogen would have been a most annoying and troublesome process, and seemed impracticable for various tolerably obvious reasons.

The following plan was thought of and carried out. Sulphuretted hydrogen was prepared in the ordinary way in a hydrogen generator as used for lead-burning, connected to a small gasholder, to allow of regulation of pressure of the gas. This hydrogen generator and gasholder had served for the lead-burning needed in erecting the battery, and were therefore at hand. From the gasholder a branch was connected on to a lead tube soldered into the centre of a sheet of lead a foot square, with the edges turned downwards. This was immersed in a lead battery box, the corners of the lead tray or sheet being supported an inch or so above the bottom of the box. The box was filled up with a strong solution of caustic soda, about 22lb. in about five gallons of water. The tray obliged the gas to pass over a large surface of the soda solution before it had a chance of escaping upwards. The pressure on the gasholder was then adjusted until only a very occasional bubble escaped from under the tray, thus ensuring as nearly as possible a complete absorption of the gas by the soda. As a matter of fact, very little gas escaped, and no serious annoyance was caused in the building. A solution of a sulphide of soda was thus prepared, and this was added in small doses to the sulphuric acid solution, a funnel with a leaden pipe reaching to the tank's bottom being used, to ensure a complete action on the whole body of liquid. Each addition of this solution produced a most violent agitation in the acid liquid, and promoted its complete mixture better than hours of paddling would have done, though a paddle was also used during the two days of mixing. The liquid was very turbid after this treatment, but settled in the course of three or four days, the sulphides precipitated falling below the cock level of course. The clear liquid gave no precipitate with sulphuretted hydrogen, showing its freedom from the objectionable metals. About 30lb. of crystallised sulphate of soda was added to the solution afterwards.

It may be claimed for the use of the sulphide of soda that it purifies the acid with a mere fraction of the inconvenience resulting from the use of hydrogen sulphide, especially when it can be bought ready made; that it is very cheap, much cheaper than sulphide of barium, which has also been used for the purpose; that it introduces no useless or prejudicial substance into the solution, but that the sulphate of soda resulting is well known to be beneficial to the cells; and that it robs the solution of no acid as the barium sulphide does.

The battery for which this solution was made has been in use over a year, giving very good results, partly due, certainly, to the absence of objectionable metal in the electrolyte.

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The purple or permanganate-like colouration during charging is very pronounced in these cells. It seems to the writer to be produced solely at the positive plates, which it envelopes like a thick skin during the middle part of the charging time, slowly diffusing with the circulation of the acid at the sides and ends of the cell, but always keeping away from the negative plates. It would, therefore, seem to be a result of oxidation, probably of iron present in the solution. Possibly the presence of sodium may assist in its production; but, as the writer has not investigated the matter, these are only guesses, of little value except for basing experiments on.

It may be added that the preparation of these four tons of strong acid solution was carried out without material damage to person or property, the worst accident happening to a man who kicked over an opened carboy, and fell on top of it. His nether garments were a sad sight afterwards. A large quantity of whitening was kept at hand for the purpose of soaking up any acid spilt. This is better than soda, ammonia, or sawdust, because it is very cheap, and both neutralises the acid, and remains in a solid state easily removed and inoffensive. It should be kept in every battery room. A bottle of ammonia for application to clothes and skin in case of need is an obvious precaution; but for acid on the face or other tender part plentiful cold water at once, and oiled rags afterwards if the skin is destroyed are the best remedies. The writer once got strong sulphuric acid in one eye, but immediate and forcible application of cold water prevented permanent damage.

OBSERVATIONS ON THE GRADIENT OF ATMOSPHERIC POTENTIAL AND ON THE RADIATION OF ULTRA-VIOLET LIGHT FROM THE SUN.*

BY JULIUS ELSTER AND HANS GEITEL.

It has been conjectured by von Bezold and Arrhenius that the phenomena of atmospheric electricity are directly connected with solar radiation. The discovery by the authors of the photo-electric action produced on various substances by the most refrangible rays of sunlight (called *ultra-violet* for the sake of brevity), appeared to confirm this view, and led them to investigate the matter experimentally. After constructing a photometer based upon the discharge of electricity by light, they commenced in Wolfenbüttel a series of observations of ultra-violet radiation from the sun on clear days, which extended from September, 1889, to October, 1891. Some of the observations (July, 1890) were made at the Sonnblick Observatory, or its low-level station of Kolm-Saigurn. Along with these measurements they determined by Exner's method the intensity of the earth's electric field at hourly intervals when the weather permitted. The first section of this Paper treats of the measurements of atmospheric electricity, the second of the construction and trial of the photometric apparatus; in the third section the electric and photometric observations are compared, and the fourth part deals with the absorption of ultra-violet light by the atmosphere.

The gradient of atmospheric potential was determined in absolute measure as follows: A beam protruding from a window supported a burning petroleum lamp at any one of five measured distances from the wall. The lamp was connected to the leaves of a calibrated Exner electroscope, and served to equalise the potentials of the air and the leaves; the outer case of the electroscope was put to earth by connecting to a gas-pipe. Readings were taken at each distance, and a correction was made for the disturbance produced by the wall of the house; all observations were reduced, so as to give the potential difference between the earth and a point in free space 100cm. above its surface. The atmospheric potential was found to be greatly disturbed during the formation of clouds or rain; the observations made within the two hours preceding such formation were therefore rejected. On the other hand, isolated cirrus clouds, and such as were not being precipitated, gave rise to no appreciable disturbances. On very windy days it was impossible to keep the lamp alight, and observations were suspended; but with a moderate wind the readings taken at still moments agreed among themselves.

The results are discussed from two points of view—(1) with reference to the values of the potential gradient at different times of the day or year, (2) with regard to the relation between potential gradient and humidity of the air. The highest monthly average of potential gradient occurs in December, its value being 470 volts per metre; it falls more or less continuously to 102 volts per metre in June, and then rises again until December (*see* Fig. 3, electrometer readings). With the exception of three extremely cold days in December, 1890, the air was always found to be positively charged, the negative charge on these days being possibly due to the friction of frozen snow particles blown over the ice surface of the earth by a strong S.E. wind. The hourly observations during the winter months November—March showed the potential gradient to be higher in the evening than in the morning, reaching a maximum generally about 9 or 10 p.m.; the curves for these months are, however, very irregular. In the summer months much greater regularity prevails, a high value in the forenoon decreasing to a low minimum at sunset, or (in the case of June and July) a few hours before sunset.

* Abstracted from *Wied. Ann.*, XLVIII. (1893), pp. 338-373. By Dr. James L. Howard.

In comparing potential gradient and humidity, the records of the meteorological station at Brunswick were made use of to furnish the values of the latter. According to a theory of Exner the relation of potential-gradient, P, to humidity, q, is given by $P = A/(1 + \kappa q)$, where κ and A are constants, and q is measured as the number of grammes of moisture in a cubic metre of air at the earth's surface. As long as q is less than 8·0, the results confirm Exner's theory, but for greater values they differ entirely from it.

In order to determine the intensity of the ultra-violet solar radiation an actinometer was constructed, the action of which depends on the photo-electric properties of these rays. A surface of chemically-pure amalgamated zinc connected to a negatively-charged electroscope was exposed to the sun's rays and the rate of disappearance of the charge was noted. It was found that a fresh amalgamation, followed by rubbing with dry tissue paper, served to almost completely restore the surface after exposure to light. By this device a surface having always the same composition and degree of polish was obtained, thus enabling the observations of different days to be compared. Preliminary experiments were undertaken to determine the relation between the intensity of illumination of the plate and the rate of disappearance of its charge. For this purpose a constant source of ultra-violet light was required, and was furnished by the sparks of a 2-cm. spark induction coil, the secondary terminals of which were placed about 1mm. apart and connected to the coatings of a Leyden jar. On completing the primary circuit short bright sparks appeared between the terminals of the coil and continued with great regularity until the circuit was again broken. Exposure of the zinc plate to light was effected by placing it in front of the terminals, and the time of exposure was reckoned from the instant of making the primary current to that of breaking it. The exposure box is shown in Fig. 1.

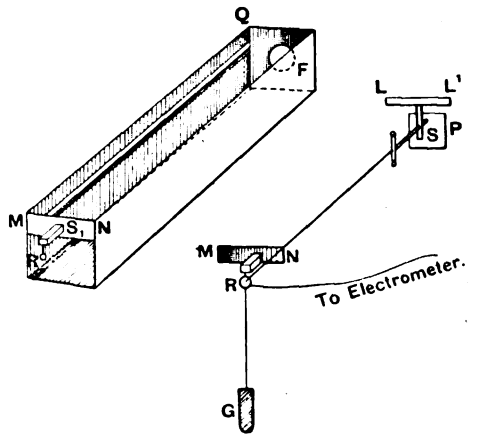

Fig. 1.—Experimental Ultra-Violet Actinometer.

The plate P is carried by a rod of sealing-wax S, which is fastened at right angles to a wooden cross-piece L L'. A wooden box about 100cm. long and 100sq. cm. in section (nearly square) is provided with a removable lid, and one of its smaller sides contains a circular window, F, about 2·5cm. in diameter, and glazed with transparent selenite. The opposite face is completely cut away with the exception of the narrow strip M N, on the outside of which a metallic ring R is fastened by means of a rod of sealing-wax S_1. The rod L L' can be slid along the box, and is supported by two projecting strips, one of which, M Q, is seen in the figure; P then swings freely without touching the sides of the box. A thin wire attached to P passes through the ring R to a small weight, G, which keeps it stretched. The connection to the electrometer is made at R. The electrometer used was an aluminium-leaf electroscope, provided with a graduated scale, and calibrated by charging from a battery of many cells. In order to screen the plate P and the electrometer from the direct electrostatic action of the induction-coil, a sheet of tin-plate about 21cm. in diameter, with a hole at its centre covered by fine iron-wire gauze, was inserted between the selenite window F and the terminals of the coil.

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The result of the preliminary experiments confirmed an assumption made by the authors that the change in the rate of discharge produced by light is proportional to the intensity of the light; the rate of discharge being taken as the ratio of the loss of charge per second to the original charge. The initial potential of the plate was usually about 230 volts, and the time of exposure to light amounted in some cases to two minutes.

With sunlight the much greater intensity of illumination would have necessitated an extremely short exposure of the plate. To avoid this, the electrical capacity of the electrometer and the exposed surface were increased by the addition of a small condenser, and the movable plate P was replaced by a fixed small amalgamated zinc knob. Two such actinometers were constructed of similar design; the knob of one was left exposed to radiation from all parts of the sky, and thus measured the total ultra-violet illumination falling upon any point, while the other had its knob surrounded by a tube which could be directed to receive the radiation sent directly from the sun. The latter form is depicted in Fig. 2.

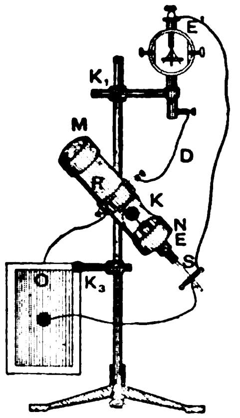
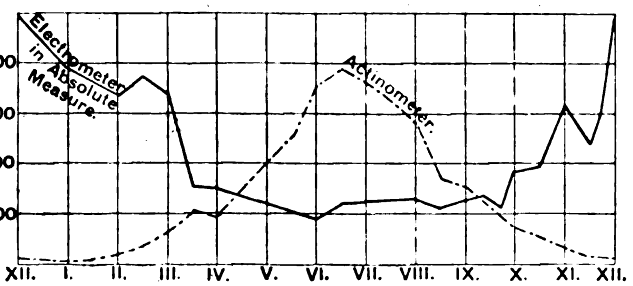


Fig. 2.—Solar Ultra-Violet Actinometer.

The apparatus consists of an upright rod carrying three clamp supports, K_1, K_2, K_3, by which the electrometer, exposure-tube, and condenser are respectively supported. One coating of the condenser, the exposure-tube, and the case of the electrometer are all connected together and earthed; the leaves of the electrometer, the knob K (insulated by ebonite at E), and the other coating of the condenser form the charged system. A charge is imparted by connecting to a dry-pile, and exposure is effected by taking off a cap which covers the end M of the exposure-tube.

The intensity of the ultra-violet radiation from sun and sky, as measured at noon, increases from a minimum in December to a maximum about 60 to 80 times as great during the latter half of June (see Fig. 3, dotted line); the value then falls again to the minimum in December. The curve is not symmetrical, the actinometer (at Wolfenbüttel) receiving more illumination from June to December than from December to June. This points to a sort of lag in the transparency of the air, analogous to that observed in connection with air-temperature and solar declination. The hourly observations show the same lag, afternoon readings being much greater than those taken at the corresponding time before noon; this phenomenon has been noticed in the case of the chemical rays also by M. Marchand at Fécamp. In March, April, September, and October the maximum intensity of ultra-violet radiation occurs before noon, and in March and April the curves show a well-defined depression at noon. Calorimetric and bolometric measurements have previously indicated a diminution in the sun's radiation at the time of its culmination (Crova and Houdaille, *Ann. de Chim. et Phys.*, 1890, p. 88).



Simultaneous Actinometer and Electrometer Observations. (Yearly Curves.)

Fig. 3.—Annual Variations of Atmospheric Potential-Gradient and of Ultra-violet Solar Radiation (dotted line). The abscissæ denote months of the year.

From the values of the atmospheric potential-gradient (P) and those of intensity of ultra-violet radiation (I) measured at the same time, the authors seek to establish an empiric formula connecting the two phenomena. The observations are fairly consistent with the relation $P = P_0 / (1 + \kappa I)$ where P_0 and κ are constants. A less satisfactory agreement is obtained when I is taken as the total diurnal illumination instead of the illumination at any particular moment. It is shown that if during the day the earth's surface discharges electricity into the layers of atmosphere vertically above it at a rate proportional to the intensity of its illumination, and if the night be long enough for the restoration of electric equilibrium, then the formula given above ought to hold good, taking I as the total diurnal illumination. Exact agreement of theory and experiment is hardly to be expected, since the rays which cause the earth's surface to lose its charge may not be the same as those which affect the zinc plate, *e.g.*, long waves may be effective in the case of the earth's charge. If such an electric convection be assumed its electro-magnetic effect would account for the diurnal variations of the magnetic elements; it has been shown by Schuster (*Phil. Trans.*, Vol. 80 (1889), p. 467), that these variations can be explained by the existence of electric currents in the atmosphere, the intensity of which depends on the sun's position.

During the experiments it was observed that the ultra-violet radiation was generally greater or less according as the air contained more or less moisture. As moist air is generally supposed to absorb ultra-violet light this seemed somewhat paradoxical. Experiment showed that the increased rate of discharge was not due to bad insulation, variation of temperature, or change in sensitiveness of the zinc surface; moreover, a similar observation has been made by Roscoe in the case of chemically active rays of sunlight. The authors consider that the presence of fine dust in the air is the cause of decrease in its transparency; on moist days, if dust is present, clouds form, and so prevent observation; but if the sky be clear and the air moist, the amount of dust must be very small, and consequently the air very transparent.

The concluding section of the Paper treats of the absorption of ultra-violet light by the earth's atmosphere. The intensity of the ultra-violet radiation received directly from the sun was measured for different values of the sun's altitude; from the measurements of each day the transparency of the air and the intensity of the radiation at its entrance into the earth's atmosphere were calculated. Experiments were made at Wolfenbüttel, Kolm-Saigurn, and at the summit of the Sonnblick. The results indicate a large amount of absorption in the upper and lower regions of the atmosphere, and a much greater transparency at intermediate heights. The authors explain this by supposing that nearly all the waves which the air can absorb are sifted out in the upper atmosphere, the rest passing on without much absorption. On reaching the lowest layers dust is encountered, and the intensity is diminished because of its presence. Similar irregularities in the absorption of solar radiation throughout the whole spectrum have been previously observed by Langley at Mount Whitneyins, and by Crova and Houdaille at Mont Ventoux.

BOOKS RECEIVED.

"The Gas, Water and Electric Lighting Companies' Directory." 1894. Price 10s. (London: Hazell, Watson and Viney, Limited.)

"The Magneto Hand Telephone." By Norman Hughes. (London: E. and F. N. Spon.) 1894.

"L'Eclairage à Paris." By Henri Marechal. (Paris: Baudry and Co.) 1894.

"Electricity, Electrometer, Magnetism, and Electrolysis," by G. Chrystal, M.A., and W. N. Shaw, F.R.S. (Reprinted from the ninth edition of the "Encyclopædia Britannica.") (London: Adam and Charles Black.) Price 5s. 1894.

"*Journal* of the Institution of Electrical Engineers." No. 113. Vol. XXIII. Price 4s. (London: E. and F. N. Spon.)

"Dynamo Attendants and their Dynamos." By Alfred H. Gibbings, A.I.E.E. Price 1s. (London: Sidney Rentell.) 1894.

"Die Prinzipien der Mechanik." Vol. III. of the collected works of the late Heinrich Hertz. Mk. 12. (Leipzig: J. A. Barth.) 1894.

"A Treatise on the Measurement of Electrical Resistance." By W. A. Price, A.M.I.C.E. Price 14s. (Oxford: Clarendon Press.) 1894.

A New Unit.—An American newspaper, in a description of electrical units, speaks of "the unit of injunction, called the henry." This unit is very well known in the electrical commercial world, though not by the name of henry. It is a unit which, perhaps, is a little too abundant. The standard unit is preserved at the law courts.

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BRITISH ASSOCIATION AT OXFORD.

LORD SALISBURY'S PRESIDENTIAL ADDRESS.

As Chancellor of the University it is my duty to tender to the British Association a hearty welcome, which it is my duty as President of the Association to accept. In presence of the high priests of science I am only a layman, and all the skill of all the chemists the Association contains will not transmute a layman into any more precious kind of metal. Yet it is my hard destiny to have to address on scientific matters probably the most competent scientific audience in the world. I bespeak some spark of the divine emotion of compassion in my attempt to discharge this duty.

The relations of the Association and the University are those of entire sympathy and goodwill, as becomes common workers in the sacred cause of diffusing enlightenment and knowledge. But we must admit that it was not always so. A curious record of a very different state of feeling came to light last year in the interesting biography of Dr. Pusey, which is the posthumous work of Canon Liddon. In it is related the first visit of the Association to Oxford in 1832. Mr. Keble, at that time a leader of University thought, writes indignantly to his friend to complain that the honorary degree of D.C.L. had been bestowed upon some of the most distinguished members of the Association. "The Oxford doctors," he says, "have truckled sadly to the spirit of the times in receiving the hodge-podge of philosophers as they did." It is amusing, at this distance of time, to note the names of the hodge-podge of philosophers whose academical distinctions so sorely vexed Mr. Keble's gentle spirit. They were Brown, Brewster, Faraday, and Dalton. When we recollect the lovable and serene character of Keble's nature, and that he was at that particular date probably the man in the University who had the greatest power over other men's minds, we can measure the distance we have traversed since that time, and the rapidity with which the converging paths of these two intellectual luminaries—the University and the Association—have approximated to each other. This sally of Mr. Keble's was no passing or accidental caprice. It represented a deep-seated sentiment in this place of learning, which had its origin in historic causes, and which has only died out in our time. One potent cause of it was that both bodies were teachers of science, but did not then in any degree attach the same meaning to that word. Science, with the University, for many generations bore a signification different from that which belongs to it in this assembly. It represented the knowledge which alone in the Middle Ages was thought worthy of the name of science. It was the knowledge gained not by external observation, but by mere reflection. The student's microscope was turned inward upon the recesses of his own brain; and when the supply of facts and realities failed, as it very speedily did, the scientific imagination was not wanting to furnish to successive generations an interminable series of conflicting speculations. That science—science in our academical sense—had its day of rapid growth, of boundless aspiration, of enthusiastic votaries. It fascinated the rising intellect of the time, and it is said—people were not particular about figures in those days—that its attractions were at one time potent enough to gather round the University 30,000 students, who, for the sake of learning its teaching, were willing to endure a life of the severest hardship. Such a state of feeling is now an archæological curiosity. The revolt against Aristotle is now some three centuries old. But the mental sciences which were supposed to rest upon his writings have retained some of their ascendency even till this day, and have only slowly and jealously admitted the rivalry of the growing sciences of observation. The subject is interesting to us, as this undecided state of feeling coloured the experiences of this Association at its last Oxford visit, nearly a generation later, in 1860. The warmth of the encounters which then took place has left a vivid impression on the minds of those who are old enough to have witnessed them. That much energy was on that occasion converted into heat may, I think, be inferred from the mutual distance which the two bodies have since maintained. Whereas the visit of 1832 was succeeded by another visit in 15 years, and the visit of 1847 was succeeded by another visit in 13 years, the year 1860 was followed by a long and dreary interval of separation, which has only now, after four-and-thirty years, been terminated. It has required the lapse of a generation to draw the curtain of oblivion over those animated scenes. It was popularly supposed that deep divergencies upon questions of religion were the motive force of those high controversies. To some extent that impression was correct. But men do not always discern the motives which are really urging them, and I suspect that in many cases religious apprehensions only masked the resentment of the older learning at the appearance and claims of its younger rival. In any case, there is something worthy of note, and something that conveys encouragement, in the difference of the feeling which prevails now and the feeling that was indicated then. The old learning no longer contests the share in education which is claimed by the new, or is blind to the supreme influence which natural knowledge is exercising in moulding the human mind.

A study of the addresses of my learned predecessors in this office shows me that the main duty which it falls to a President to perform in his introductory address is to remind you of the salient points in the annals of science since last the Association visited the town in which he is speaking. It will be more suitable to my capacity if I devote the few observations I have to make to a survey, not of our science, but of our ignorance. We live in a small, bright oasis of knowledge, surrounded on all sides by a vast, unexplored region of impenetrable mystery. From age to age the strenuous labour of successive generations wins a small strip from the desert and pushes forward the boundary of knowledge. Of such triumphs we are justly proud. It is a less attractive task—but yet it has its fascination as well as its uses—to turn our eyes to the undiscovered country which still remains to be won, to some of the stupendous problems of natural study which still defy our investigation. Instead, therefore, of recounting to you what has been done or trying to forecast the discoveries of the future, I would rather draw your attention to the condition in which we stand towards three or four of the most important physical questions which it has been the effort of the last century to solve.

Of the scientific enigmas which still, at the end of the nineteenth century, defy solution, the nature and origin of what are called the elements is the most notable. It is not, perhaps, easy to give a precise logical reason for the feeling that the existence of our 65 elements is a strange anomaly, and conceals some much simpler state of facts. But the conviction is irresistible. We cannot conceive, on any possible doctrine of cosmogony, how these 65 elements came into existence. A third of them form the substance of this planet. Another third are useful, but somewhat rare. The remaining third are curiosities scattered haphazard, but very scantily, over the globe, with no other apparent function but to provide occupation for the collector and the chemist. Some of them are so like each other that only a chemist can tell them apart; others differ immeasurably from each other in every conceivable particular. In cohesion, in weight, in conductivity, in melting point, in chemical proclivities they vary in every degree. They seem to have as much relation to each other as the pebbles on a sea beach, or the contents of an ancient lumber room. Whether you believe that creation was the work of design or of inconscient law, it is equally difficult to imagine how this random collection of dissimilar materials came together. Many have been the attempts to solve this enigma; but up till now they have left it more impenetrable than before. A conviction that here was something to discover lay beneath the persistent belief in the possibility of the transmutation of other metals into gold, which brought the alchemy of the Middle Ages into being. When the immortal discovery of Dalton established that the atoms of each of these currents have a special weight of their own, and that, consequently, they combine in fixed ponderable proportions, from which they never depart, it renewed the hope that some common origin of the elements was in sight. The theory was advanced that all these weights were multiples of the weight of hydrogen—in other words, that each elementary atom was only a greater or a smaller number of hydrogen atoms compacted by some strange machinery into one. The most elaborate analyses, conducted by chemists of the highest eminence—conspicuously by the illustrious Stas—were directed to the question whether there was any trace in fact of the theoretic idea that the atoms of each element consist of so many atoms, or even of so many half-atoms, of hydrogen. But the reply of the laboratories has always been clear and certain—that there is not in the facts the faintest foundation for such a theory.

Then came the discovery of the spectral analysis, and men thought that with an instrument of such inconceivable delicacy we should at last find out something as to the nature of the atom. The result has been wholly disappointing. Spectral analysis in the hands of Dr. Huggins and Mr. Lockyer and others has taught us things of which the world little expected to be told. We have been enabled to measure the speed with which clouds of blazing hydrogen course across the surface of the sun; we have learnt the pace—the fabulous pace—at which the most familiar stars have been for ages approaching to, or receding from, our planet, without apparently affecting the proportions of the patterns which, as far as historical record goes back, they have always delineated on the evening sky. We have received some information about the elementary atoms themselves.

In the last few years the same enigma has been approached from another point of view by Prof. Mendeléeff. The periodic law which he has discovered reflects on him all the honour that can be earned by ingenious, laborious, and successful research. He has shown that this perplexing list of elements can be divided into families of about seven, speaking very roughly: that those families all resemble each other in this, that as to weight, volume, heat, and laws of combination the members of each family are ranked among themselves in obedience to the same rule. Each family differs

from the others; but each internally is constructed upon the same plan. It was a strange discovery—strangest of all in its manifest defects. For in the plan of his families there were blanks left; places not filled up because the properly constituted elements required according to his theory had not been found to fill them. For the moment their absence seemed a weakness in the professor's idea, and gave an arbitrary aspect to his scheme. But the weakness was turned into strength when, to the astonishment of the scientific world, three of the elements which were missing made their appearance in answer to his call. He had described beforehand the qualities they ought to have; and gallium, germanium, and scandium, when they were discovered shortly after the publication of his theory, were found to be duly clothed with the qualities he required in each. This remarkable confirmation has left Mendeléeff's periodic law in an unassailable position. But it has rather thickened than dissipated the mystery which hangs over the elements.

The discovery of these co-ordinate families dimly points to some identical origin, without suggesting the method of their genesis or the nature of their common parentage. If they were organic beings all our difficulties would be solved by muttering the comfortable word "evolution"—one of those indefinite words from time to time vouchsafed to humanity, which have the gift of alleviating so many perplexities and making so many gaps in our knowledge. But the families of elementary atoms do not breed; and we cannot therefore ascribe their ordered difference to accidental variations perpetuated by heredity under the influence of natural selection. The rarity of iodine, and the abundance of its sister chlorine, cannot be attributed to the survival of the fittest in the struggle for existence. We cannot account for the minute difference which persistently distinguishes nickel from cobalt by ascribing it to the recent inheritance by one of them of an advantageous variation from the parent stock.

The upshot is that all these successive triumphs of research—Dalton's, Kirchhoff's, Mendeléeff's, greatly as they have added to our store of knowledge, have gone but little way to solve the problems which the elementary atoms have for centuries presented to mankind. What the atom of each element is—whether it is a movement, or a thing, or a vortex, or a point having inertia; whether there is any limit to its divisibility, and, if so, how that limit is imposed; whether the long list of elements is final; or whether any of them have any common origin—all these questions remain surrounded by a darkness as profound as ever. The dream which lured the alchemists to their tedious labours, and which may be said to have called chemistry into being, has assuredly not been realised; but it has not yet been refuted. The boundary of our knowledge in this direction remains where it was many centuries ago.

The next discussion to which I should look in order to find unsolved riddles which have hitherto defied the scrutiny of science would be the question of what is called the ether. The ether occupies a highly anomalous position in the world of science. It may be described as a half-discovered entity. I dare not use any less pedantic word than entity to designate it, for it would be a great exaggeration of our knowledge if I were to speak of it as a body or even as a substance. When, nearly a century ago, Young and Fresnel discovered that the motions of an incandescent particle were conveyed to our eyes by undulation, it followed that between our eyes and the particle there must be something to undulate. In order to furnish that something the notion of the ether was conceived, and for more than two generations the main, if not the only, function of the word "ether" has been to furnish a nominative case to the verb "to undulate." Lately our conception of this entity has received a notable extension. One of the most brilliant of the services which Prof. Maxwell has rendered to science has been the discovery that the figure which expressed the velocity of light also expressed the multiplier required to change the measure of static or passive electricity into that of dynamic or active electricity. The interpretation reasonably affixed to this discovery is that, as light and the electric impulse move approximately at the same rate through space, it is probable that the undulations which convey them are undulations of the same medium. And as induced electricity penetrates through everything, or nearly everything, it follows that the ether through which its undulations are propagated must pervade all space, whether empty or full, whether occupied by opaque matter or transparent matter, or by no matter at all. The attractive experiments by which the late Prof. Hertz illustrated the electric vibrations of the ether will only be alluded to by me, in order that I may express the regret deeply and generally felt that death should have terminated prematurely the scientific career which had begun with such brilliant promise and such fruitful achievements. But the mystery of the ether, though it has been made more fascinating by these discoveries, remains even more inscrutable than before. Of this all-pervading entity we know absolutely nothing, except this one fact: that it can be made to undulate. Whether, outside the influence of matter on the motion of its waves, ether has any effect on matter or matter upon it, is absolutely unknown. And even its solitary function of undulating ether performs in an abnormal fashion which has caused infinite perplexity. All fluids that we know transmit any blow they have received by waves which undulate backwards and forwards in the path of their own advance. The ether undulates athwart the path of the wave's advance. The genius of Lord Kelvin has recently discovered what he terms a labile state of equilibrium, in which a fluid that is infinite in its extent may exist, and may undulate in this eccentric fashion without outraging the laws of mathematics. I am no mathematician, and I cannot judge whether this reconciliation of the action of the ether with mechanical law is looked upon as a permanent solution of the question, or is only what diplomatists call a *modus vivendi*. In any case it leaves our knowledge of the ether in a very rudimentary condition. It has no known qualities except one, and that quality is in the highest degree anomalous and inscrutable. The extended conception which enables us to recognise ethereal waves in the vibrations of electricity has added infinite attraction to the study of those waves, but it carries its own difficulties with it. It is not easy to fit in the theory of electrical ether waves with the phenomena of positive and negative electricity, and as to the true significance and cause of those counteracting and complementary forces to which we give the provisional names of negative and positive, we know about as much now as Franklin knew a century and a half ago.

I have selected the elementary atoms and the ether as two instances of the obscurity that still hangs over problems which the highest intellects have been investigating for several generations. A more striking but more obvious instance still is life—animal and vegetable life—the action of an unknown force on ordinary matter. Biology has been exceptionally active and successful during the last half-century. Its triumphs have been brilliant, and they have been rich enough not only in immediate result but in the promise of future advance. Yet they give at present no hope of penetrating the great central mystery. Men may, perhaps, have overrated the progress of nineteenth-century research in opening the secrets of nature; but it is difficult to overrate the brilliant service it has rendered in ministering to the comforts and diminishing the sufferings of mankind.

If we are not able to see far into the causes and origin of life in our own day, it is not probable that we shall deal more successfully with the problem as it arose many million years ago. Yet certainly the most conspicuous event in the scientific annals of the last half-century has been the publication of Mr. Darwin's work on the "Origin of Species," which appeared in 1859. In some respects, in the depth of the impression which it made on scientific thought, and even on the general opinion of the world, its momentous effect can hardly be overstated. But at this distance of time it is possible to see that some of its success has been due to adventitious circumstances. It has had the chance of enlisting among its champions some of the most powerful intellects of our time, and perhaps the still happier fortune of appearing at a moment when it furnished an armoury of weapons to men, who were not scientific, for use in the bitter but transitory polemics of the day. But far the largest part of its accidental advantages was to be found in the remarkable character and qualifications of its author. The equity of judgment, the simple-minded love of truth, and the patient devotion to the pursuit of it through years of toil and of other conditions the most unpropitious—these things endeared to numbers of men everything that came from Charles Darwin apart from its scientific merit or literary charm. And whatever final value may be assigned to his doctrine, nothing can ever detract from the lustre shed upon it by the wealth of his knowledge and the infinite ingenuity of his resource. The intrinsic power of his theory is shown at least in this one respect, that in the department of knowledge with which it is concerned it has effected an entire revolution in the methods of research. Before his time the study of living nature had a tendency to be merely statistical; since his time it has become predominantly historical. The deepest obscurity still hangs over the origin of the infinite variety of life. Two of the strongest objections to the Darwinian explanation appear still to retain all their force.

I think Lord Kelvin was the first to point out that the amount of time required by the advocates of the theory for working out the process they had imagined could not be conceded without assuming the existence of a totally different set of natural laws from those with which we are acquainted. His view was not only based on profound mechanical reasoning, but it was so plain that any layman could comprehend it. Setting aside arguments deduced from the resistance of the tides, which may be taken to transcend the lay understanding, his argument from the refrigeration of the earth requires little science to apprehend it. Basing himself on these considerations, Lord Kelvin limited the period of organic life upon the earth to 100 million years, and Prof. Tait, in a still more penurious spirit, cut that 100 down to 10. But, on the other side of the account stands the claims of the geologists and biologists. I see, in the eloquent discourse of one of my most

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recent and most distinguished predecessors in this Chair, Sir Archibald Geikie, that the controversy is still alive. The mathematicians sturdily adhere to their figures, and the biologists are quite sure the mathematicians must have made a mistake. I will not get myself into the line of fire by intervening in such a controversy; but until it is adjusted, the laity may be excused for returning a verdict of "not proven" upon the wider issues the Darwinian school has raised.

The other objection is best stated in the words of an illustrious disciple of Darwin, who has recently honoured this city by his presence—I refer to Prof. Weismann. We cannot demonstrate the process of natural selection in detail; we cannot even, with more or less ease, imagine it. It is purely hypothetical. Variation by artificial selection, of course, we know very well: but the intervention of the cattle breeder and the pigeon fancier is the essence of artificial selection. The biologists do well to ask for an immeasurable expanse of time, if the occasional meetings of advantageously varied couples from age to age are to provide the pedigree of modifications which unite us to our ancestor the jelly-fish.

It seems strange that a philosopher of Prof. Weismann's penetration should accept as established a hypothetical process the truth of which he admits that he cannot demonstrate in detail, and the operation of which he cannot even imagine. The reason that he gives seems to me instructive of the great danger scientific research is running at the present time—the acceptance of mere conjecture in the name and place of knowledge, in preference to making frankly the admission that no certain knowledge can be attained. "We accept natural selection," he says, "because we must—because it is the only possible explanation that we can conceive." As a politician, I know that argument very well. In political controversy it is sometimes said of a disputed proposal that it "holds the field," that it must be accepted because no possible alternative has been suggested. In politics there is occasionally a certain validity in the argument, for it sometimes happens that some definite course must be taken, even though no course is free from objection. But such a line of reasoning is utterly out of place in science. We are under no obligation to find a theory, if the facts will not provide a sound one. To the riddles which nature propounds to us, the profession of ignorance must constantly be our only reasonable answer. The cloud of impenetrable mystery hangs over the development, and still more over the origin, of life. If we strain our eyes to pierce it, with the foregone conclusion that some solution is and must be attainable, we shall only mistake for discoveries the figments of our own imagination.

Prof. Weismann adds another reason for his belief in natural selection which is certainly characteristic of the time in which we live. "It is inconceivable," he says, "that there should be another principle capable of explaining the adaptation of organisms without assuming the help of a principle of design." The whirligig of time assuredly brings its revenges. Time was, not very long ago, when the belief in creative design was supreme. Even those who were sapping its authority were wont to pay it a formal homage, fearing to shock the public conscience by denying it. Now the revolution is so complete that a great philosopher uses it as a *reductio ad absurdum*, and prefers to believe that which can neither be demonstrated in detail, nor imagined, rather than run the slightest risk of such a heresy. I quite accept the Professor's dictum that if natural selection is rejected we have no resource but to fall back on the mediate or immediate agency of a principle of design. In Oxford, at least, he will not find that argument is conclusive, nor, I believe, among scientific men in this country generally, however imposing the names of some whom he may claim for that belief. I would rather lean to the conviction that the multiplying difficulties of the mechanical theory are weakening the influence it once had acquired. I prefer to shelter myself in this matter behind the judgment of the greatest living master of natural science among us, Lord Kelvin, and to quote as my own concluding words the striking language with which he closed his address from this chair more than 20 years ago: "I have always felt," he said, "that the hypothesis of natural selection does not contain the true theory of evolution, if evolution there has been in biology. . . . I feel profoundly convinced that the argument of design has been greatly too much lost sight of in recent zoological speculations. Overpoweringly strong proofs of intelligent and benevolent design lie around us, and if ever perplexities, whether metaphysical or scientific, turn us away from them for a time, they come back upon us with irresistible force, showing to us through nature the influence of a free will, and teaching us that all living things depend on one everlasting Creator and Ruler."

Telegraphs in Japan.—No less than 1,181 tons of telegraph wire were imported into Japan last year through Yokohama, as against 1,053 tons in 1892.

ELECTRIC POWER, HEATING AND LIGHTING.*

BY G. BINSWANGER, M.I.E.E.

The author stated that his object was to show some of the latest developments of Electrical Science, mainly in the field of domestic appliances, with a view of discussing the advantages they may offer to architects seeking to improve the present ordinary methods of motive power, heating, lighting, ventilating, cooking, &c. He wished at the same time to indulge in a few speculations as to how far such developments of electrical apparatus and their possible improvements and extensions might influence the education of the future architect, and as to how he will take advantage of them for improving our houses, and the consequential alteration in his plans and structures of our future buildings.

The author proceeded to explain the theory and action of electric motors by means of simple experiments, and alluded to the back pressure and self-regulating properties of motors. After briefly discussing the peculiar conditions of alternate-current motors, he directed attention to some of the main advantages of an electric motor over other motors, such as steam, gas, oil, or water engines.

Simplicity.—There is absolutely no technical skill required to handle an electric motor. Turn a switch, and it starts or stops; turn a multiple switch, and by means of resistances the speed can be varied. No knowledge of pressure or water gauges, of valves, exhaust, &c., is required.

Attendance.—The electric motor may be said to require absolutely no attendance beyond occasional oiling of its bearings; no stoking of boilers; no cleaning; hardly any repairs. It adjusts itself to any load within its range.

Range of Power.—A feature of the electric motor is the ease with which it may be designed to have the power of a watch, or that of the largest locomotive.

Compactness.—In proportion to the power developed in an electric motor, the space it occupies is extremely small. Its size depends largely on the speed its armature is intended to revolve at, but even at low speeds an electric motor is smaller than any other motor.

Safety.—A steam engine, with its dangerous boiler, a gas or oil engine subject to explosion, could not well be placed by an architect inside a house. No fear of danger of any kind need deter you from putting an electric motor right into a drawing-room, as it is so absolutely safe.

Position.—An electric motor can be placed anywhere conveniently in a house; it requires little fixing, hardly any foundation; it is not unsightly; and, owing to the fact that it can be started and stopped from any distance, it can be placed in ordinarily inaccessible places.

Cleanliness.—It is absolutely clean, not even the oiling of its bearings need cause any dirt or mess. Can we say this of other motors?

Noiselessness.—Compared to a gas or oil engine, an electric motor is quite noiseless. Some of the alternating motors at high frequency issue a kind of hum, but direct-current motors are quite noiseless.

Efficiency.—The efficiency of electric motors of the larger sizes is very good, and ranges from 60 to 80 per cent. As they are self-regulating there is little waste when run on small loads, but their main efficiency and economy lies in the fact that they consume power only when doing work.

With such a convenient and efficient motor at the disposal of the architect, they might expect to see it figure largely in many of his plans and undertakings. It must influence his future considerations in building our dwellings, public edifices, and factories.

Factories.—The author felt confident that the invention of the electric motor would revolutionise the planning and building of our factories. At present, mills and factories for the most part are driven by steam power, and it is essential to bring the machines as near the source of power as possible, in order to avoid the cost and waste inherent in transmission by shafting and belting. No such consideration need affect the designing of factories in the future. The power of the electric current can be transmitted easily, cheaply, and practically without loss through two wires; the motors can be placed directly near or upon the machines to be driven.

Home Industries.—Not only will the factory buildings themselves be constructed on different lines owing to this fact, but he looked forward to an increase of home industry in which the several members of a family may be employed. From a social and economical point of view, this will prove a great advantage to many an industry and to many a community. It will, of course, receive due consideration in planning the construction of our workmen's dwellings. He looked forward also to the employment of electric motors in large public buildings, hotels, and in private houses.

* Abstract of a Paper read before the "Congress of Public Health" (Engineering and Building Construction Section), July 31, 1894.

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Ventilation.—He believed this was an important question for architects, and one which has not yet found a definite solution. The usefulness of the electro-motor in driving fans for ventilation has been again and again demonstrated and recognised—there can be no doubt that it will be employed largely for this purpose in the future, and will therefore have a considerable influence on the construction of buildings that require proper ventilation.

Lifts, Cranes and Trams.—At present lifts are only used in large buildings, because the power required is costly, or requires room, or cannot be obtained conveniently. No doubt, with such a source of power as the electric current within the reach of private houses, they might look forward to seeing lifts, cranes, and other methods of mechanical conveyance introduced into smaller houses. He supposed the want of such mechanical conveyance was now influencing the construction of many a house—why should the kitchen be near the dining room if we can get our dishes sent into the room by merely pushing a button?

Electric cranes have done good work in docks, and are much preferred to steam cranes. They will, no doubt, be largely employed in many of the operations necessary in the construction of buildings.

Many other instances could be cited to prove the usefulness of the electric-motor, and he could not urge too strongly upon architects the desirability of studying this question, and employing the electric-motor wherever possible.

HEATING BY ELECTRICITY.

Imagine a house built without flues, without chimneys, without hot-water pipes, and yet perfectly heated, perfectly ventilated, and with perfect cooking arrangements! Such a house could be built to-day, if we call electricity to our aid. Many such houses, no doubt, will be built within a not too distant period. Imagine the question of smoke abatement solved in this way!

Heating by electricity is no new invention, in fact every current flowing through a conductor produces heat in proportion to the resistance of such conductor, expressed by the law C^2 R., or heat equals the square of the current multiplied by the resistance. The application of such heating to industrial and domestic uses on anything like a practical scale is comparatively new, scarcely two years old. It is the natural outcome of the fact that we can procure in our houses a practically unlimited supply of current.

Just as in the electric lamp, so in the case of electrical heating apparatus, precautions must be taken against the undue burning up of the resistances, and this is done by embedding them in a substance which is a non-conductor of electricity, which also protects it from oxidation, and at the same time will, by its close proximity to the surface to be heated, conduct away readily the heat produced in the wire resistance. This substance is either refractory cement or vitreous enamel. To heat the atmosphere in rooms, radiators or stoves are made; they could heat either by radiation or convection.

The author exhibited such a radiator. The heat produced in the wire resistance embedded in the cement was transmitted to an iron surface having many projections and blackened. It required a current of 10 amperes at 100 volts to warm a room of about 3,000 cubic feet. This method of heating the atmosphere by electricity is still too young to predict the success of its ultimate employment, in preference to heating by coal or gas.

What he wished to demonstrate was, that it could be done, and that such heating would present certain qualities which are not possessed by the present methods at our disposal, and which are mainly: There is no combustion, consequently there is no air required and no oxygen consumed. There is no flue wanted. The apparatus can be placed in many positions impossible with the old arrangements. The heat can be subdivided, and more easily directed and concentrated upon the space to be heated. It is perfectly clean. It is always ready, and requires no manual labour for starting.

Cooking.—The application of electricity to cooking operations will no doubt effect quite a revolution in our households, and will influence the planning of our buildings accordingly. All apparatus and utensils usually employed for cooking are now made in the manner already explained. Ovens are fitted with small radiators at the sides and top. An "electric oven" is, in contrast to the blackness of coal and gas ovens, made of bright brass or tinned iron; as bright as possible inside to procure reflection of heat, and bright and highly polished outside to prevent radiation.

Kettles, saucepans, grillers, toasters, fish kettles, &c., were shown to the audience. These have the resistance wires embedded in cement underneath on the outer surface of their bottom plates, and are thus brought into close proximity to the liquid or material to be heated, so that the heat is at once transmitted thereto, and, by having such articles as kettles and pans polished, extremely little loss occurs through radiation. All the usual necessary operations of cooking can be performed by electricity, and he had it on the authority of experts, including City aldermen, that the quality and perfection of electrically cooked viands is indisputable, and that the method is far superior to our present old-fashioned ones.

The employment of electrical heating for other purposes in our houses had not been neglected. Ladies can have their electric hair curlers, gentlemen their electric shaving pots. A great future lies open to electrical heating in industrial applications. He made many irons for laundries, tailors, as well as for domestic use, and they are much appreciated as offering great advantages. Another interesting application is that of electrically-heated branders, for packing cases, bacon, and branders for bookbinding.

In short, he affirmed that there was not a single operation performed in our daily life by coal or gas that could not also be performed by electricity, and that mostly in a superior and more advantageous manner.

Electric Lighting.—The author wished to seize this opportunity of talking to architects, to say a few words upon a subject in connection with electric lighting, a subject which, to his knowledge, had so far received but little ventilation before architects, to whom it must mean a good deal. The method adopted in this and many other countries is to run two wires in wood casing, having two grooves in it. This method is a compromise between the electrical engineer and the fire-insurance inspector; the third party, who ought to have a voice in the matter has never been consulted—I mean the architect. I had heard many architects complain that this method is one which does not commend itself to them; it is difficult, and sometimes impossible, to provide for it in new houses, and often disfigures the walls of existing buildings, to be installed with electric wires. By some it is looked upon as a necessary evil. This need not be so. He felt confident that a departure from present arrangements could be effected which would be appreciated both by the builder and the architect. He felt sure that the co-operation of the architect and electrical engineer would eventually produce such a modification as is felt to be desirable, and even necessary, by the electrical profession itself. He thought that all architects should acquaint themselves with the elements of applied electricity; every architect should have a fair conception of the meaning of such terms as "volt," "ampere," "ohm" and "watt." He ought to be familiar with the properties of wires, their carrying capacities, their resistances, and of materials used for insulating those wires necessary to fit them for use in electrical installations. A knowledge of these and similar subjects would be of considerable service to him in preparing his plans for our modern buildings, which will be all the better for being supplied with all the comforts and luxuries capable of being bestowed upon us by making electricity our servant.

Cost.—He had so far refrained from referring to what would be the cost of employing the electric current for the purposes of which he had been speaking. Doubtless, they would say, here lies the crux of the whole question. There can be no doubt that the operations can be performed; but they would be of little practical value if their cost should be beyond their clients' means. His reply to this was that the cost is not excessive, or beyond the means of the moderately rich, even at the price at which the current is being generally sold; but there are indications and grounds sufficient at hand that might lead them to expect that one day electricity will also supply energy for light, power and heat to the poor.

They might with confidence look forward to being able to obtain, at a not too distant period, cheap electric energy, concurrently with perfect and economical apparatus, for employing it for lighting, power, and heating. In view of this, architects will do well to contribute to the early and general adoption of electricity for such purposes, and thorough co-operation of architects and electrical engineers will, he felt confident, be of great value, and conducive to the furtherance of the objects which this Congress of Public Health has at heart.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *July* 28, 1894.

The North-Western Electrical Association.—This Association held a successful Convention at St. Paul, on July 18th, 19th, and 20th, at which several Papers of value were read. This is but the second meeting of this Association, and its success will probably lead to the formation of other local bodies, thus probably detracting from the importance of similar national organisations. The large attendance is the more notable from the inconvenience in travelling on account of the railroad difficulties in the West, and the exceedingly depressed state of business.

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Municipal Ownership.—Mr. Allen R. Foote read a Paper at the St. Paul Convention on "Municipal Ownership." His argument, in part, was that with human nature as imperfect as it is better results can be obtained from the private operation of non-competitive monopolies than by their political management. He also affirms that only through private ownership can the economic principles involved be fully realised. He argues for the legislative enactment of laws which, while favouring private ownership, will yet only permit the economic advantages inherent in such ownership to be enjoyed, thus giving the public the full benefit they would receive through public ownership, added to the advantages that would accrue through proper business management.

Incandescent Lamp Economy.—Mr. A. D. Page, manager of the Edison Incandescent Lamp Department, read a Paper at the above meeting on "Incandescent Lamps, their Use and Abuse," in which he shows that lamps should be judged by some better standard than life, and insists upon the great importance of uniform voltage to obtain the highest results of economy from incandescent lamps, and condemns the practice of American central stations of raising their voltage to keep up the candle-power of old lamps. He states that the only practical method of keeping the average candle-power of lamps on a station at a point which will be satisfactory to consumers, or on a competitive basis with other methods of lighting, is to keep records of the average life on the entire station where free renewals are furnished, and then to take out of the sockets and break up all lamps which are dim, by this means keeping down the average life to whatever constant is decided as the best under local conditions. Where lamps are sold to customers, to keep the candle-power of lamps in use on the circuit of a central station at a point which will insure satisfaction is a difficult problem. Whether the customer is on a meter or on a contract basis, it is poor economy for him to keep lamps in his sockets which are giving only 50 per cent. of their initial light; but, for the company which sold him the lamps and supplies him with current to call his attention to the fact that lamps in his sockets are giving only about eight candles, and attempt to sell him lamps at 50 or 60 cents each, is not likely to bring about the desired result. To meet the above difficulties a number of central stations in different parts of the country are now selling lamps at retail to their customers at cost and a few stations even below cost, at the same time doing all in their power to prove to them that only by a liberal use of lamps can they obtain the greatest amount of light for a given expenditure of money. At the present price of lamps, where fuel is high and the customers' bills are made up on the basis of lamp hours, it would, without question, pay the station to use high economy lamps, breaking them at a point which insures satisfaction as to average life, and keeping the average life comparatively short. It is urged by Mr. Page that whatever economy or make of lamp it is decided to use, by no means can the efficiency of the station be so greatly increased as by making every possible effort in the direction of maintaining a constant voltage at the lamps.

Cost of Producing Electrical Energy.—At the same meeting Mr. B. J. Arnold read a Paper on the cost of producing electrical energy. He states that with a properly-designed direct-connected plant we may reasonably expect to deliver to the consumer from stations having a capacity of not over 1,500 kilowatts, electrical energy for 5c. per kilowatt hour, which includes total cost of production and depreciation of plant; but excludes capital charges and profit, the cost of good coal being $2. 50c. per ton. In larger stations, he says that the cost can be brought down to 3½c., and quotes a statement to the effect that at Cologne, Hanover, and Dusseldorf electrical energy is delivered at 6·65c., 5·2c., and 4·54c. respectively. In this connection the figures in the report of the Massachusetts Electric Light Commissioners are of interest for comparison with Mr. Arnold's statement. In the large central stations of that State, which are about the only ones that pay dividends, it is shown that the ratio of operating expenses to the income from the sale of current is over 0 6, which brings up the cost to over 8c. per kilowatt hour, operating expenses alone being considered, depreciation and capital charges being excluded; and this seems to be about as good a result as is now achieved in this country.

LEGAL INTELLIGENCE.

Woodhouse and Rawson United (Limited).

MONDAY, AUGUST 6TH.

Mr. F. L. RAWSON, further examined by the Official Receiver, said: The circular dated February 12, 1891, which related to the issue of debenture stock—which, it was stated, would be a first charge on the whole of the Company's undertaking—was only issued to the holders of the existing debenture stock, who could not possibly be misled by the omission of the qualification that the new debenture stock would be a first charge only after the existing debentures had been paid off. The prospectus for the new issue was in all cases sent out with the circular, and therein the qualification was plainly stated. He could not absolutely say that the Directors saw the actual circular sent out, but they approved a draft in which alterations were subsequently made; he would not, however, have altered any important principle in the circular without going to the Board.

By Mr. Pilling: The sums paid to him by the Phœnix Trust Company did not constitute a repayment in full of the loans he had made to that Company; but they were payments on account, subsequent to which he made further advances. The Company was never out of his debt, so far as he recollected. Some of the payments were on account of expenses; certainly much more than £5,000 was paid to him in that way, probably from £15,000 to £20,000. He repeated that the United Company took no risk in connection with the formation of the American Elmore Company. They entered into an agreement under which they were to pay all the expenses of the promotion; but the shares were underwritten, and about £15,000 had been subscribed before that agreement was entered into. The Phœnix Company underwrote the capital, the agreements being entered into at the same time; one would not have been made without the other. He should doubt the statement that at this time the Phœnix Company was indebted to the United to the extent of £7,000. The Phœnix Company performed other services for the consideration they received, which was three-fourths of the profits made; there was an immense amount of work which they did in connection with the Elmore Companies, and to give an idea of the extent of it he might state that they must have spent between £200 and £300 in telegrams and cablegrams alone. Probably the share of the Phœnix Company in the profits in the American Elmore did amount to £34,000 in shares and cash. Approximately one-fourth of these profits should have come to witness under ordinary circumstance; but, as a matter of fact, it did not. His recollection was that he received about £200 in fees from the Phœnix Company, and probably the other Directors received a like amount. The United Company did not apply for any shares in the French Elmore Company. Witness and Mrs. Rawson each applied for a thousand shares; but as only a certain number of shares was set apart for the shareholders of the United, both withdrew their applications. He subsequently went into the market and bought some of the shares at a premium in order to have an interest in the Company. Probably the Phœnix Company received about the same amount from the formation of this Company as from the American Company. Whatever it was, they received it in cash, but laid it out again in shares, because they thought a very large profit would accrue upon those shares. The United Company was not consulted with regard to this investment in French Elmore shares. Quite likely the United Company became possessed of £20,000 worth of debentures in the Austro-Hungarian Company, this being their share of the commission on the sale of the German patents. Upon the distribution of the assets of the Phœnix Company, a large parcel of Deferred shares in the American Elmore Company fell to the United. It had been recently stated by Mr. William Elmore to the Foreign Elmore Company that the money would be received in full on those Deferred shares. It was untrue that the other shareholders in the Phœnix Company received Priority shares in the American Elmore Company, whilst Witness and the United Company had all the Deferred shares. The division of the assets was made after a long contest, lasting until three o'clock one morning, in which he fought hard for a fairer division than was at first proposed. When the settlement was finally made it was put before the Board of the United, and agreed to. The United got a large amount of the Priority shares. With regard to the estimate of profits, £75,000, which appeared in the original prospectus, that sum was probably arrived at after discussion between the Board of the Limited Company and the new Directors. Witness was quite prepared to accept his share of the responsibility for that estimate. As a matter of fact, it was a wonderfully accurate one, and realised more than the sum stated. Mr. Pixley examined the estimate, and reported that it appeared to be a fair one. He was almost certain that the estimate was actually made by the new Directors upon the figures he placed before them, but he could not be absolutely certain.

By the Registrar: The figures he submitted included the valuation of the shares, which were taken at the price of the Stock Exchange quotations.

By Mr. Pilling: The Limited Company had not £314,000 to divide amongst its shareholders at the time of the liquidation, and the balance-sheet produced did not show a sum sufficient to pay the shareholders back their money four or five times over. With regard to the loans made to him by the United Company, £28,000 was for the purpose of purchasing Preference shares, for which he paid 5s. premium. The shares were left with the Company until he paid for them. He still held those shares, with the exception of 100 which he gave to Mr. North as a present, and 5,000 which he gave, also as a present, to his brother, Mr. Stepney Rawson, who had not, he considered, been adequately paid for the work he had done. He obtained the consent of the Board before transferring those shares. He did not think he had sold a single share, but had steadily increased his holding in the United Company. As a further security for the loan made to

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him the Company had a charge on his interest in the founders' shares. There was an arrangement by which he assigned the £10,000 voted to him by the shareholders of the Limited, but which he had not received, to the United Company. The reason for that was, that there was an intention on the part of the liquidators of the Limited to conceal the fact that the United owed them a certain amount, until by revealing it they could secure an advantage. He was aware of this, and assigned the £10,000 to the United in order that when the liquidators of the Limited sprung their surprise, they might be met with the answer that instead of the United owing them anything they were in the debt of the United. As a matter of fact, the Limited tried to bring off their surprise, but the countermine of the £10,000 settled their mine. The Directors of the United, whilst he was in their debt, never allowed him to take any cash by way of dividends on his shares, or in any other way unless he gave them good reasons why it was necessary that he should have the cash. For instance, he paid for the Okonite shares out of the dividends due to him. He took 10,000 Ordinary shares in the Okonite Company in order to help the United Company; he bought them in the market. The Stock Exchange was not particularly favourable to any of the Companies they brought out, and in the absence of any actual transaction would call the shares at a discount; he, therefore, gave his brokers instructions to go in and buy up all shares offered at about par, and he secured £10,000 worth in that way. It was a well-known fact that in the absence of any transaction of that kind jobbers in the market could practically smash a new company. At that date he did not think he would have any difficulty in paying for the shares. He went to the Directors, and told them he had arranged to borrow £5,000, and if they would lend him the debentures he would hand over as security the shares he had bought. Later on, as he could not pay them back, they said they must debit him with the amount at par, notwithstanding that at that time they were selling at a discount. The result of the whole of the transactions was not to leave a balance of £32,000 against him, but left him a creditor.

The REGISTRAR directed witness's attention to one or two points which it was desirable that he should bear in mind in making his statement, particularly in regard to the powers taken to carry on the financial branch of the business. Witness had spoken of the Memorandum of Association as giving a specially wide power in this respect; but he found upon reference to a large number of prospectuses and Memoranda of Association, that it was practically a common form; in 70 out of 93 which he had examined he found a clause practically identical with that pointed to in this case.

It having been arranged that any further questions by counsel for the Directors should be deferred until after witness had made his statement,

Mr. RAWSON proceeded to give a brief history of the formation of the various companies. He said he was engineer to the first electric lighting company, which was formed in 1879, and went into partnership with Mr. Woodhouse in 1881. Their business was divided into four branches—manufacturing, supply, contract, and work in connection with patents. The business rapidly increased, and they acquired a considerable reputation. In order to keep up with the increase of business the Woodhouse and Rawson Electric Manufacturing Company was formed in 1885, the partners being paid entirely in shares for the business. Later in the same year the merchants' business was formed into a Company called the Woodhouse and Rawson Electric Supply Company, of Great Britain, Messrs. Woodhouse and Rawson being again paid in shares. The Woodhouse and Rawson Electric Contract and Maintenance Company was formed about two years later to take over the northern portion of the business for the installation of electrical works, being practically a partnership with the Crossley Telephone Company, a very strong local company. Owing to the action brought by the Edison-Swan Company with regard to incandescent lamps, an immense amount of work fell on the shoulders of witness, and it was impossible for him to give the necessary attention to the rapidly-growing business, and in 1887 Woodhouse and Rawson (Limited) was formed in order that the assistance of Mr. A. Hoster as joint Managing Director might be obtained. Mr. Hoster was a mechanical engineer, and his duty was more especially to look after the manufacturing business. This had developed from the manufacture of incandescent lamps into the manufacture of every description of light electrical apparatus. Mr. Woodhouse died, and the business of Woodhouse and Rawson (Limited) developed so rapidly that Mr. Hoster found he could give no time to the manufacturing branch, and therefore, in 1888, as the manufacture of lamps had been regained, witness endeavoured to amalgamate the manufacturing business with several other manufacturing companies, and an arrangement was ultimately made to amalgamate the business of C. L. Baker and Co. and the Woodhouse and Rawson Manufacturing Company. The proposed new directors insisted, against witness's wish, upon including the business of Woodhouse and Rawson (Limited), which had gradually been taking up work in connection with patents and inventions. Negotiations went on with regard to the amalgamation all through the end of 1888, and at the beginning of 1889 the new Directors insisted that the Supply Company should also be included. Witness did his best to prevent the amalgamation of the whole of the companies, but Sir John Stokes backed up the new Directors on the ground that his experience was that the companies would be much more economically and better managed if they were amalgamated; further, Sir John Stokes wanted to get rid of the Founders' shares in Woodhouse and Rawson (Limited). Originally it had been contemplated to include in the sale of Woodhouse and Rawson the Hammersmith Electric Lighting Act, together with various other companies; these were gradually eliminated by the new Directors, on the ground, partly, that the prices were too high, and partly on the ground that insufficient evidence was put before them with regard to the possible future of the businesses. Originally the profits of Woodhouse and Rawson (Limited) were to have been taken over from the end of July, 1888. Owing to the very long time it took the Directors to make their investigations, Woodhouse and Rawson (Limited), when they had sold the foreign Elmore patents to the Société des Métaux for £700,000 in the early part of 1889, refused to hand over these profits. This sale was not actually carried out, owing to the difficulties that the Société des Métaux got into; and ultimately the foreign Elmore patents were sold to an English company. The new Directors then insisted that the profits for the year, instead of being handed over, should be deposited as security for the guaranteed payment of a dividend of 10 per cent., which was afterwards raised by the new Directors to 15 per cent. for three years. During the great delay that took place in the negotiations, the position of the Manufacturing Company had not been improving, as proper arrangements could not be made for the management of it. Witness went to live at the works in order to be able to give a little time to them, and worked very hard to get it into a proper position. Witness stated to the new Directors that he did not expect to be able to pay a dividend from the industrial profits alone for the first three years; but he saw his way, from work in progress, to pay a dividend of 15 per cent., including the profits from the financial business. At the end of three years he thought the industrial portion alone would show sufficient profit to pay 5 per cent., while the reserve from the financial side would enable them to pay 10 per cent. until the industrial business had increased sufficiently. During the first year of the Company's operations witness worked such long hours that the Directors thought, considering his previous hard work, it was impossible for him to attend to both departments and, consequently, they appointed Mr. North as manager of the industrial branch of the business. Some time in 1891 Mr. North complained that he could not get his portion of the work done, owing to witness requiring to supervise everything that was being done. Witness stated that he did not trust Mr. North, but the Directors upheld Mr. North in his independent management. In November, 1891, it was found that Mr. North had betrayed the confidence reposed in him, and Mr. Stutchbury was appointed general manager, to get the industrial business into order. In the beginning of 1892 witness stated to the Board that the only thing, in his opinion, that could be done was to close all the branches of the business that were losing money, and to start the industrial business on a comparatively small scale, until it was thoroughly under way. Mr. Stutchbury reported that, with £15,000 working capital and all debts paid, he could make a success of the industrial portion of the business without cutting down the business in the way proposed. Witness stated that he could easily raise the amount required, but said that Mr. Stutchbury had not sufficient experience to act as manager. Witness urged his views as to reducing the business, and some of the Directors stated that, if those views were acted upon, they would not remain on the Board, as the Company was an industrial business, not a financial one, and that Mr. Stutchbury had definitely stated that he could make the industrial portion of the business a success, that the aim of the Directors had been always to increase the industrial portion of the business, and that they were not going to alter this. Witness warned the Directors of what the result would be, but agreed to carry out their views. Mr. Stutchbury found the task harder than he expected, owing to the position into which Mr. North had allowed the business to get, and it was not until the end of 1892 that the losses being made on the industrial portion of the business were substantially put an end to. The result of the year's working, however, was a heavy loss all round, notwithstanding that salaries were reduced by more than 50 per cent., and the Directors waived more than 50 per cent. of their fees. The action of the Edison-Swan Company resulted in a loss of £14,742, the loss at Kidsgrove was £17,784, whilst the loss in other departments, together with the large depreciation in plant, stock and tools, owing to the Edison-Swan action, amounted to £37,274. There was a large depreciation in the quoted prices of securities, amounting to over £26,000, so that, after paying expenses, there was a loss of £86,000, notwithstanding the interest on loans and investments received being over £7,000. At the general meeting of shareholders a committee of consultation was appointed to assist the Directors. Instead of endeavouring to do this, they sent out a circular which had misstatements of fact in it, the result being absolutely to prevent the Company carrying on its business, and accordingly it went into voluntary liquidation, which, afterwards, owing to the report of the Committee, was made a compulsory liquidation.

Touching on points suggested by the learned Registrar, the WITNESS said: Woodhouse and Rawson (Limited) did not care to go into the business of financing the Elmore business, and he found the money himself, and laid out a plan of operation for Mr. Elmore, who worked at the process until he made it the great success it ultimately became. Then he (witness) gave the Limited Company the benefit of his contract with Mr. Elmore—a certain percentage on what the patents might realise, retaining only the option on the ground that the option was not strictly the business of Woodhouse and Rawson (Limited); but when it became of the value o £30,000 he gave that up too. With regard to his commission, the first year he said he would not take the £14,000 which was due to him until the shares were realised, or, if the Board liked, he would take the shares themselves at the actual price at which they stood in the balance-sheet; he also stated that, now that they saw how successful the Company was, he was quite ready to cancel his engagement and enter into any other agreement they might wish. At the end of October, 1891, or in November, he offered to give up not only the 25 founders' shares he held in the Phœnix Company, but also the dividends he had received that year, if they thought it was an incorrect thing for their Managing Director to be interested in that Company in the way he was; but, looking to the large profits which the Company had made in consequence of the connection, they thought it was only right that he should retain the Founders' shares. Witness had never received a penny of promotion money in his life; and since the liquidation he had given the whole of his time to the affairs of the United Company. The owners of a very large industrial business offered him £5,000 to advise them in connection with the formation of a company, most of the capital for which was to be subscribed privately, and offered the Directors of the United to do the work in their name and hand the

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profit over to them; but, as they felt it was not quite the sort of business they wished to take up, he did not accept the offer. His reason for mentioning these things was to show that throughout the existence of the Limited and United Companies he did everything he could to advance the interests of the Companies, without thinking of himself, excepting, that he hoped to ultimately reap the benefit of being the Managing Director of a successful company.

The REGISTRAR said he was bound to say that that was the impression which had been made upon his mind throughout this enquiry.

WITNESS proceeded to explain why he thought the prospectus was sufficiently clear as to the nature of the business it was intended to undertake, but said that at the outset it was never intended to devote so much attention as they ultimately did to the flotation of companies to work patents; but the success of their first venture was so great that very numerous offers were made to them in connection with the exploitation of other patents, and where they saw what they deemed a suitable opportunity in connection with electrical inventions they embraced it. There was clearly an opening for a business of that kind, as private firms did not care to take up inventions which would require a great deal of expenditure to work up, and they thought they saw their way to making considerable profits in that way, and by means which he considered might fairly be considered as fairly within the scope of an industrial business—the purchase of patents, the development of inventions, and the selling again of the patents at a profit. At the time they took up the Elmore patents the process was absolutely discredited, experts having declared strongly against it; but he was able subsequently to convince some of the leading people in the copper world, who were at first opposed to the idea that it was of any value, that it would do all that Mr. Elmore claimed for it, and was as great an advance in copper manufacture as was the Bessemer process in regard to steel. Witness repeated the explanation he had previously given as to Mr. Edmunds's valuation of the patents, saying that the report was written in his office at the dictation of Mr. Edmunds, blanks being left for the amounts, and afterwards filled in by Mr. Edmunds. He did not think that valuation was at all a satisfactory one, and he was greatly surprised at the smallness of some of the amounts. There was absolutely no ground for the suggestion that the original partnership of Woodhouse and Rawson was insolvent. The terms of the agreement with the British Electric Company were that the United were to receive for their patents in England £45,000 in debentures and £49,000 in Ordinary shares in the British Company; but that did not go through, as difficulties with the Edison and Swan Company arose. Witness had given very definite instructions, both to Mr. North and the head accountant, that the accounts between the Manufacturing Company, who were manufacturing for the British, and the British, who were selling to the Supply Company, should not in any way go through the books of the United But, notwithstanding those instructions, an account was opened in the books of the United, as if the United were manufacturing for the British Company's selling to the Supply Company. The solicitors, under advice, and from counsel, said that that would render the licence held by the British Company liable to be cancelled, as the British had no right to assign their power to manufacture and sell. He thought probably the reason why there was no mention of his report regarding the Phœnix Trust Company being produced at the Board meeting, was that it was produced during a period between the resignation of Mr. Dundas and the appointment of Mr. Stutchbury as secretary, and the clerk who entered the minutes during that time did not perform the duty efficiently. His secretary, who was assistant-secretary of the Company at the time, was in Court, prepared to swear that he himself took the report into the Board-room whilst the Board was sitting. Witness had not finished his statement when the Court rose, and it was agreed to hold a further sitting on Wednesday morning.

WEDNESDAY, AUGUST 8th.

Half-an-hour was spent in discussing the best mode of procedure with regard to Mr. F. L. Rawson's personal statement, and eventually it was arranged that there should be a further adjournment in order that he might complete a written statement and put it in.

Halifax and Huddersfield Union Banking Company (Limited) v. Andrews and Preece (Limited).

In the Chancery Division Mr. Justice Chitty gave judgment in this action, which was brought by plaintiffs as debenture-holders. A Receiver and Manager had already been appointed, and the Company now appeared, and admitted that they had no defence. His Lordship accordingly declared the plaintiffs entitled to an account of what is due for principal and interest, and to an inquiry as to what property was comprised in the debentures, with liberty to apply in Chambers as to a sale.

The Chicago Electric Elevated Railway.—In July the contract for the electrical equipment of the Metropolitan Elevated Railroad of Chicago was signed. The contract, which was given to the General Electric Company, requires two 1,500 kilowatt and two 800 kilowatt direct-connected generators, and 55 motor cars, with two 100-H.P. motors each. These motors will be sufficient to operate three car trains, and as the traffic requires longer trains in the future the number of motors will be increased to four to a car.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

The 1894 Edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK contains 1,000 closely-printed pages, and several new and useful features have been added. The price of the Directory and Handbook is 7s. 6d. Postage in the United Kingdom, 9d.; abroad, 1s. 4d. *The 1895 edition is in active preparation.*

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," being four Lectures delivered before the Royal Institution in April-May, 1894, by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is in preparation, and will shortly be published.

"THE WORK OF HERTZ."—The lecture delivered by Dr. O. J. Lodge at the Royal Institution on June 1st is being reprinted with corrections and additions, and many illustrations, and will shortly be ready, price 2s. 6d.

"ELECTROMAGNETIC THEORY," by Oliver Heaviside, is now ready, price 12s. 6d. (abroad 13s.). Prospectus on application.

"THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application to the Publisher.

"DRUM ARMATURES AND COMMUTATORS."—This book, written by Mr. F. Marten Weymouth, is also ready; price 7s. 6d (abroad 8s.). Prospectus on application.

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. (abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application to the Publisher.

TENDERS INVITED.—The Corporation of Sunderland require a supply of grip boxes and connectors, tenders for which must be sent in by the 16th inst.

——— Tenders are invited for the best scheme, with cost, for lighting and heating a Presbyterian Church to be built in Newcastle-on-Tyne, and tenders are to reach the Secretary of the Building Committee, 20, Jesmond-road, Newcastle-on-Tyne, by the 15th inst.

——— Tenders are required for the ground work and concrete foundations for the new electric light central station to be erected in the Vastern-road, Reading. Persons willing to tender must communicate with Mr. Albury, 154, Friar-street, Reading.

——— Tenders are invited for the electric lighting of the glass houses at the Botanical Gardens, Edgbaston, Birmingham. Further particulars are given in our advertisement columns, and tenders must be sent in to Prof. Hillhouse, M.A., not later than September 1st.

TENDERS ACCEPTED.—The Electric Lighting Committee of the Belfast City Council have accepted the tender of Messrs. Marshall, Fleming and Jack for the supply and erection of an overhead travelling crane at the central electric lighting station.

——— Messrs. Babcock and Wilcox (Limited) have secured the contract for the additional boilers now being laid down at the Corporation electric light works, Waterloo-street, Glasgow.

——— The Public Library Committee of the Colchester Town Council have accepted the tender of Messrs. Christy Bros. for lighting the library buildings by electricity.

——— The tender of Messrs. Graham and Biddle, of 463, Oxford-street, London, W., has been accepted for the electric lighting of the residence of Mr. J. H. Renton, in Park-lane, for the sum of £534. The same firm have secured the tender for lighting, &c., the residence of Mr. F. Samuels, in Bryanston-square, W., for the sum of £445; and for a lighting installation and organ-blowing apparatus by electricity for the Wardens of the West London Synagogue, Upper Berkeley-street, W., for the sum of £189. For these installations Mr. W. J. Fryer acts as electrical engineer.

——— The Kingston-on-Thames Town Council have accepted the tender of Messrs. Robey and Co. for the gas engines for the electric lighting station for £126.

——— The Technical Education Committee of the Yarmouth Corporation have received the following tenders for lighting the School of Art, South Quay:—

Crampton and Co., Cambridge (accepted)	£57	18	6
Laurence, Scott and Co., Norwich	81	16	4
Crompton and Co., Chelmsford	86	5	0
Durrant, Yarmouth	96	17	11

SALE OF PLANT.—A large quantity of second-hand electric plant is advertised elsewhere for disposal, including engines, boilers, dynamos, E.P.S. cells, instruments, switchboards, &c., the whole

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in good condition. Further particulars can be obtained of Mr. H. Cuthbert Hall, A.I.E.E., consulting engineer, 46, Queen Victoria-street, London, E.C.

SALES BY AUCTION.—Messrs. Fuller, Horsey, Sons and Cassell have received instructions to dispose of the extensive manufacturing premises at present occupied by Messrs. Latimer Clark, Muirhead and Co. (Limited), and also the plant and machinery, which is being sold under the liquidation by order of the Receiver, Mr. James Worley. The sale of the premises will take place on Tuesday, September 4th, at 23, Regency-street, Westminster, S.W. (unless previously disposed of by private contract), and the plant and machinery will be sold on Tuesday, Wednesday, and Thursday, September 4th, 5th, and 6th, at the same address at 11:30 a.m. Some further particulars are given in our advertisement columns, and all information can be obtained of the auctioneers, 11, Billiter-square, E.C.

VACANT APPOINTMENTS.—The Corporation of Dewsbury require a properly qualified practical electrical engineer to take charge of the new electric lighting station and works. Further particulars will be found in our advertisement columns, and applications must be sent in not later than 9 a.m. on Friday, the 17th inst.

——— The Portsmouth Corporation require a junior assistant at the electric lighting works. The salary is £65 per annum. Applications must be sent in before the 15th inst. to Mr. E. Price, Superintendent, Electric Station, Portsmouth.

——— The Electricity Supply Company for Spain (Limited) require a thoroughly competent assistant electrical engineer at a commencing salary of £200 per annum. Some further particulars are given in our advertisement columns, and applications must be sent in to the Secretary of the Company not later than the 13th inst.

——— The Corporation of Blackburn require an engine and dynamo attendant for the Blackburn electricity works. Some particulars are given in our advertisement columns, and applications must be sent in to Mr. Robert E. Fox, Town Clerk, Town Hall, Blackburn, by the 25th inst. The Corporation also require a central station wireman, for which post applications have to be sent in to Mr. Fox by the same date.

LIQUIDATIONS.—A meeting of the Aladdin Primary Electric Battery Company (Limited) is to be held at 5, Fenchurch-street, E.C., on September 11th, at 2, to receive an account of the winding-up.

——— A compulsory order for the winding up of Barnard, Bishop and Barnards (Limited), metal workers, &c., of Norwich and London, has been made on the application of the Westfälische Actien-Gesellschaft für Bergbau Eisen.

BANKRUPTCIES.—At the Leeds Bankruptcy Court application was made to Judge Gates, Q.C., for the discharge of Edwin Moorhouse, electrician, of Leeds. The receiving order was made on October 21, 1891. "Heavy costs of litigation as to interest under his father's will, and interest on mortgages," was stated to be the cause of the failure. He commenced business in October, 1889, when he took a partnership in the firm of Mori and Co., electricians, of Leeds, and paid £600 as his share of the capital. The business was a fairly good one, and in May last a third partner, Mr. R. P. Stocks, still a minor, was taken into the firm. He introduced £850 capital. In August last year Mr. Mori retired, on condition that he was reserved the right to re-enter any time within three years, on paying a third share of the then value of the business, the firm having the use of his name for the same period. It was alleged that the business was then quite solvent. The debtor was entitled to a legacy of £3,000 under his father's will, which was payable in June, 1889, and he received £500 in advance on account; but, when time for payment arrived, the executors stated that the legacies could not be paid in full, and the debtor declined to abate, he having borrowed £650 on security of the legacy. Mr. Moorhouse is now in the employ of a local electrical engineer at a salary of about £150 per annum. Ultimately, the certificate was suspended for two years.

——— A receiving order has been issued in the estate of Arthur Shippey, electrical engineer, of 13, King-street, Cheapside, E.C.

——— William J. S. Green, electrician, 86, Lozells, Aston, near Birmingham, has filed a deed of arrangement with his creditors, the unsecured liabilities being given as £182. 18s. 10d., and the estimated net assets £115. 15s.

DOULTON'S STONEWARE CONDUIT.—In addition to Edinburgh and Sunderland, where large quantities of this conduit have been laid, the arc-lighting mains at Chelmsford, which were originally carried overhead, are now all placed in conduits and the old poles removed. Doulton's conduit is of comparatively recent introduction, but already upwards of 72 miles of "ways" have been laid.

WESTON ELECTRICAL INSTRUMENTS.—Messrs. Elliott Brothers inform us that they have taken over the sole supply for Great Britain and the colonies, of all the instruments for electrical measurements manufactured by the Weston Electrical Instrument Company of Newark, New Jersey. The designs of Mr. Weston for central station and laboratory standard instruments are already well known and duly appreciated for their reliability. In the United States these instruments are now almost exclusively used. As an example it may be stated that the switchboard of the largest Edison station in New York is being fitted with 127 instruments of the Weston type.

MR. J. A. EDMONDSON.—In reference to a Note appearing in our last issue, Mr. J. A. Edmondson desires us to state that the dynamos used at the Huddersfield Co-operative Society's installation were of the Edmondson type, and not as stated. The whole of the plant, with the exception of the engine, being supplied by Mr. Edmondson. This firm has in hand several important installations—one at Dewsbury for Messrs. Newsome, West and Co. (Limited) for 600 lights, and others at London, Bradford, and Barnsley.

MEDICAL BATTERY COMPANY, LIMITED (in liquidation).—The creditor members of the Committee of Inspection of this Company are congratulating themselves and the shareholders generally at the scheme sanctioned by the High Court for the reconstruction of this Company.

SUNBEAM LAMPS.—The Sunbeam Lamp Company have just issued a new price list of large and small "Sunbeam" incandescents, lamp-holders, shades, &c. The list can be obtained on application to the Secretary of the Company, Park-road, Gateshead-on-Tyne.

THE "VENLOO" INCANDESCENT LAMP.—We are informed that Messrs. E. Goossens, Pope and Co., of Venloo, Holland, have appointed Messrs. Pope and Boddy, of 26, Pall-mall, Liverpool, sole agents in the United Kingdom for the sale of Venloo lamps. In *The Electrician* of November 25, 1892, Mr. Clarence P. Feldmann, in an article entitled "Life and Efficiency Tests of Incandescent Lamps" points out the characteristic feature of these lamps, for which a considerable demand has arisen.

"ENGINEERING MAGAZINE."—The August number of this well-known magazine is now ready, and fully maintains its reputation as the best of the engineering monthlies. The contents include: "Our Enormous Annual Loss by Fire," "The Battle-Ship as a Fighting Machine" (by Mr. George W. Melville, Engineer-in-Chief of the United States Navy), "Colorado's New Gold Camps" (illustrated), "The Early Life of Great Inventors," "The Prevailing Jealousy of Wealth: Should Fortunes be Limited by Law?" "The Chicago Drainage-Channel and Waterway" (illustrated), "Electricity Direct from Coal" (by Dr. William Ostwald), "Electric Welding and Metal Working" (by Mr. Hermann Lemp, illustrated), "Beginnings and Future of the Arc Lamp" (by Mr. S. M. Hamill, illustrated), "Theatre-Building for American Cities" (illustrated); and the usual Editorial Departments on Electricity, Railways, Architecture, &c. *The Engineering Magazine* is sent post free for 1s. 3d. per copy, the annual subscription being 12s. 6d. Orders should be sent to the Publisher, *The Electrician* Office, Salisbury-court, Fleet-street, E.C.

"FIRST AID."—We have received the first number of a new monthly journal entitled *First Aid*. It is devoted to ambulance work, a subject worthy of more notice from employers of labour in factories, &c., than it at present receives.

INCOME TAX.—The Income Tax Adjustment Agency reminds the public (our readers amongst the number) that they should be more than ordinarily careful to ascertain beyond doubt whether they have been over assessed. The Agency points out that many whose incomes are not £500 will overlook the fact that they are entitled to abatement as to £160, instead of the £120 as hitherto. A point is also made of the fact that many hundreds of people pay income-tax upon incomes derived from investments where the tax has already been deducted. These persons are entitled to a readjustment of the tax, and it is not yet too late to recover income-tax over paid in respect of the last three years ended April 5, 1894.

TRADE MARKS.—It is said that the British Ambassador at Berlin has forwarded to the Foreign Office a translation of the new German law for the protection of merchandise marks, and the document has been issued as a Parliamentary paper.

POSTCARDS.—The Postmaster-General has submitted to the Treasury a scheme under which the public will be permitted to send through the post private correspondence cards with a halfpenny adhesive stamp attached, instead of being compelled to purchase the postcards now issued by the Department. We understand that this concession is largely due to the action of Mr. Henniker Heaton.

COOKING BY ELECTRICITY.—Satisfactory proof of the rapid advance in public favour of cooking by electricity is evidenced by the fact that many restaurateurs in London and elsewhere are installing electric cooking apparatus throughout their culinary departments. In many cases the electric apparatus is only used as an auxiliary to gas or coal fires, but in several instances the electric

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system has entirely superseded coal or gas. At the Imperial Restaurant, a large building in Queen Victoria-street, near the Mansion House, London, cooking is entirely effected by electricity, and Mr. Percival, the proprietor, issues the following notice: "Although electricity has been publicly demonstrated to be capable of use for the generation of heat for culinary purposes, and although its advantages of freedom from dirt, dust, odour, or vitiated atmosphere is fully proved, I claim to be the first in Europe to entirely adopt the system, which not only insures cleanliness, but at the same time places at the disposal of the *chef* a means of absolutely controlling the temperature to suit the requirements of particular dishes. Visitors are invited to inspect the electrical arrangements at any time, except during the busy luncheon hours."

SECONDARY EDUCATION.—The Royal Commission on Secondary Education have adjourned their sittings to October 2nd, when they will be resumed, and continued until about the middle of September. It is considered probable that the inquiry will conclude about Whitsuntide, 1895. The report of the Commission is looked forward to with much interest by educationalists throughout the country, and is expected to result in a comprehensive measure for the advancement of technical education.

THE DUNMOW FLITCH.—Those of our readers who are acquainted with Mr. Angelo Fahie, of Monkstown, Dublin, will congratulate him upon his success in obtaining the historic flitch, which is awarded "to the couple whose lives have been most distinguished by domestic happiness" for the period of one year and a day previous to the gathering at Dunmow, Essex, which took place on Monday last.

ABERDEEN.—The Royal Lunatic Asylum is undergoing extensive alterations, involving the reconstruction of the old buildings and the erection of a new hospital. When completed, the electric light is to be adopted throughout the premises, in which plant will be erected. Messrs. New and Mayne have obtained the contract for wiring the new building to the plans and specifications of Dr. R. Mullineux Walmsley, consulting engineer to the Asylum authorities.

ABERGAVENNY.—Mr. E. Manville has presented his report to the Improvement Commissioners on the lighting of the town by electricity, and the report has been adopted.

ALDERLEY EDGE.—The Local Board have decided to apply for a Provisional Order for supplying electric current within this district. This step has been taken, it is stated, in order to forestal the application of a private company.

ASHFORD.—The Lighting Committee have met and discussed the subject of introducing the electric light. It was finally decided that no steps be taken at present.

ASTON.—It has been decided to put down additional power plant at the public baths, and an engine is to be provided for use in lighting the institution, which is now dependent on the pumping engines for power. The engine is to be provided by Messrs. Fowler, Lancaster and Co. (Limited) at a cost of about £100.

BELFAST.—The Electrical Committee of the City Council report that the various contractors for the electric lighting works are proceeding to the completion of their contracts, which it is anticipated will all be perfected within the specified time. The question of the introduction of the electric light into the reading room of the reference library was also under discussion at the last meeting, and the opinion was generally expressed that a great improvement would be effected could the light be introduced in place of gas. Councillor Henderson said the Library Committee would introduce the light if it were financially possible, but they were very much in debt.

BOWNESS.—Pending a satisfactory arrangement with the Windermere Electric Light and Power Company, it has been decided by the Local Board to withhold their sanction to the application for a Provisional Order.

BRIDLINGTON QUAY.—The sea front has now been completely lighted by electricity, and the town is to be congratulated on the success attained. The plant is in good working order, and the Building and Lighting Committee of the Town Council consider the money has been well spent. The lighting of the town by gas is in a very unsatisfactory state, but the Committee hope to be in a position to make more satisfactory arrangements next year. Mr. Brown, the Council's electrical engineer, has been publicly congratulated upon the success of his efforts in carrying out the installation on the quay.

CHURCH LIGHTING.—The work carried out by Messrs. Laing, Wharton, and Down at the Leeds parish church is now complete, and on Sunday evening last about 250 incandescents illumined the sacred edifice. The change from gas was much appreciated by the congregation.——The church of St. Martin-on-the-Hill, Scarborough, has been lighted throughout by electricity, the lamps, about 100 in number, being distributed in three-light clusters. The work has been successfully carried out by Messrs. Walker and Hutton.

COUNTRY HOUSE LIGHTING.—Philiphaugh, the historic residence of Mr. Strang Steel, near Kelso, is now lighted by electricity, power being obtained from Philiphaugh Burn. The current is used for lighting, heating, and supplying power to machines for household and other purposes. About 450 lamps are included in the installation, the work for which has been carried out by Messrs. Mavor and Coulson.

COVENTRY.—The City Council have received a letter from the Electric and General Contract Corporation asking for the appointment of a sub-committee for the purpose of settling with the engineers of the Corporation the question of the tramways at Grey Friars' Green. It was ordered that the matter be referred to the Improvement Sub-Committee, with instructions that the Corporation's engineers should report the result of the conference to the Council.

DARLINGTON.—At last week's meeting of the Town Council, in moving the adoption of the Gas Works Committee's report, Mr. Barron referred to the large consumption of gas, and the probable necessity of enlarging of the works. He considered this enlargement could be obviated by the Council deciding to introduce the electric light, to which suggestion the Gas Works Committee offered no objection. The matter is to be considered at a future meeting.

DUNDEE.—In connection with the increased demand for electric light it has been resolved by the Gas Commission that a new storage battery set be provided at an estimated cost of from £1,000 to £1,500, and tenders are to be advertised for. The Commissioners have entered into an agreement with the E. P. S. Company for the upkeep of the storage battery for five years at an annual charge of £76.

ELECTRICITY IN THE EAST.—There is a proposal to light Kwala Lumpur, Selangor, Straits Settlements, by electricity, water power being obtainable about seven miles distant.

EMBEZZLEMENT.—John Alexander, aged 32, labourer, was charged before Mr. Newton, at Marlborough-street, London, with embezzling the sum of £4, the moneys of his employers, the Electrical Company (Limited). The evidence showed that the prisoner was in December last sent by his firm to receive the sum in question and absconded with it. He afterwards voluntarily surrendered to the police at Mansfield, Notts., and confessed his guilt. One month's imprisonment.

EWELL (SURREY).—The Local Board of this district were up to June the owners of an Electric Lighting Provisional Order. This has now expired, and the Board, while desirous of taking no active steps themselves, are anxious that the Board of Trade should not entertain any application made for lighting the district by electricity by outsiders.

FOLKESTONE.—It will be remembered that at the time the Folkestone Corporation decided not to proceed with their electric lighting scheme, which had previously received the assent of the Corporation, Mr. Baker, a prominent citizen, upon whose initiative the Council were induced to negative their scheme, promised to produce a new plan by which the town could be supplied with electric current at a total cost of about £12,000, as against the original estimated outlay of £35,000. So far Mr. Baker's scheme has not been forthcoming, notwithstanding several promises from that gentleman. At the last meeting of the Corporation, when the scheme was to have been discussed, Mr. Baker was not present. It has, therefore, been decided that the discarded scheme and that prepared by Mr. Baker (if it is ready) shall be discussed at the next Council meeting. It is more than likely that the Corporation's original scheme will, with certain modifications, be ultimately adopted.

HULL.—After careful consideration, the Electric Lighting Committee have decided to recommend the Council to sanction the purchase of the additional plant stated by the Corporation's electrical engineer to be necessary to meet the forthcoming winter's demand for electric current, at a cost not to exceed £2,800.

KINGSTON-ON-THAMES.—A pleasing incident took place at the last meeting of the Corporation, when the members presented Mr. J. E. Edgcome, electrical and mechanical engineer, with a silver salver on the occasion of his marriage, as a mark of their esteem and confidence.

LONDON GAS CHARGES.—The movement recently set on foot by members of the London Vestries to call a conference of London local authorities to discuss the question of the unequal charges made by the various London gas companies is gaining ground, and in September next an important gathering is likely to meet for the purpose of considering the question of obtaining a uniform rate in the price charged for gas throughout the metropolis. The movement appears already to have partly effected its purpose, the Gas Light and Coke Company, which is the largest of the London companies, and whose district is north of the Thames, having notified

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its intention of reducing the price of gas 2d. per 1,000ft. from the close of the current quarter. The price of the gas supplied by this Company will still remain 15 per cent. higher than the principal company in the southern district. An important deputation waited upon Mr. Bryce, President of the Board of Trade, yesterday, on this subject, when representatives from the Vestries of St. Luke's, Kensington, Clerkenwell, Chelsea, Hackney, Hammersmith, St. James, Westminster, Paddington, Islington, Shoreditch, Bethnal Green, and the Holborn Board of Works, were present, accompanied by a large number of Metropolitan Members of Parliament. The deputation pointed out that their object was to secure a Parliamentary enquiry in respect of all the gas companies in the metropolis, including Brentford, so far as these companies served the district, represented by the London County Council. Having heard the deputation, Mr. Bryce said that in addition he had received many memorials and resolutions passed by local authorities making a number of suggestions which were, however, so varied that they presented serious difficulty to the Board of Trade. In dealing with this question some asked for a Parliamentary inquiry and others for a Board of Trade inquiry. In the case of a Parliamentary inquiry they would be able to consider the question of the unification of the companies, and their acquisition by public authority. This plan had been carried out in nine of our great towns, in each case with satisfactory results. It was, however, a very large question, and they could not separate from it the terms which would have to be made with existing shareholders. At the time when the Parliamentary bargain with the gas companies was made, he was free to confess he thought it was a very bad bargain. If the Board of Trade had had their way a much better arrangement for the people of London would have been come to. They had, however, learnt something by experience, and had taken care in the case of the recent Electric Lighting Acts to safeguard the interests of the public. If legislation was desired it was quite clear that Parliament would not be satisfied with anything else than a Parliamentary enquiry as preliminary to such legislation.

Newcastle-on-Tyne.—The special committee appointed to report upon the proposed lighting of the City by electricity under the Corporation scheme have decided to obtain the opinion of Prof. A. B. W. Kennedy, and to arrange for him to visit the City and report to the Council. The Local Gas Company have sent in a bill for £600 for the lamps which have been extinguished by the electric lights now in use, the Company contending that once a lamp is ordered, it cannot be dispensed with except by agreement with the Company.

Rugby School.—The Rugby School Electric Lighting Company are putting down additional motive power by replacing the 100-h.p. tandem gas engines at the electric lighting station with a new one of the same type, but of 120 h.p.

Salford.—It is announced that the lighting works will be complete in time for the winter supply. The price at which the public are to be supplied has not yet been decided upon.

Salisbury.—The Town Council have engaged the services of Mr. Robert Hammond to advise them in connection with the licence applied for by the Salisbury Electric Light and Supply Company at an inclusive fee of £50. Mr. Hammond has prepared a report which was to be submitted to the council yesterday (Thursday).

Shoreditch (London).—The Electric Lighting Order obtained by the Vestry expires this year, and the Board of Trade have intimated, in reply to the Vestry's request, that they will consider it in force for another year, to enable the Vestry to carry out their electric lighting scheme.

Southend-on-Sea.—The Marine Park and Gardens just opened, which comprise about 15 acres of ground on the Beaumont estate, and to which there is a direct approach from the sea front, is lighted by electricity.

South Shields.—At the last meeting of the Corporation the deputation, consisting of the Mayor, Aldermen Rennoldson and Eltringham, the Electrical Engineer (Mr. J. A. Jeckell), and the Town Clerk, who were appointed some time back to visit some of the principal electric lighting stations in the leading provincial towns, reported that they had visited Huddersfield, Derby, Burton-on-Trent, Bristol, and Oxford, and had inspected the central stations there. A description of the various works which had been visited was presented to the Electric Lighting Committee, and this contained recommendations as to the type of boilers, engines, and dynamos to be used. It was resolved: (1) That the marine type of boiler and the vertical type of engine, compound or triple expansion, with surface condensers to each, and direct coupled, if practicable at a moderate speed, as recommended by the deputation, be adopted; and (2) that the scheme of high and low tension mains, as shown on the plans submitted by the Electrical Engineer, be approved, and that he be instructed to prepare specifications in accordance with them.

Stockton.—The Town Clerk has communicated to the Board of Trade, requesting an extension of the Electric Lighting Order granted to the Council in 1890. After discussion it was decided that the Corporation were prepared to give effect to the provisions of the Order within two years.

St. Pancras (London).—At their last meeting the Electricity Committee reported that in consequence of the demand for current in the district north of the Cobden sub-stations having exceeded that contemplated when the mains were originally put down, it was necessary that supplementary feeders and mains should be laid to augment those already put down. It was essential that this work be carried out at once, so that it may be completed and ready for the coming winter demand. The cost would amount to about £2,800. The Committee recommended that the sanction of the Vestry be given to this outlay, so that the work might be done at once. It was stated that if the extension were not carried out the department would be in a difficulty during the ensuing winter. When the King's-road station was completed the Committee would have a further report to make. Prof. Robinson has consented to a reduction of his commission for this extension. He will now receive ½ per cent. for drawing the plans, and 2 per cent. for superintending the laying of the mains; thus receiving 2½ per cent. instead of 4 per cent., or a saving of 1½ per cent. on the outlay. The Committee have plans for laying mains for the whole of the parish; but, so far as North St. Pancras is concerned, will have to wait until the King's-road station is complete. The Committee's recommendations were unanimously adopted.

Theatre Lighting.—The Coliseum at Oldham is now lighted by electricity, upwards of 300 incandescents and 3 arcs being used. The work has been carried out under the supervision of Mr. G. St. John Day. Mr. Day has used a wood casing and covering of his own design.——The Tyne Theatre, Newcastle-upon-Tyne, has recently undergone redecoration and refurnishing. Included in the improvements is the adopiton of the electric light throughout the building.

The Transvaal.—Some time back a suggestion was made by Major Leaver to utilise electric power for supplying various batteries in the Rand district with current. A scheme approximating to the Major's idea was prepared by Messrs. Siemens and Halske, who proposed to erect a central station at Brakpan, in the neighbourhood of the gold mines. This scheme was estimated to cost about £275,000, and the capital has been obtained, a portion in the Rand district and a portion at Berlin. A concession has been granted for carrying this scheme into effect. Another scheme, upon a much more extensive scale, and estimated to require a capital of about £700,000, has been prepared by Mr. R. Lewis Cousens, M.I.C.E., electrical engineer, of Johannesburg, who proposes to obtain the necessary power from the river Vaal. This would necessitate the cutting of a canal five miles in length, and would secure an effective fall of 100ft. for turbine purposes. The current would be conveyed to the mines over about 40 miles of cable, and be equal to about 20,000 effective horse-power, which would provide for all emergencies, or probable extensions. The position of the generating station is to be on the Farm Vishgat, close to Engelbrecht's Drift. It is claimed for this scheme that it will almost entirely do away with the necessity for the use of steam engines. Mr. Cousens' plan has not been made the subject of a concession, but negotiations with the Government have been going on for the purpose of obtaining the necessary permission for the erection of poles to carry the cable. The plans prepared by Mr. Cousens have received the approval of the executive. The whole of the surveys have been completed, and it is ultimately intended to erect 10 turbines, 3 being at first installed, and the remainder as demand arises. It is proposed to charge about ⅜d. per i.h.p. per hour, and this is calculated to be about the cost at the present time to companies using economical engines. The scheme appears to meet with the warm approval of those more immediately concerned, and Mr. Cousens is to be congratulated on the success of his endeavours to bring his scheme to maturity, and upon his success in obtaining the grant from the Government to proceed with the undertaking.

Waterloo and City Railway.—The Chairman at the meeting yesterday of the shareholders of this Company, was able to announce that in response to the application for capital the shares were over applied for to the extent of 20,000, and the stock still remains at a premium. He was futher able to announce that no calls will be required—at any rate for this year. A full report of the proceedings, which were purely formal, will be found elsewhere.

Winchester.—The City Council have decided to adopt the report of the Joint General Purposes and Electric Lighting Committees, under which application is to be made for a Provisional Order at a cost of about £250. A scheme is before the Council from the Brush Company, which will ultimately doubtless receive its support.

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WORCESTER.—The Watch Committee of the Corporation announce that Mr. Preece, their consulting engineer, and the Brush Company, the contractors for the work, have fixed October 11th as the date for the opening ceremony of the electric lighting station. The Guildhall and Public Hall and the street lamps will then be ready for lighting, and the Electrical Exhibition will be ready for opening.

WREXHAM.—In reference to the proposal of the Wrexham Town Council to effect a transfer of the Provisional Order granted to the local electric lighting company, a letter has been received from the Board of Trade pointing out that, "as the undertakers have not constructed any works under the Order they do not appear to possess any undertaking which, in the opinion of the Board of Trade, could properly be purchased by the Corporation." If, therefore, the Corporation desire to obtain statutory powers to supply electrical energy within the district, the Board of Trade are prepared to consider the expediency of revoking the Company's Order and granting a fresh one to the Corporation. The negotiations between the Company and the Corporation are apparently at an end.

YARMOUTH.—In addition to the lighting of the School of Art for the Technical Education Committee of the Yarmouth Corporation, Messrs. Crampton and Co., of Cambridge, are putting in the light at the Cromwell Hotel, Yarmouth.

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

July 30, 1894.

14,570. G. HUSSEY, Clitheroe. An automatic electric contact.

14,580. A. YOUNG, Edinburgh. Continuous electric brakes for railway trains.

14,602. J. B. G. A. CANET and A. HILLAIRET, London. Improvements in controlling appratus for electro-motors.*

14,607. R. LAMB, London. Improvements in electric cable traction-apparatus.

14,614. A. H. BEARD, London. Improvement in electric-magnetic motors.

July 31, 1894.

14,634. C. E. BUELL, Glasgow. Galvanic battery.

14,642. V. I. FEENY, London. Electrical battery. (F. Dubero and P. Mohrdieck, United States.)*

14,651. G. C. DYMOND, Liverpool. Improvements in electrical heating devices. (J. A. G. Trudeau, Canada.)*

14,689. F. TALLACK, F. W. TALLACK and L. HÉNDLÉ, London. Improvements in secondary batteries.

14,691. H. H. LAKE, London. Improvements in governing devices for motors. (Cie. de l'Industrie Electrique, Switzerland.)

August 1, 1894.

14,765. R. GREVILLE-WILLIAMS, London. Improvements in appratus for electrically effecting the reproduction at a distance of graphic matter or designs written, printed, stencilled, photographed, or otherwise produced.

14,768. A. L. SHEPARD. London. Improvements in electric arc lamps.

14,769. R. W. HILL. London. Improvements in or relating to apparatus for the production of sulphuric acid by the aid of an electric current.

August 2, 1894.

14,841. W. E. HUNNEX. Croydon. An improved diaphragm for phonographs and similar sound-recording and sound-producing machines.

14,847. J. E. LIARDET. London. Improvements in the means for storing electric energy.

14,850. R. LANGHANS. London. Improvements in the manufacture and production of filaments or incandescing media for electric lamps.

14,858. J. Y. JOHNSON. London. Improvements in the purification of saccharine juices by electrolysis. (E. Javaux, C. F. Gallois, and F. Dupont, France.)

14,859. W. G. LITTLE and C. W. G. LITTLE. London. Improvements in or connected with means for the supply or distribution of electricity.

August 3, 1894.

14,922. W. FIEDLER. London. Electrically-worked apparatus for regulating signals.

14,926. F. T. HOLLINS. London. Improvements in electric telegraph and signalling apparatus.

SPECIFICATIONS PUBLISHED.

NOTE.—All Specifications can now be obtained at the uniform price of 8d. each.

1893.

13,533. HUTCHINS. Clip for extracting and replacing electric fuses.

14,056. LONGSDORF. Electrolytes for primary batteries.

18,911. TYER. Electrical contact apparatus worked by passage of railway trains.

18,912. TYER. Electrical railway signalling apparatus.

23,170. MILLER and WOODS. Electrical transformers.

1894.

8,061. CARMICHAEL. Electro-chemical decompositions.

8,086. BRADT. Electric alarm for pressure gauges.

10,658. GOLBY (Neumann). Electric bells.

10,659. GOLBY (Neumann). Suspending incandescent electric lamps.

11,418. KINGSBURY (Western Electric Company). Telephone transmitters.

COMPANIES' MEETINGS AND REPORTS.

United River Plate Telephone Company (Limited).

The eighth ordinary general meeting of this Company was held on Friday at Winchester House under the presidency of Mr. J. Irving Courtenay (Chairman).

The SECRETARY (Mr. Robert Herring) read the notice convening the meeting.

The CHAIRMAN said: In reviewing the operations of the past year in the River Plate, it is satisfactory to note that the business of the Company has shown a decided improvement over that of the preceding year. We have gone through another very trying period of disturbance—political and monetary—and, though we cannot but feel disappointed that our efforts have been to a large extent neutralised by the unexpected rise in the gold premium, still it is a matter for congratulation that the receipts have continually increased, and also their net value for the year. It might reasonably have been expected that the number of subscribers would have fallen off as a consequence of the depressed condition of commercial affairs in the Plate; but, on the contrary, there has been during the year an increase of 606, for though there have been many withdrawals, the number of new subscribers has always exceeded those withdrawn, and upon this Mr. Krabbe (our local Director), who was present at our meeting last year, and addressed you, remarks: "Considering the very bad position of a large part of business in Buenos Ayres, which has been to a great extent the result, in the first place, of over-speculation in imports, and in the second place, of the very serious drought that the country has been experiencing for some seasons, the increase in subscribers must be considered extremely satisfactory, and shows that all through the crisis there is a natural increase, though small, in the total of business in Buenos Ayres—a healthy promise for the future. Of course this is to a certain extent the result of the *necessity* that the telephone is becoming; but we have other signs, such as tramway passengers, which also show an increase, and prove that it is resulting from increase of business in the city." The receipts at par of exchange are £134,053, being an increase of £18,711 over the previous year. I indicated when I last addressed you that you might expect some increase in the working expenses. The working expenses for the past year at par of exchange are £60,874, as compared with £57,669, and the percentage is 45·41 per cent., as against 49·99 per cent. in 1893, which testifies to the economical management in the Plate, where economies have been made in every possible direction; but we have had to increase the salaries of our employés, and the full effect of these additional charges has yet to be felt. In the Construction Department at Buenos Ayres, the work has been unusually heavy owing to the changes for new buildings, and this is likely to continue. We have had to make a number of lines for new subscribers while changing and altering our way-leaves in various parts of the city. The municipality is advancing rapidly with the new Avenida, which will necessitate a considerable outlay in getting across it with our lines. Our manager (Mr. Chappell) reports that the service continues good, and the complaints from subscribers have been very few. I sometimes think that shareholders hardly realise the difficulty there is in maintaining a good service during such revolutionary outbreaks as occurred last year, and the risks the staff of the Company have to run when a central station becomes an important strategical position, as was the case with ours last year. The manager and staff deserve much credit for the energy and pluck they have displayed in the interests of the Company. I now come to the most serious point of all, namely, the loss on exchange. As you are aware this is a matter over which we have no control whatever. The loss on exchange is enormous, and for the year under review amounts to £54,124. 17s. 9d., the highest figure yet reached. The fluctuations in the gold premium are so frequent and rapid that I do not wish to offer an opinion as to what its course may be in the future. So far as the past year is concerned, the loss on exchange swallows up the larger part of the profit that otherwise would be available for distribution among our shareholders. The net profit, after paying the Debenture interest and all other charges, is £9,782, and I repeat that it is most gratifying and encouraging—amid the turmoil and distress that has prevailed throughout the Argentine Republic, in common, mark you, with almost any other part of the world you can name—to be able to record this result. It is, indeed, full

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of hope for us. As mentioned in the report, we have allocated to certain accounts the sum of £4,270, of which the principal item is a sum of £3,000 transferred to depreciation and renewal fund. The net balance to be carried forward to next year will then stand at £6,417. 17s. 4d. Upon this review of the situation, there can, surely, be no doubt as to what should be the policy of the Directors, and that is to husband the cash resources of the Company and to strengthen its financial position as best they can. I feel certain that we shall have your support in giving practical effect to this policy. I now move—

"*That the report and accounts submitted to this meeting be, and they are, hereby received and adopted by the Company.*"

Mr. FRANK W. JONES, in seconding the motion, said their staff on the other side had passed through trying times since they last met. One instance would suffice to show what dangers they had been exposed to. During the late rebellion the Company's central office at Rosario, which stood rather high, was occupied by troops more or less as a fortress, and five men were killed in the building. He was thankful to say that none of their men were killed, although one or two were seriously injured.

The report was then adopted.

Mr. F. GREEN proposed the re-election of the retiring Directors—the Chairman and Mr. George Cooper. He said he had worked with both gentlemen now some years, and he could assure the shareholders that they devoted themselves to the interests of the Company.

Mr. G. DAVEY TURNER seconded the proposition, and it was agreed to unanimously.

The CHAIRMAN: I thank you on behalf of Mr. Cooper and myself for re-electing us. Mr. Cooper is well known in the City of London and in Argentina. He is now in the River Plate, and no doubt he will assist our officers and advisers there in doing their best for the shareholders.

Mr. A. O. CHUDLEIGH moved the re-appointment of the auditors Messrs. Cooper Brothers and Co., at a fee of 25 guineas.

Mr. J. R. BAILLIE seconded the motion, which was adopted.

Mr. FRANK W. JONES then proposed

"*That the thanks of the meeting be given to the General Manager in the River Plate, Mr. Chappell, the Buenos Ayres Manager, Mr. Parker, and their general staff; also to the local consulting Directors, Messrs. Fels and Krabbe, for the ability and zeal with which the business of the Company in the River Plate has been conducted during the past year.*"

Mr. J. R. BAILLIE said he was in Buenos Ayres last year, and had the pleasure of meeting Mr. Krabbe and Mr. Chappell, and from what he saw there he had pleasure in seconding the proposal.

The resolution was then carried unanimously.

The CHAIRMAN: I am glad to find that amongst those present we have a shareholder who has been out there and seen these gentlemen face to face. What he says only confirms all we have heard. Mr. Jones will communicate your vote of thanks to the proper quarter.

The proceedings then terminated.

Crompton and Co. (Limited).

The following is the text of the sixth report of the Directors of this Company, which is to be presented at the annual general meeting of shareholders, to be held at the Cannon-street Hotel, E.C., on Monday next, the 13th inst., at three o'clock:—

For the period under review (the year to March 31st last) the amount of the Company's business has satisfactorily increased, but the net profits, in consequence of close competition, show a reduction as compared with last year, and this, notwithstanding the fact that the Directors by careful management have reduced the expenses in many departments. The net profits for the year amount to £11,741. 2s. 7d., and after providing for debenture interest, and the payments set out in the revenue accounts, there remains a balance of £6,116. 3s. 5d., out of which the Directors propose to set aside £1,000 for contingencies and doubtful debts, to pay a dividend of 3s. per share on the Preference shares, and to carry forward the balance. The Directors regret that the net profits are insufficient to allow for the full dividend on the Preference shares; at the same time they do not think there is anything discouraging as to the future of the Company. The works are in first-rate order and condition, and under the new management the cost price of manufacture has been considerably reduced, while the various departments outside the works are at the same time being carefully reorganised with the view of reducing expenditure to the utmost without affecting their efficiency.

Since April, 1891, the Directors have entered into no contracts whatever under which the payments for work done were to be partly made in shares or securities, but they feel that the value of some of the securities previously taken as part payment may be considered doubtful. Recognising the necessity of reducing such doubtful assets or securities to their proper value in the Company's books, they propose that an amount of £20,000 shall be written off, and to enable this to be done they have obtained the assent of the two Managing Directors, Messrs. Crompton and Albright to relinquish an equal amount of Ordinary shares. The effect of this transaction will not be to deprive the Company of any value which the securities in question may hereafter attain, and the reduction of the amount of Ordinary shares must be for the benefit of the members generally.

The Directors are glad to be able to report that the cooking and heating department of the Company, which has been practically established during the past year, is likely, in their opinion, to prove a very valuable addition to the Company's business.

In response to their circulars in January last with regard to the proposed issue of £100,000 of Four and a-Half per Cent. Debentures, the Directors have received promises from the debenture and shareholders of the Company to subscribe for the new issue to the amount of nearly £32,000; but as this support was insufficient to enable the issue to be made with any certainty, the Board considered it better to wait for the statement of accounts now presented. It is intended to take further steps to place the debentures during the ensuing autumn; but they wish to urge upon the shareholders that it is in their own interests to assist in this issue, which is of such great importance to the Company. At the same time, they would remind the shareholders that the security for these debentures is undoubted. The property of the Company, even after the reductions before referred to, amounts to £236,618, including uncalled capital, but without reckoning the value of patents and goodwill, and the income of the Company for the last six years has averaged £11,839 per annum, while the interest required for the total proposed issue of debentures would only amount to £4,500 per annum.

The Chairman (Viscount Emlyn) retires by rotation, but offers himself for re-election; and the auditors (Messrs. J. H. Duncan and Co.) also offer themselves for re-election.

An extraordinary general meeting of the shareholders of the Company will be held at 3:30 p.m., or so soon as the business of the above ordinary general meeting is concluded, for the purpose of considering, and, if approved, of passing, the following special resolution:—

"*That the capital of the Company be reduced from £300,000 to £280,000 by cancelling paid-up capital which has been lost, or is unrepresented by available assets, to the extent of £20,000, by cancelling 4,000 Ordinary fully paid-up shares of the Company, numbered 2,785 to 6,784 inclusive, which have been issued.*"

Waterloo and City Railway Company.

The first half-yearly general meeting of this Company was held on Thursday at Waterloo Station, Mr. W. S. Portal (Chairman) presiding.

The Secretary (Mr. Fred. J. Macaulay) read the notice convening the meeting.

The CHAIRMAN, after affixing the seal of the Company to the register of shareholders, in the course of which he observed that the shareholders numbered 475, said: This being the first half-yearly meeting, there is very little for me to say, but that little is of a hopeful nature, and I trust that at each succeeding meeting, whoever has the honour of presiding may have a good account to give of the proceedings in connection with the Company. As you are aware the prospectus has been issued, and I may inform you that as a response 2,000 shares were applied for in excess of what were required. The stock has been from the first at a premium, and still remains so. The construction of the main portion of the line has been given on tender, at less than the Parliamentary estimates, to the responsible firm of Messrs. Mowlem, Burt and Co. One of the cylinders, which is 12ft. in diameter, is now laying in the contractor's yard, and is rather an exceptional sight. The engineer reports that the borings are on the whole satisfactory, and already staging has been prepared in the river close to Blackfriars Bridge. I have been asked to say if any calls will be made, and my reply is that no calls will be required, at all events this year. That part of the line which has been entrusted to Messrs. Mowlem, Burt and Co. will be finished, it is expected, in two and a-half years. The terminal stations in the City and here at Waterloo are still under consideration, and will form the subject of separate contracts. With regard to the question of the Forged Transfers Acts, mentioned in the report, we recommend you to adopt these Acts, as all the railway companies except one have done. I may add that we do not intend to make any charge to the registered shareholders. All the necessary consents from the several public bodies have been obtained, and up to the present time no obstacles have been encountered by the engineers, and everything is making satisfactory progress. I can only hope that if I am spared to meet you another year I shall be able to give you a good account of what has taken place. I will now move that the report and statement of accounts be adopted.

Lieut.-Col. Hon. H. W. CAMPBELL (Deputy-Chairman) seconded the motion, which was adopted unanimously.

The CHAIRMAN then proposed—

"*That the Directors be and they are hereby authorised to exercise, in respect of transfers now or hereafter entered in the books of the Company, the powers given by the Forged Transfers Acts, 1891 and 1892, to make compensation for any loss arising from a transfer of any shares in pursuance of a forged transfer or of a transfer under a forged power of attorney.*"

Lieut.-Col. Hon. H. W. CAMPBELL seconded the resolution, which was carried, and the meeting terminated.

Birmingham Central Tramways Company (Limited).

The report of the Directors of this Company, which will be submitted at the meeting to be held at the "Queen's Head Hotel," Stephenson-place, Birmingham, on Wednesday next, at 12:30 o'clock, states that the working profit for the past year, omitting the Corporation charges for maintenance, amounts to £52,804. 8s. 11d., as compared with £50,424. 1s. 10d. for the year ended June 30, 1893, showing an improvement of £2,380. 7s. 1d. The Corporation charges for maintenance, however, have again advanced by the sum of £1,729. 14s. 11d., which reduces the net comparative increase of working profit to £650. 12s. 2d. The revenue account shows a balance of £24,978. 3s. 5d., to which has to be added the sum of £3,438

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6s. 9d. brought forward from last year's account, making altogether £28,416. 10s. 2d. The Directors propose to divide this sum as follows :— £10,000 to reserve account against depreciation ; the payment of the 5 per cent. guaranteed dividend, amounting to £5,000 ; a dividend of 2½ per cent. upon the Ordinary shares (amounting to £9,700) for the year ending June 30th, payable September 1st next ; and £3,716. 10s. 2d. to be carried forward.

The Directors state that the position of the Company is one of assured and increasing strength and security ; but impress upon the shareholders the wisdom of dealing boldly and speedily with certain items of capital expenditure, which are not now fairly represented by assets of the Company, and to which reference is made in the auditors' report.

Mr. Martyn J. Smith has retired from the Board, and Mr. John Booth and Mr. Ebbsmith now retire by rotation, and offer themselves for reelection ; as do Messrs. Howard Smith, Slocombe and Co., auditors.

The working of the Electric Department of the Company's system is shown below :—

Dr.	£	s.	d.	Cr.	£	s.	d.
To electric haulage...	£3,482	7	10	By traffic receipts ...	£9,604	3	7
„ machinery	2,151	15	11	„ advertisements...	130	2	6
„ car repairs..	384	8	3				
„ traffic expenses...	1,010	15	6				
„ permanent way and buildings (exclusive of Corporation charges)	28	6	0	Miles run	139,123		
„ general charges...	1,462	4	6	Passengers carried	1,303,833		
	£8,519	18	0				
„ balance to revenue account	1,214	8	1				
	£9,734	6	1		£9,734	6	1

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "The Electrician" Electrical Trades' Directory and Handbook, 1894, pages 274-300, *&c., &c.*]

LEA, HOHRSTADT AND CO. (LIMITED).—This Company was registered on August 1st with a capital of £10,000, in £10 shares, to carry on the business of fancy brass manufacturers, stampers and piercers, electroplaters, engineers' tool makers, engineers, &c., at Birmingham, or elsewhere.

ELECTRIC LIGHTING AND GENERAL DEVELOPMENT SYNDICATE (LIMITED).—The annual returns of this Company, made up to August 8, 1893, and June 5, 1894, were both recently filed. Out of a nominal capital of £700, in £10 shares, 48 have been taken up, and of these 20 were issued as fully paid. Upon the remaining 28 shares the full amount has been called and paid.

ELECTRO-CHEMICAL COMPANY (LIMITED).—The annual return of this Company, made up to June 26, 1894, has been filed. Out of a nominal capital of £200,000, divided into 26,000 £10 per Cent. Preference and 14,000 Ordinary shares of £10 each, 17,005 Preference and all the Ordinary shares have been taken up. Of these 5,000 of the former and all the latter have been considered as fully paid. Calls amounting to £3 per share have been made on the 12,005 Preference shares, resulting in the payment of £35,548, and leaving £467 in arrears.

ELECTRIC TIME DISTRIBUTING AND CLOCK COMPANY (LIMITED).—The annual return of this Company, made up to June 26, 1894, has been filed. Out of a nominal capital of £5,000, in £1 shares, 2,084 shares have been taken up. Of these, 2,000 were issued as fully paid. Upon 82 shares the full amount has been called, and a call of 10s. per share has been made on the remainder, resulting in the total receipt of £83.

ELECTRICITY USERS' ASSOCIATION (LIMITED).—The statutory return of this Company, made up to July 3rd, was recently filed. The capital is £2,000, in £1 shares, and 107 shares are now taken up. Consequent upon a call of £1 per share which has been made, £57 has been received, leaving £50 still to be paid.

CITY NOTES.

AMALGAMATION OF FRENCH CABLE INTERESTS.—A general meeting of the shareholders of the Compagnie Française du Télégraphe de Paris à New York is, says the *Bulletin d'Electricité et de la Télégraphie*, to be held on the 31st inst., with the object of deciding the question of its absorption into the Société Française des Télégraphes Sousmarins, whose shareholders are also to meet on the same date. The same journal, in the course of a critical review of the position of the two companies, enters fully into the relations between them and the French Government, and points out that some difficulty will be experienced in obtaining the necessary quorum of votes to bring about the proposed amalgamation.

CITY AND SOUTH LONDON RAILWAY.—The traffic returns of this Company for the week ended August 5th were £848, as against £804 in the corresponding period of 1893, being an increase of £44. The total receipts for the half-year amount to £4,306, as against £4,237 for the corresponding period of 1893, an increase of £69.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—This Company's estimated traffic receipts for the month of July amounted to £1,400, as against £1,656 in the corresponding period of last year.

GAS LIGHT AND COKE COMPANY.—At the meeting of this Company, held last week, the question of the price of gas north and south of the Thames was dealt with at some length by the Chairman, Col. W. T. Makins, to whom Mr. Livesey, the Chairman of the South Metropolitan Company, replied. Mr. Livesey contended that the excessive charges made by the Gas Light and Coke Company had brought the Gas Workers' Union into existence, and had so placed the gas companies under the control of the men's unions that the South Metropolitan Company could stand it no longer, and resolved to take independent action, with the result that everyone was benefited, including the working-man himself. Colonel Makins acknowledged the beneficial effect of Mr. Livesey's action, but, in regard to the higher price charged by the Gas Light and Coke Company for the north of the Thames district, pointed out that the southern Companies were not nearly so much affected by competition with the electric light as was the northern Company. Hitherto Col. Makins has rather derided the idea of the electric light affecting the Gas Light and Coke Company's receipts. His remarks on this occasion point to a chastened spirit. Facts are stubborn things, and having once admitted the influence of the electric light on the receipts of the great corporation over which he presides, it is not unlikely that Col. Makins will see occasion to make further reference to the subject at future meetings. The references at the meeting to the huge profits made by the metropolitan gas companies since 1887 were given at the enormous figure of £16,978,000.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic returns of this Company for July, 1894, amount to £25,600, and from January 1st to July 31, 1894, £155,400. In the corresponding months of 1892 and 1893 the amounts were £152,000 and £156,800 respectively.

GULCHER (NEW) ELECTRIC LIGHT AND POWER COMPANY (LIMITED) (*in liquidation*).—An extraordinary general meeting of this Company is to be held at the offices of Messrs. Kemp, Ford and Co., 73, Lombard street, E.C., on Thursday, the 16th inst., at 11 o'clock, when the resolution passed at the meeting of the Company held on the 1st inst. will be submitted for confirmation as a special resolution. The resolution is set out in our issue of July 27th, page 379.

KNIGHT AND CROWTHER (LIMITED).—The Directors propose dividends for the half-year ended June 30th, on the Preference shares of 6½ per cent., and on the Ordinary shares of 7 per cent. (making 6½ and 6 per cent. respectively for the year).

LONDON ELECTRIC SUPPLY CORPORATION (LIMITED).—With regard to the action taken by Lord Wantage in foreclosing on the Debentures held by him in this Corporation, it would appear that the shareholders were unable to pay off the Debentures when they became due, and his Lordship, therefore, to protect the concern, took possession. In addition to holding the Debentures, Lord Wantage is by far the largest shareholder (both Ordinary and Preference) in the concern, and the next largest shareholders are satisfied with his Lordship's action, and regard it as the best step to be taken under the circumstances. The Corporation's business will go on just as hitherto, and it is anticipated that Lord Wantage will be able to effect those considerable economies in the working of the business which, with a full Board of Directors, it has been found difficult to bring about. Mr. Bain, who has for many years acted as accountant and secretary to the Corporation, has been appointed receiver and manager, and still holds his position as secretary, so that no confusion is likely to arise in the various interests at stake. The action taken by Lord Wantage has not come upon the shareholders with surprise, as the difficulty of redeeming the Debentures as they became due loomed before them for some time past. The Corporation has been unfortunate, but the shareholders have been kept fully acquainted with the position of affairs. It is to be hoped, in the interest of all parties, that the altered conditions may prove the turning point in the fortunes of the Corporation.

OSWESTRY ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The Directors of this Company have arranged to guarantee a minimum dividend of 3 per cent. per annum upon the share capital called up from time to time up to £4,000, such guarantee to be in force for a period of three years from the date of the first supply of electricity to the town by the Company, but is not to apply to the shares held by the present Chairman.

STOCK EXCHANGE NOTICES.—The Stock Exchange Committee have ordered £100,000 Five per Cent. Debenture Stock (in lieu of scrip) of the City of London Electric Lighting Company (Limited), to be quoted in the Official List.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the week ended August 3rd (after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited), were £2,335.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the two weeks ending July 31st were £1,754, as compared with £1,781 for the corresponding period of last year.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share	Last Divi-dend.	Name.	Previous Week's Price, Aug. 1.		Price Wednesday, Aug. 8.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Aug. 8. Highest	Lowest
			TELEGRAPHS.					£ s. d.		Highest	Lowest
£1,012,880	Stock	10/0	Anglo-American .... xd	37	40	37	40	6 4 6	Jan., Apr., July, Oct.	..	..
£2,933,560	Stock	20/0	Do. Preferred .... xd	70	72	70	72	6 5 0	,, ,,	71¾	70½
£2,933,560	Stock	5/0	Do. Deferred	6½	6¾	6½	6¾	..	..	6⅝	..
£184,500	100	4%	African Direct Teleg. 4% Deb. (Reg. & Bearer)….	101	104	101	104	3 16 11	January and July	..	..
130,000	£10	3/0	Brazilian Submarine	12	12½	12½	12¾	5 2 0	Mar., June, Oct., Dec.	12¾	12½
£18,700	£100	5%	Do. 5 per Cent. Bonds .... xd	..		..		..	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906) ….	107	111	107	111	3 16 11	June and December	..	—
10,000,000	$100	$1¼	Commercial Cable Capital Stock	139	143	139	143	4 17 11	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	12½	13½	12½	13½	5 18 6	February and August	..	—
6,000	10	10%	Do. Preference 10 per Cent.	19½	20½	19½	20½	4 17 7	,, ,,	..	..
12,931	5	1/7½	Direct Spanish (£4 paid)	4	4½	4	4½	4 8 11	April and October —	..	—
6,000	5	10%	Do. Preference 10 per Cent.	9½	9¾	9½	9¾	5 2 7	,, ,,	—	—
£30,000	Stock	4½%	Do. 4½% Debentures of £50 each	103%	106%	103%	106%	4 4 11	..	..	..
60,710	20	2/0	Direct United States Cable, 1877 .... xd	8	9	8	9	6 13 4	Jan., Apr., July, Oct.	8¾	8¾
400,000	10	5/6	Eastern	15½	15¾	15½	15¾	4 2 6	,, ,,	15¾	15½
70,000	10	6%	Do. 6 per Cent. Preference........ xd	16	16½	16½	16¾	3 11 8	,, ,,	16½	16⅜
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock ….	116	119	116	119	3 7 3	May and November	..	..
£102,100	100	5%	Do. 5 per Cent. Debentures, 1899........ xd	105	109	105	109	4 11 9	February & August	..	—
250,000	10	2/6	Eastern Extension	15⅝	15⅞	15⅝	15⅞	4 8 2	Jan., Apr., July, Oct.	15¾	15⅝
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock........ xd	114	117	114	117	3 8 5	February & August	..	—
£62,700	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900….	103	106	103	106	3 17 3	January and July	..	—
£95,100	100	5%	Eastern and S. African 5 p. Cent. Mor. Deb., 1900..	103	106	103	106	3 17 3	,, ,,	..	—
£300,000	100	4%	Do. 4% Mortgage Debentures, 1909 (regd.) xd	103	106	103	106	3 15 6	February & August	..	—
£200,000	£25	4%	Do. 4% Mauritius Sub. Debs........	107%	110%	107%	110%	3 12 9	May and November	..	..
180,227	10	2/6	Globe Telegraph and Trust	8½	8½	8⅝	8⅝	5 4 4	Jan., Apr., July, Oct.	8$\frac{9}{16}$	8$\frac{9}{16}$
180,042	10	6%	Do. 6 per Cent. Preference........	15¾	15⅝	15⅝	15⅞	3 15 7	,, ,,	15⅝	15⅝
150,000	10	5/0	Great Northern........	20	20½	20	20½	4 3 9	Jan., April, and July	—	..
£190,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	105	108	105	108	4 12 7	March & September	—	—
17,000	25	37/6	Indo-European	44	46	44	46	5 8 8	May and November	..	..
37,548	10	5/0	London Platino-Brazilian	5	7	5	7	..	,, ,,	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	108	111	108	111	5 8 1	March & September	110½	110
£100,000	£100	4%	Pacific European Tel. 4% Guar. Debs. "Red" 1942 ..	102	105	102	105	3 16 2	..	..	—
11,839	8	4/0	Reuter's	4½	5½	3	5	..	April and October —	—	..
3,381	£100 Cert.	25/0	Submarine Cables Trust 6 per Cent.*	108	113	108	113	5 6 2	,, ,,	..	..
15,609	10	5/0	West African Telegraph	3	5	3	5	..	January and July	..	..
£249,900	100	5%	Do. 5 per Cent. Debentures	102	105	102	105	4 15 3	March & September	103½	..
30,000	10	2/0	West Coast of America	2½	3	2½	3	..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902........	96	101	96	101	7 18 5	June and December	..	..
88,321	10	9d.	West India and Panama	1	1½	1	1½	..	..	1½	1$\frac{1}{16}$
34,563	10	6%	Do. 6 per Cent. 1st Preference	10	10½	10	10½	5 14 3	May and November	10$\frac{7}{16}$	10$\frac{4}{16}$
4,669	10	6%	Do. 6 per Cent. 2nd Preference	9	10	9	10	6 0 0	,, ,,	..	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917........	107	110	107	110	4 5 7	June and December	..	—
64,242	15	7/6	Western and Brazilian	6¾	7½	6¾	7½	..	May and November	7	..
33,129	7½	7/6	Do. 5 per Cent. Cumulative Preferred	5¾	6½	5¾	6½	..	..	—	..
33,129	7½	4/6	Do. 5 per Cent. Deferred........	1¾	2½	1¾	2½	..	..	1⅞	..
£171,900	100	6%	Do. 6 per Cent. Debs., Series "A" 1910 .. xd	105	108	105	108	5 11 1	February & August	..	..
£214,800	100	6%	Do. 6% Mort. Debs., Series "B" 1910...... xd	105	108	105	108	5 11 1	,, ,,	..	..
$1,211,000	$1,000	7%	Western Union 7% 1st Mort. (Building) Bonds ….	115	120	115	120	5 16 8	May and November	—	..
£166,900	£100	6%	Do. 6 per Cent. Sterling Bonds........	100	104	100	104	5 15 5	March & September	..	..
			TELEPHONES.								
44,000	5	10/0	Chili Telephone (fully paid)	1	2	1	2	..	..	—	—
224,850	10/0	2½d.	Consolidated Telephone Const. & Maintenance ..	⅛	¼	⅛	¼	..	May and November	—	..
171,504	£1	6d.	Oriental Telephone and Electric (fully paid)........	¼	⅝	½	⅝	..	Yearly —	¼	..
484,597	5	3/4	National	4¾	5	4¾	5	5 0 0	June and December	4$\frac{15}{16}$	4¾
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	14	15	14	15	4 0 0	,, ,,	14$\frac{11}{16}$	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid) ..	13½	14½	13½	14½	4 2 9	,, ,,	..	..
119,234	5	3/4	Do. 5% Non-Cumulative 3rd Pref.	5¾	5⅝	5¾	5⅝	4 8 11	..	5½	—
1,000,000	Stock	4½%	Do. Debenture Stock, 4½%	109	112	109	112	4 10 0	January and July —	..	..
58,000	5	1/0	United River Plate	1	2	1	2	..	,, ,,	..	..
£146,733	Stock	5%	Do. 5 per Cent. Debenture Stock	85	95	85	95	5 5 3	,, ,,	..	—
			ELECTRICITY SUPPLY COMPANIES.								
40,000	£10	..	City of London Electric Lighting (fully paid) ….	12½	13½	12½	13½	..	..	..	..
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	14	14½	14	14½	4 2 9	..	14⅜	14½
19,900	£5	..	Electricity Supply Co. for Spain........	..		..		..	..	..	—
£30,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	4½	5½	4½	5½	..	—	..	..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900........	..		..		—	..	..	..
8,322	£5	..	House-to-House Electric	..		..		—	..	..	—
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid).	..		..		—	..	..	—
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)........	..		..		—	January and July —	—	—
45,000	£5	2/6	Liverpool Electric Supply (fully paid)	6½	6⅝	6½	6⅝	—	..	—	—
111,000	5	..	London Electric Supply........	¼	⅜	¼	⅜	..	..	—	..
49,900	£10	5/0	Metropolitan Electric Supply (fully paid)	8½	9	8½	8¾	2 17 2	..	..	..
£150,000	Stock	4½%	Do. 4½% Debs. (Bonds of £10, £20, and £40)..	3	5 pm	3	5 pm	4 11 9	June and December	..	..
6,452	£10	..	Notting Hill Electric	4½	5½	4½	5½	—	..	..	—
19,980	£5	2/0	St. James and Pall Mall .... xd	7	7½	7	7½	..	..	—	—
20,000	£5	7%	Do. 7 per Cent. Preference........ xd	8½	8¾	8½	9	3 17 9	—	—	..
59,900	5	2/0	Westminster Electric Supply (fully paid) …. xd	6	6½	6	6½	3 9 3	—	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
90,000	8	1/6	Brush Electrical Engineering	2¾	3	2¾	3	6 0 0	..	2$\frac{13}{16}$	2¾
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	2¼	2½	2¼	2½	4 16 0	..	2$\frac{7}{16}$	2¼
£125,000	Stock	4½%	Do. 4½ per Cent Debentures	110	113	110	113	3 19 8	March & September	..	..
20,000	5	2/6	Crompton and Co., 7 per Cent. Cumulative Pref...	2½	3	2	2½	—	January and July —	..	..
12,139	5	..	Edison and Swan United	—		—		..	—	—	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid) ..	—		—		..	..	—	..
120,000	2	..	Electric Construction	¼	¾	¼	¾	—	—	—	—
12,845	2	..	Do. 7 per Cent. Cumulative Pref.	1½	1¾	1½	1¾	..	—	..	—
91,195	2	10/0	Elmore's Patent Copper Depositing	1	1½	1	1½	..	—	—	..
20,000	5	..	Fowler-Waring Cables (fully paid)	½	1½	½	1½	..	—	..	..
50,000	10	10/0	India Rubber, Gutta Percha, &c., Works	23	24	23	24	5 4 2	February & August	23$\frac{11}{16}$	23⅜
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103	105	103	105	4 5 9	March & September	..	—
15,995	£10	6/4	International Okonite Ordinary	..		..		—	..	—	—
16,000	£10	—	Do. 8 per Cent. Preference........	—		—		—	December and June	—	—
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid)......	—	¼	—	¼	—	..	—	..
78,949	5	3/6	Swan United (£3 10s. paid)	..		..		..	May and November	..	..
37,350	12	12/0	Telegraph Construction and Maintenance …. xd	40	42	40	42	5 14 3	March and July —	41½	..
£150,000	100	5%	Do. 5 per Cent. Bonds	102	105	102	105	4 13 6	January and July	—	—
37,514	£5	—	Woodhouse and Rawson Ordinary (£3 15s. paid)..	—		—		..	..	—	—
41,098	£5		Do. Preference (fully paid)........	—		—		..	—	—	—
£63,870	10	10/0	W. T. Henley's Telegraph Works Ordinary........	7	8	7	8	6 5 0	..	..	..
£30,000	10	..	Do. Preference	..		..		..	..	..	..
			RAILWAYS AND TRAMWAYS.								
£630,000	Stock	1%	City and South London Railway........	36	38	36	38	1 16 2	May and November	..	..
7,000	10	5%	Do. 5% Perpetual Preference	12¾	13½	12¾	13½	3 15 6	May and November	..	..
£67,130	Stock	4%	Do. 4% Perpetual Debenture	120	122	120	122	..	..	..	..
37,500	£10	1%	Liverpool Overhead Railway	8⅜	8½	8½	8⅜	..	..	..	..
6,295	10	5%	Do. 5% Preference	13	13½	13	13½	3 14 1	..	..	—
£125,000	Stock	4%	Do. 4% Debenture	111	113	111	113	3 10 10	January and July ..	..	—

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NOTES.

The atmosphere of Oxford appears to have infused something of the old spirit of vigour into the recent meeting of the British Association; not only was the attendance good, but the Papers and discussions were excellent both in quantity and quality. The formation of new sections, the sub-sectioning of others, and the temporary coalescence of engineers and mathematicians, of physicist, and physiologists, have been attended with the happiest results. Not a little of the success of the Oxford meeting must, however, be attributed to the charming environment and the convenience which such a city possesses for simultaneous gatherings of moderate dimensions. Papers and discussions of every degree, from the profound to the popular, were offered, and even outsiders who could not follow the arguments must have enjoyed the human side of some of the debates. The cock-sureness of the four-figure physicist with his theories of vision could be compared with the cautiousness of the physiologist ready to dispute any cut-and-dried theory, but eager to accept any hypothesis rather than none. Good solid work was represented in brief reports on determinations of electrical resistance, and comparison of standards. A *résumé* of the leading Papers will be found elsewhere in our present issue, and here we will allude to one or two of the more popular discussions.

Confusion is often bad enough when, in scientific literature and discussions, different terms are employed for the purpose of expressing identically the same idea. But it becomes a hundred times worse confounded when to this is added the vice of using the same term to express a number of totally distinct or—what is even worse—slightly different ideas. The bulk of the speakers who took part in the discussion on Mr. Parker and Prof. S. P. Thompson's Papers, at the British Association on Monday, were guilty of the latter sin. Almost every speaker who adverted to the point which had been raised by Sir Frederick Bramwell—viz., the relative costs of gas and electric light—spoke of "the number of 8-c.p. lamps per *unit*." This led Mr. Swinburne very pertinently to put the simple question: What *is* a unit? Prof. S. P. Thompson also sinned in this respect by appropriating the word "reactance" to express the idea usually conveyed by the word "impedance." An alternating current, he said, is determined by the ratio of the electromotive force to the reactance! Now, not only have Oliver Heaviside and other mathematicians employed this word "reactance" to express only that term in the impedance expression which is due to magnetic induction, but this meaning of the word has become fairly generally adopted, and it has even been authoritatively accepted in America. Prof. Thompson's act in annexing the word to express what everyone else knows as "impedance" is therefore liable to lead to confusion.

The point which Sir Frederick Bramwell raised was one which has often been discussed, but which is incapable of exact calculation. Mr. Preece had given the easily remembered and interesting formula: "Gas at 3s. per thousand equals electricity at sixpence a unit." What Sir Frederick wanted to know, and what Mr. Preece did not appear to be able to demonstrate on the spot, was—how the interesting formula was arrived at. The performances of fish-tail and argand burners, and of hotel waiters who turn off the electric light promptly whenever it is wanted as well as whenever it is not, were somewhat vaguely discussed. But nobody seemed able to put down the actual figures, and conclusively show that the consumer who pays sixpence for his unit gets as much light as he who pays three shillings for his 1,000 cubic feet of gas. If meter rents and interest on first cost of wiring and fittings were reckoned; if the dirtiness of gas burners could be compared with the dirtiness of lamp globes; if saving of decorations and doctors' bills could be computed, and a price fixed for the convenience of being able to turn up the light whenever it is wanted, the ratio might be reduced to a rigidly arithmetical quantity. The old rule was to take sixpence a unit as equivalent to six shillings per thousand. For the last four or five years it has been safe to multiply the price of the unit by ten to give the price per thousand, and the result of careful analysis of the tests of gas burners, published in *The Electrician* in December last, justified the use of the factor 8. Unless Mr. Preece can give good reasons for using the factor 6, we should prefer to say that electric supply at sixpence is equivalent to gas at *about* three shillings per thousand.

The question which Mr. Thomas Parker put to Mr. Preece as to the efficiency of his system of "Signalling through Space" reminds us of the remark which a puzzled individual made to us at the close of the meeting. So much fuss had been made about the fact that a current started in a wire in one place will generate a current in a wire in another place

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even though there is no electrical conduction from one wire to the other, that our puzzled friend—who is a very clever electrical engineer, by-the-bye—asked us to correct him if he was wrong in believing it to be a fact that a current may be started in the secondary circuit of a transformer by starting a current in the primary, even though there be no conduction between the two circuits. We said he was quite right; and then he seemed much puzzled to know why such a "to do" had been made about the occurrence of the same thing in the signalling business. Speaking of transformers, and of the efficiency of signalling by electro-magnetic waves, leads us to remark on the absurdity of trying to prove that the efficiency of signalling in this way can ever be more than a microscopic quantity. In the transformer, with its interlaced primary and secondary coils and its good iron magnetic circuit, the efficiency is indeed something to be very proud of—at full load. But, how can anything but an insignificantly small efficiency be expected when the two circuits are many miles apart, and when, instead of a few inches of good magnetic iron, there are many miles of bad magnetic air? Yet such are the conditions of Mr. PREECE's ingenious system of signalling by electromagnetic waves. Mr. PREECE, however, very skilfully turned the edge of Mr. PARKER's inquiry upon the questioner, by reminding Mr. PARKER that the big currents used in his Liverpool Overhead Railway were no end of a nuisance for miles around to telegraphic and telephonic operators.

THE justification of the running of a 3ft. flywheel at a peripheral speed of 666ft. per second by reference to an American torpedo, as is done by Mr. SWINTON in our correspondence columns, is not very sound engineering, and we cannot agree with him that such a wheel of solid steel would be safe. But Mr. SHARP has indicated one way of putting an initial compression on the rim, which would help to keep it together. It is possible, however, to provide this initial force otherwise than by tension of the arms, which ought not to have additional work thrown on them. In connection with the heavy, sudden, and short loads required for electric welding, it was proposed by Prof. G. FORBES and Mr. HALPIN, if we remember right, to make a flywheel rim of channel section, and to wind it full of steel wire under tension. This plan, which seems much less expensive than the only other alternative, namely, shrinking on a hoop, would possibly provide a safe flywheel for these extreme speeds.

THE connection between "scientific dress-making" and electrical science and engineering is not very apparent; but the action which was tried before Mr. Justice WRIGHT, and was recently taken to the Court of Appeal, may be, nevertheless, of some interest to our readers. The art of scientific dress-making consists, as we understand it, in the use of what an engineer would call a template, but which was described as a sleeve chart, "a sheet of thin cardboard in the shape of a sleeve, with various lines, scales, and figures printed on it, together with holes through which pencil-marks could be made on paper or material placed beneath it." This "chart" had been registered under the Copyright Act, and it had been held by Mr. Justice WRIGHT that it was capable of being so registered. The defendant, however, appealed, and it was contended on her behalf that the chart was not a "book, map, chart, or plan" within the meaning of the Act, that it had no literary merit, and that it would be useless and unintelligible without further explanation. Mr. Justice WRIGHT thought that a map, chart, or plan need not be topographical; but the LORD CHANCELLOR observed that the words and figures on the "chart" did not in combination convey any intelligible idea, nor could they be of the slightest use to anyone, apart from the cardboard upon which they were printed. The cardboard was, in fact, a measuring apparatus or tool, and he did not think it necessary to determine whether such an apparatus could be the subject of letters patent as an invention, though he was far from saying that it could not be so, if novel. Lord Justice LINDLEY said that the thing was in truth a measuring machine, and no more a chart than a scaled ruler. If what was published was not separately published, was not a publication complete in itself, but was only a direction on a tool or machine, to be understood and used with it, such direction could not, in his opinion, be severed from the tool or machine of which it was really part, and could not be monopolised by its inventor under the Copyright Act.

So much for copyright. We now turn to the most recent treatise on "The Law of Patents," by Mr. HENRY CUNYNGHAME, an important book which we have not yet reviewed, and find that the subject matter for a patent must be for some kind of manufacture. If extended to a new process, that only means a process resulting in an article. An art, or principle, or a new metal cannot be patented, unless in such a way as to amount to a craft or manufacture. "An invention for some mathematical process, which, however useful, was not a manufacture, could not be patented. Thus, a new method of computing logarithms, or a new cypher, or a new method of book-keeping, would not be good subjects of patents. It follows again that the author of a book cannot be said to 'manufacture' it. . . . The author would not be patenting a new craft, but only the product . . . of an art, and could in no sense term himself a manufacturer." This being so, we venture to think that there is a considerable gap between the Copyright Act and the Patent Acts, through which many valuable inventions might fall. The officials at the Copyright Office hesitated, to our knowledge, some years ago, to accept a design of a chronograph dial containing a number of computed scales, and the inventor of a certain slide rule has endeavoured to protect himself by both copyrighting and patenting his instrument. A mere template could no doubt be patented, but slide rules are old, and any new application consists in the imprinting on them of calculated scales with numbers and words. The slide rule is of course a manufacture, but the scales are the product of an art; the inventor seems here to be an author, not a manufacturer. A pocket rule might be made with quotations from Shakespeare printed on it: would this be patentable? Or with some useful formulæ, or with some useful tables arranged as curves. These, printed on paper, are obviously no subject matter for a patent. The foot rule on which they are placed cannot alter

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their character. Can a slide rule on which they are engraved, or on which perhaps printed scales are pasted, materially alter the nature of the invention? At what point, then, can words, figures and scales, on slide rules and many other instruments of like nature, be rejected from Stationers' Hall and accepted at the Patent Office? The LORD CHANCELLOR did not deem it necessary for him to determine whether the sleeve chart could or could not be patented. Is it anybody's business to do so?

THE opinion which was pretty generally expressed, both at New York and Chicago, in the discussion on Mr. FARNHAM'S Paper on the "Destructive Effect of Electrical Currents on Subterranean Metal Pipes," was that the difficulties which had been experienced in the States in connection with the use of an uninsulated return for electric tramways were a thing of the past; the putting of the negative pole to earth, and of plenty of copper underground being considered a practically complete solution of the problem. Speakers, however, did not remember to point out that this lavish use of copper, even at £38 a ton, goes a long way to neutralise the much-boasted superiority of the single-trolley system in the matter of low first cost. If, as Mr. NELSON W. PERRY argues from the experience of Cincinnati, in an article which we reprint in the present issue, the remaining electrical and mechanical drawbacks of the double trolley have been successfully overcome, it would certainly seem as if they would come to it at last even in America, as being cheaper in operating expenses and giving rise to no telephone interference or electrolytic troubles; indeed, the makers of double-trolley equipment would do well to advertise their wares by the catch line, "Double your trollies and halve your troubles."

IF Mr. PERRY is correct in his statements—and human nature being much the same in the States as elsewhere, only more so, it is highly probable he is correct—neither the single nor the double trolley has as yet been adopted in America on its merits. The single-trolley system, it would seem, owed its vogue to the fact that manufacturers wanted to make 200 per cent. profit, and, the double-trolley system costing 30 per cent. more than the single, as then carried out, manufacturers had to choose between reducing their rate of profit in order that the double-trolley equipment might not be prohibitively expensive, and making out that salvation lay only with the single trolley. In Cincinnati, on the other hand, the tramway company and telephone company shareholders were mostly the same individuals; hence the remarkable local recognition of the many virtues of the then forlorn double trolley. Welded tracks also, about which we have heard so much lately, do not appeal to Mr. PERRY; both at Johnstown and Boston he states that this winter "the rails stretched and stretched until they could stretch no longer, and then they broke" at the rate of ten breaks to the mile. Pessimistic, however, as he is, he admits track welding may mitigate the electrolytic evil, though he will not admit that it can be eradicated in this manner; but, after all, eradication is only a question of degree, complete mitigation = eradication.

Cable Interruptions.—No interruptions are recorded this week.

Personal.—Mr. E. G. Jones, late assistant engineer to the St. James and Pall Mall Electric Light Company has been appointed electrical engineer to the Corporation of Cape Town.

British Association Attendance.—The number who attended the Oxford meeting was 2,321, a number in excess by several hundreds of last year's meeting, and the receipts were £2,175.

Honorary Degrees.—The honorary degree of D.C.L. was conferred by the University of Oxford upon a number of distinguished members of the British Association. Prof. Boltzman, M. Cornu, and Prof. S. P. Langley were among the recipients.

The Budapest Electric Underground Railway.—The Hungarian Minister of Commerce has granted the concession for the construction of the underground electric railway in Budapest. This line will be two miles in length. It is to be opened on April 1, 1896.

Street-watering by Electric Cars.—Toronto is said to be succeeding very well with its plan of watering the principal streets by the aid of the trolley. The streets on which the electric cars run are watered from a tank run by electricity along the car lines.

Obituary.—Mr. Charles Liddell, who has just died at the age of 81, took, as a partner in the firm of R. S. Newall and Co., at one time an active part in the laying of telegraph cables. He it was that, during the war in the Crimea, laid the cable between Varna and Balaclava.

Future Meetings of the British Association.—The next meeting of the Association will take place at Ipswich, and the 1896 meeting at Liverpool, and Toronto will, in all probability, be the scene of the 1897 gathering. Sir Douglas Galton will preside over the Ipswich meeting.

Electrical Trade Section.—At a meeting of this section on Tuesday last, Mr. Sydney Morse was elected Vice-Chairman, and after a few informal remarks with regard to electric traction on common roads and the rating of electric light stations, the section adjourned over the vacation.

Electro-Chemistry in Germany.—It is stated that the German Solvag Company of Bernburg has prepared plans for the establishment of works at Osternienburg for the electrolytical production of caustic potash, chlorine, and chlorite. Electricity has recently been adopted as the motive power at the bleach works of Messrs. Keferstein at Greiffenberg.

Belt and Rope Transmission.—As announced by Prof. Kennedy, in the course of the discussion on Mr. Crompton's Paper, the Société Industrielle du Nord de la France arranged at the beginning of the year for a series of experiments with a view of determining the power absorbed by belt and rope transmission under working conditions. These trials took place on the 7th, 8th, and 9th inst., a 200-H.P. engine being connected up to a 1,400-light dynamo.

Lightning.—During a heavy thunderstorm, which broke over the neighbourhood of Warminster on Friday afternoon last, about half-past four, two men who were turning hay in the middle of a large field, away from any shelter, were struck by lightning and instantaneously killed. Another man who was standing close by was knocked down, but escaped serious injury.—On Sunday the South Foreland lighthouse was struck by lightning, and a corner of the engine-house was knocked down.——On Wednesday evening last two roadmen who were sheltering in a harvest field at Holbeach while a heavy storm was raging were both killed by lightning.

The Electrician's Paradise.—It is satisfactory to learn, on the authority of a lively letter in yesterday's *Times*, that in Korea, at any rate, the electrician has the whip-hand over his employers. According to the writer of this letter, the only European not paid by the Customs who gets his pay regularly is the electrician at the Palace. The King and all his Court are so afraid of ghosts that they sit up all night. There are sorcerers—and the electric light also—to keep off the ghosts. If the electrician's pay falls into arrear the light apparatus breaks down, and cannot be repaired until he is paid up.

British Association Science Grants.—At the final meeting of the British Association Prof. Rücker read the synopsis of

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grants of money appropriated to scientific purposes by the General Committee at the Oxford meeting. The following are a few of these grants: Prof. Carey Foster—electrical standards, £25; Dr. E. Atkinson—abstracts of physical papers, £100; Mr. Howard Fox—roduction of magnetic observations made at Falmouth Observatory, £50; Prof. A. W. Rücker—comparison of magnetic standards, £25; Prof. S. P. Thompson—uniformity of size of pages of transactions, &c., £5; Sir H. E. Roscoe—wave-length tables of the spectra of the elements, £10; Prof. J. E. Reynolds—electrolytic quantitative analysis, £40; Prof. A. B. W. Kennedy—calibration and comparison of measuring instruments, £50. A total sum of £1,093 was granted.

A New Filling Material for Thermometers.—Mercury, with which thermometers are ordinarily filled, has the drawback that it freezes when the temperature sinks to $-39°$ C. Alcohol, which is also used for the same purpose, frequently contains water, so that its registration can never be fully trusted. It has now been found, says the *Journal of Gas Lighting*, that toluol, one of the products of the distillation of coal tar, is applicable as a filling. It contains absolutely no water, and does not easily evaporate; it can stand a much lower temperature than quicksilver without freezing; and, when exposed to warmth, expands with great regularity. Further, it is very cheap; and, as it is much lighter than quicksilver, the tube of the thermometer can be made larger than is now usual; thus securing greater exactitude in the registrations. It is of a dark blue colour, which is easily distinguishable in the glass tube; so that the readings of the thermometer can be easily and quickly seen.

The Heilmann Electric Locomotive.—*L'Industrie Electrique* is responsible for the following:—The Compagnie des Chemins de Fer de l'Ouest, satisfied with the experiments carried out with the locomotive of M. J. J. Heilmann, has just ordered two new ones from the Société de Traction Electrique, which owns the Heilmann patents. The new locomotives will embody the improvements and modifications suggested by experience, with a view to the bringing out of a definite working type. The steam engine considered as best fulfilling the conditions imposed on the builders is the Willans. Messrs. Willans and Robinson have, therefore, received an order through their agent, M. A. H. Crozier, for two 1,500-H.P. engines, to be delivered in January and February next. The trials of the electric locomotives are to take place in May next, and it is understood that if the results are conclusive the Heilmann locomotive will be definitely adopted. We may add that M. Heilmann has recently been decorated with the Legion of Honour.

The Brooklyn Motormen.—The street boys of Brooklyn have found a new amusement, says the *New York Times*, and some of the motormen on the Third Avenue trolley line are on the verge of nervous prostration. The boys beg, borrow, or steal old clothes, until they have succeeded in getting together a very complete man's outfit. The next thing is a dummy, life size, which is well dressed, even to hat and shoes. A dozen or more conspirators, escorting this semblance of a man, stroll carelessly on to the track in front of an advancing car, talking busily. The bell is rung loudly, the boys scatter, and the dummy falls across the track. Then the jokers discover their histrionic talent. They rush back, apparently in terror, and make futile efforts to get the man out of danger. In the meantime the motorman, who is not the bloodthirsty wretch driving the car of Juggernaut that he is popularly supposed to be, is in an agony of horror. His hair fairly stands on end, and the veins stand out on his forehead as he uses all his muscle on the brake. If he succeeds in stopping before the car goes over the prostrate form, it is pulled off the track and sent flying into the car with wild shouts. The feelings of the unfortunate man at the brake are too vehement for utterance when he discovers the trick. The scheme is very successful just about dark, and, whichever way it goes, it is great fun for the boys.

The Electric Lighting of the Houses of Parliament.—In answer to a question in the House of Commons last week, Mr. H. Gladstone stated that the matter of providing the Houses of Parliament with electric installation had already received careful consideration. The evidence showed that no complete installation of electric lighting machinery and plant could be established within the building without occasional serious interference with its proper ventilation, and they had already some experience with a partial installation, which confirmed that view. The generation of electricity within the building had been abandoned both for that reason and because the boilers now existing were no longer strong enough to bear the strain of working both the ventilation and the lighting systems. The cost of constructing a complete electrical station outside the building in connection with the warming and ventilating arrangements had been considered, and it would probably reach £30,000 or £40,000; while the expenses of wages and main tenance would also be very heavy. The subject would receive further attention; but, having regard to all the circumstances of the case, it must be deferred for the present.

Search Lights.—The use of search lights at the recent naval manœuvres has, says the correspondent of a daily paper, served only one useful purpose—to show how little thought has been given to their proper use. More than one correspondent has described how, as soon as a torpedo-boat is supposed to be in the neighbourhood, the various ships begin darting their flashes about the horizon, so that the whole fleet is half-dazed by a series of irregular flashes. Among the bewildering alternation of bright light and black darkness the best eyes become helpless, steering and aiming are alike hindered, and the torpedo-boat runs a very fair chance of escaping in the confusion. A typical scene of this kind was witnessed in Belfast Lough when the Red (B) Fleet was thrown into something like a panic by the false alarm that a Blue torpedo-boat was at hand. Yet, says the correspondent, there is little room for doubt as to the proper use of the electric light by a fleet in such circumstances. The greatest enemy of torpedo-boats and the best protection against them for a squadron is daylight. The best use of the electric light is, therefore, to create artificial daylight. There is no difficulty in a naval force so using its electric force as to light up the whole fleet and the water around it. Into this illuminated sphere a torpedo-boat will venture at its peril. There are, of course, occasions when a squadron will prefer to remain in the dark. But a fleet that has been followed by the enemy into port has little motive for concealment, its numbers and whereabouts being known to the enemy, and this was the situation of the Red (B) Fleet. Cannot some of the electrical unemployed come to the rescue?

Atlantic Cables.—Electricians are well aware that the speed of working cables is dependent upon their length and the size of the conductor. The following figures relating to the Anglo-American Company's cables are interesting as showing the gradually increasing weight of cables:—

Date of laying.	Lbs. per mile copper.	Lbs. per mile g.p.	Length.	Working speed per minute.
1865	300	400	1,900	20
1873	400	400	1,885	30
1874	400	400	1,885	30
1894	650	400	1,847	45

The last of these cables was completed on July 27th last, and previous to its submersion the cable with the largest core was that of the Commercial Company, which contained 500lb. copper and 320lb. gutta percha, its length being about 2,200 miles. As operators were unable to transmit up to the full capacity of large cores, it became necessary to adopt automatic cable working, which was first introduced by the Anglo-American Telegraph Company in 1887, and enables so large a number as 45 words per minute to be sent through the latest cable. It is not generally known that on the very day that the last Anglo cable was laid, the 1874 cable, which had been some time interrupted, was repaired by Capt. Trott, of the s.s. "Minia," at a depth of nearly three miles. As showing the growing danger involved in the multiplication of cables in the North Atlantic, it was found that the break had occurred in close proximity to where the line was crossed by the Commercial Company's cable, and out of 274 miles of new cable expended in the repair, some 40 miles was necessitated in order to avoid interrupting the crossing line.

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THE TELEGRAPH AND THE WAR IN THE EAST.

BY J. MORRIS.

The telegraph is playing a very important part in the operations of both combatants in the war now declared between China and Japan, but the Japanese are able to turn this invaluable weapon to better account than their rivals. They have taken possession of the lines and stations in Southern Corea, and are working them to advantage by their own men, trained, as our Royal Engineers are trained, in construction as well as in actual manipulation. The corps can be trusted to keep these lines in working order whilst Japan retains the control, and this will in itself be something of a novelty.

The Mikado's people have taken very kindly to the telegraph ever since its introduction in 1870. They had a couple of short lines, altogether about 40 miles in length, in operation at first, worked by Breguet alphabetical instruments, to which they managed to accommodate their rather extensive alphabet of 75 symbols. The stations, a dozen in number, were close together, and maintenance was not difficult. But in 1872 the Government launched out into a most elaborate system, the completion of the entire scheme occupying the Public Works Department about nine years. This was nothing less than a complete network of communications, bringing every outlying city of importance into direct touch with the capital. From 40 miles of line the circuits speedily grew into 4,000 miles, and at the present moment the wires measure close on 26,000 English miles, including several submarine cables of various lengths, one of the longest being that connecting Nipon (the main island) with Tsŭ-shima, the large island midway between Japan and Corea, a position which is just now of the utmost strategical importance. This bold undertaking has borne good fruit in more ways than one, and at the present moment there is hardly a point on the coast more than a few hours distant from a telegraph office, so that a fleet runner could convey the news of a hostile descent to the adjacent outpost, and a defensive force be called to the threatened region in less time than it would take the Chinamen to determine upon their point of attack. In 1876 this was demonstrated very clearly in connection with the Satsuma rebellion, the news of which was brought by a boatman to Kumamoto in one night, and flashed to the capital almost before the insurgents' rearguard had cleared from Kagoshima. The rebel General Saigo had always objected to the extension of the telegraph to his stronghold in Satsuma, and thus the lines had not been carried farther south, at that time, than Kumamoto, a town on the Satsuma border. But this was sufficient, as subsequent events proved, to give the central Government timely warning of Saigo's hostile intentions, and the loyal troops were quickly despatched to confront him before he could penetrate very far into undisturbed territory. Had not this means of communication been open to the Government, it would have taken a fortnight for a runner to reach the capital, and the rebels would the farther they went have been joined by sympathisers, rendering it far more difficult for the Mikado's forces to suppress them.

It is interesting to notice that the experience gained of the value of telegraphic communication by the Japanese in that civil war is being acted upon by them in Corea. They have promptly "requisitioned" the Corean lines, and have interdicted all messages other than those that concern themselves and their military movements. During the Satsuma affair in 1876 they closed the Japanese lines to all ordinary native traffic for some months, and allowed nothing but Government and international messages to pass over their wires from Nagasaki. In the matter of field telegraphy, too, the Japanese are adepts, their portable instruments, &c., being modelled upon apparatus which they imported from Europe. The posts are made in sections, with spiked bases to stick in the soil, and the wire runs out from reels on light hand-barrows. Altogether, it may be said that, if the Japanese are copyists, they have copied faithfully, and that they are able to appreciate to the full the value of the inventions which they thus assimilate. Practically, they absorb everything of any value that reaches their shores, and the unhappy patentee must console himself with the compliment implied in the fact of his having attracted so much attention from a progressive nation. When the first telephone receiver reached Japan from America it carried everything before it, and within a week or so there were some Edison receivers of native make being experimented upon. Such a handy instrument was sure to make headway in the East, and very complete police and fire-brigade systems of telephonic alarms and calls were instantly embarked upon. Both have rendered incalculable service in the Japanese metropolis and in all the principal cities of the Mikado's empire.

Many of the vessels of the Japanese are, of course, furnished with the electric light, and the manipulation of the projectors leaves nothing to be desired. In this respect they are as thoroughly up to date as might be expected, though they are not alone in the possession of this weapon, as some of the Chinese Pei-Yang squadron have search-lights also. It is to be presumed that the resolve of both combatants to exclude Shanghai from the sphere of their antagonism will conduce to the maintenance intact of our European-owned cables in the vicinity. Should the local mandarins conceive the idea, however, that the submerged threads off Gutzlaff are doing the Celestial cause a mischief, it will not weigh much with them that a promise of non-interference has been made. We may expect to find copper core doing duty as fishermen's toasting-forks, and the dielectric repairing holes in their sea-boots, as freely as it served those useful purposes on a former occasion. Should these undesirable incidents of a campaign evidence themselves in the near future, it is probable that the Japanese would afford every facility for the landing of a direct cable from Hong Kong on their own coasts. They have everything to gain, and nothing to lose, by keeping open their communications with Europe and America. A run like that the "Scotia" made years ago from the North Saddles to Hong Kong with the Eastern Extension cable might serve a beneficent purpose if repeated from Hong Kong to Nagasaki.

ELECTRIC STREET FIRE ALARMS.

We have recently had an opportunity of inspecting a new fire alarm system, fixed by the Single Wire Multiple Telephone Signal Company (Limited), for testing by the Metropolitan Fire Brigade, which offers several important improvements in the method of giving the earliest information of the outbreak of fires.

In order to make the matter clear, we may say there are at present about 700 street fire alarm posts now erected in London, working on a single wire between the call point and the station. Most of these are posts of the familiar form, painted red, with round tops and known as the "Saunders and Brown Patent"; but there are a few of other shapes as well as a small number of wall boxes. The existing street fire alarms are nearly all on what is known as the pull-knob system, because, after breaking the glass in the post or wall box, it is only necessary for a person giving an alarm to pull a knob or handle and wait at the post until the engine arrives to direct the firemen to the conflagration. By putting the line to earth a current is caused to pass out from the batteries in the fire station, having the effect of ringing a bell there and causing the dropping of the indicator bearing the name of the point from which the alarm was sent, and also ringing a repeater bell in the post, the stopping of which by the fireman at the station forms a reply that the call has been received. The firemen can also use the post to send certain conventional signals to the station indicating "More help wanted," "Serious," "Stop," &c. One of the drawbacks of the system is that accidental contacts on any of the wires cause false alarms, of which there are some hundreds a year in the metropolis, an unnecessary turn-out of the engines being the result. Means of distinguishing between calls and contacts are provided under this system, but the Brigades prefer to "turn-out" rather than run any risk. There are also a certain number of wilful false calls sent from call points; but it is to be hoped that the severity of the magistrates in dealing with recent cases of delinquents brought before them for this offence will have the desired effect of reducing the number of these senseless interferences with the

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existing system for protecting the lives and property of the inhabitants.

The new and improved system, which is in operation from a point near the Borough to the head-quarters of the Metropolitan Fire Brigade, claims the following advantages:—

(1) Telephonic communication between the alarm post and the fire station.

(2) Immunity from accidental false alarms by contacts on the wires.

(3) Additional likelihood of detecting wilful false alarms.

(4) Telephonic communication between fire stations and firemen in charge of fire escapes at given points.

Obviously, in any fire-alarm system the first requisites are certainty and simplicity of action. There must be nothing that an excited caller can injure or put out of gear, and, therefore a telephone with flexible cord to place to the ear, even if it could be heard above the noise of heavy traffic, is inadmissible. The Single Wire Company effect the desired object by using a special telephone transmitter, the invention of their electrician, Mr. A. C. Brown, which reproduces the voice so loudly as to be heard at a distance of several feet from the post, notwithstanding the noises of the street traffic. The Chief Officer of the Fire Brigade (Capt. Simonds) in selecting the point referred to for the experiment, clearly had wisely determined to make the test a severe one. The call point, as well as a box in which the man in charge of the escape sleeps at night, is on a "shelter" in the middle of a road paved with cobble stones, and with the incessant traffic of the busy Borough thoroughfare passing immediately in front of it. Notwithstanding this, after the glass was broken, or the door opened with a fireman's or policeman's key, conversation, in the busiest part of the day, between the street alarm and the fire station was kept up with the greatest ease.

This telephone transmitter, or some modification of it, being remarkably loud and efficient, ought, therefore, to supply a demand in a wider field than that of fire alarms. The whole of the apparatus in the post can be covered with a grill so as to make it practically impossible that it should sustain any injury, either by the breaking of the glass or otherwise.

The method now adopted for securing immunity from accidental false alarms does away with the use of electric bells, which, as well as the indicators, are frequently set in motion by the earthing of the wires for testing, or by any stray current that may transit the line. In place of the bells in the fire station the Single Wire Company use a telephone receiver, which becomes an electric hooter when a rapid make-and-break is set up by smashing the glass or opening the door of the post. As it is practically impossible that currents of such frequency can get upon the line accidentally, it seems clear that accidental calls will be entirely eliminated, thus saving a great deal of annoyance, loss of time, and fatigue to the brigades.

When anyone sends a wilful false call, obviously the best plan for the culprit is to avoid observation, and to retire as rapidly as possible from the scene of action. To send an effective alarm under the new system it will be necessary for the caller to stop at the post to reply to the questions of the fire station; in addition to which, when the glass is broken, an electric "hooter" sounds at the call point, as well as in the station, directing the attention of the police and passers-by to the spot.

When we inspected the system we were informed that about seven or eight days before, Capt. Simonds had called the attention of the secretary of the Single Wire Company to the desirability of the fire station being able to communicate, on the single fire alarm wire, with the firemen in charge of fire escapes in the streets, so as to enable the station attendant to give instructions for the escape to be sent immediately to a fire when the escape is nearer to the place of operations than the station. Seeing that the line to the post is necessarily insulated or disconnected until the glass is broken or the door opened, it is obviously impossible to ring an electric bell in the fireman's shelter, which is always close to a call-point; and it seemed at first that it was not possible to attain the desired result without using an independent wire.

A method of effecting the communication, without in any way interfering with the fire alarm, had, when we saw the system, however, been worked out by the electrician of the Company and was then in operation. This was effected by discarding bells and using a telephone trumpet, which is actuated by rapid electric impulses in such a way that the current necessary for working the fire alarm is unable to escape to earth. The electric hooter in action is sufficiently loud to awaken a sleeping fireman, or to attract his attention if at some distance from the box. Under this arrangement the fireman in charge of an escape is always in telephonic communication with the station.

It will be seen from the foregoing description that, if this system be adopted and found to work as well in practice as it certainly did experimentally, engines in future can proceed direct to the fire instead of having to go first to the call-point, which may be out of their way; and that, where necessary, fire escapes and ambulances can be ordered to the burning building when the alarm is first given. In addition to this, firemen can go at any time to given points and converse with the fire stations; and, as the fire stations have electric communication with the police, the latter can also utilise the system, if need arise, to communicate with their head-quarters. The Single Wire Company's system of street fire alarms certainly appears to be a great advance on existing devices, and seems to provide all facilities and safeguards that can be desired.

A great authority on matters connected with the extinguishing of fires recently expressed the opinion that, to insure safety of life and property in London as far as possible, by enabling the engines to be on the spot within the shortest time after the discovery of fire, 10,000 additional street fire alarms would not prove sufficient, adding that he did not suppose the County Council would provide money for so large a number. Some time previously the manager of a fire insurance company, by way of justifying an increase of premium from 7s. 6d. to 12s. 6d. per cent., said that, from his Company's experience of recent fires, they had to make good not only the loss caused by fire in the building insured, but damage occasioned by a conflagration which might have originated in any of ten adjoining buildings on either side. It is well known that most of the principal London office have been heavy losers by recent fires, and premiums for manufacturing and warehouse premises have been lately considerably increased. We venture to make a suggestion for the consideration of the fire offices. A fire, as a rule, is easily extinguished if appliances are promptly on the spot—the fire at St. Mary Axe might probably at the commencement have been extinguished by a single bucket of water, and that at Finsbury have been confined to one building had the engines been enabled to reach the spot within a quarter of an hour of the outbreak—would it, therefore, not pay the insurance corporations to bear some part of the cost of additional fire alarm call points, especially in the Metropolis? The Companies used to contribute to the cost of the fire brigades, and if the "perpetual want of pence which vexes public men" prevents the authorities providing sufficient protection, such an offer from the Companies might not only induce the County Council to add to the number of existing fire alarm posts, but, by calling public attention to the matter, put pressure upon them to equip the Metropolitan Fire Brigade in a manner not only worthy of London, but such as to give the most adequate protection possible to the lives and property of its citizens. To maintain 10,000 street fire alarms, in addition to the 700 already existing, in the "province covered with houses," which now embraces nearly 150 square miles, would cost some £60,000 a year; and it is probable that if the forty chief fire insurance companies were each to subscribe an average of £500 per annum (which they would surely save in reduced claims), aggregating £20,000, the much-needed work would be carried out, at once effecting a great saving of life and property.

Unless steps be taken to provide the promptest possible notification of the outbreak of fire, with the lofty buildings, the façades of which are full of windows, everywhere being erected throughout the country, there will, sooner or later, in some combination of circumstances, or owing to a high wind, be such an outbreak or simultaneous conflagrations as will overpower the efforts of the brigades, and call attention in an unpleasantly emphatic manner to the fact that we are perpetually in peril from that "good servant" which is "a bad master."

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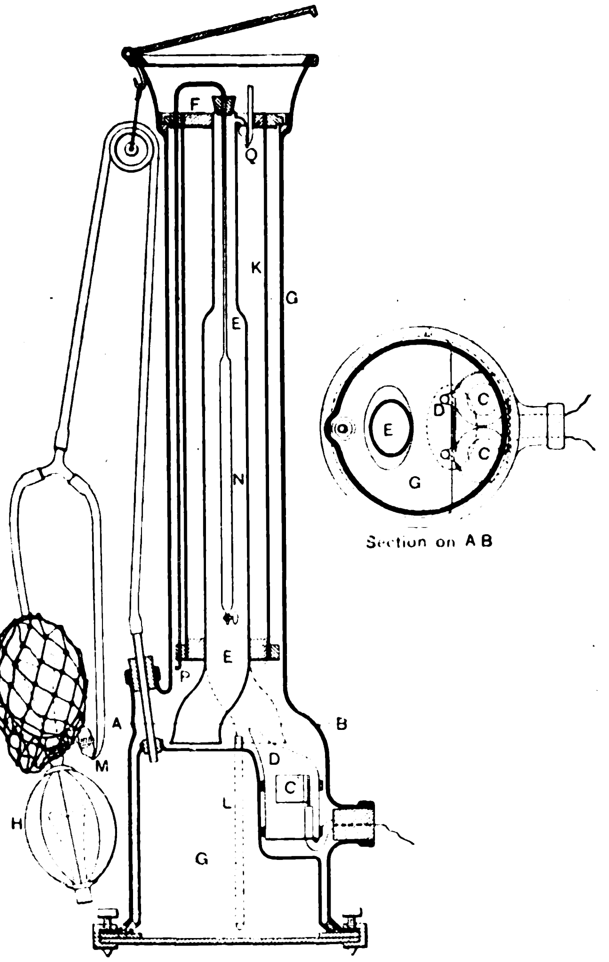
THE NABER VOLTAMETER.

Prof. Kohlrausch has recently expressed his surprise that the most ancient instrument for measuring electric currents—viz., the gas voltameter—is so seldom used. He attributes this to the difficulty in arranging for the separate collection of hydrogen without gradually increasing the resistance of the instrument, and, in order to reduce this resistance, he has brought the electrodes close together, thus sacrificing the advantages of collecting the gases separately. Herr Naber, of Amsterdam, has recently devoted much attention to the construction of an improved voltameter, which, he claims, is capable of measurements of great accuracy, and which, therefore, may be used as a standard laboratory instrument. The arrangement will be seen in the accompanying illustration, which shows a sectional elevation of the instrument and a horizontal section upon the plane A B. The electrodes C are spiral in form, and are placed under the glass hoods D, which



The Naber Gas Voltameter. Sectional Elevation.

terminate in nozzles about 4mm. diameter. These hoods are held together by rubber bands, as shown. A burette, E E, fully graduated along its stem, is supported from a collar, F, and is capable of rotation, allowing either one or both of the gases to be collected, or of being turned in the position shown in the illustration, thus shutting off the gases altogether from the burette without interrupting the current passing between the electrodes. The burette is contained in an outer glass vessel G, which is half full of the electrolyte—weak sulphuric acid. In order to neutralise the pressure of the gas to be measured, arrangements are provided for adjusting the level electrolyte outside the burette with the level of the liquid within this part of the instrument. This is effected by air pump H, by which air may be forced into the air vessel G. This vessel is filled with the electrolyte, and a tube passing nearly to the bottom allows the liquid to be forced out into the annular space between the outer vessel G and the cylinder K, in which the burette is fastened. The weight of the hanging air-pump H H keeps a kink in the rubber tube M, which is otherwise open. On raising the air-pump this kink disappears, and the electrolyte enters the receiver G through the tube L, the air escaping at M.

An air thermometer, N, is suspended in the burette, and by its indications corrections may be made for temperature and for barometric pressure. The open end of the thermometer is turned up at P to prevent the ingress of any bubbles of gas. A tube, Q, closed by a kink, as shown, or by a stop-cock, allows the gas to escape from the burette. The rest of the construction of the apparatus is clearly shown in our illustration. Electrolytic investigations in chemical laboratories are now becoming so common that an instrument of this kind should prove very useful. The direction and approximate magnitude of the current can be seen by simple inspection of the electrodes. The current in amperes can be determined by turning the burette on and off at definite and suitable interval of time; but its chief use, no doubt, is to measure the total quantity passed in coulombs, or fractions of a Board of Trade unit.

THE DOUGLAS-LAXEY ELECTRIC TRAMWAY.

This interesting little line, which was opened to the public on the 28th ult., was constructed under the Douglas and Laxey Electric Tramway Act, passed by the legislature of the Isle of Man on May 30, 1893, and promulgated by the Governor, Council and Keys, in Tynwald assembled, on Nov. 17, 1893. It is a double line throughout, 3ft. gauge, and 7 miles long. As will be seen from the profile of the line, it starts at a point 20ft. above mean high water, and rises in a distance of about 1½ miles to Lagbirrah, where it is 258ft. above the sea. It then falls to the Groudle Glen, which it crosses by a fine stone bridge of three arches. Rising again it reaches the highest point when it crosses the public road to Laxey at the Half-Way House, at a height of 337ft. above the sea. After once more descending, and reascending, it finally descends to Laxey, where the terminus is just below the town, at a height of 115ft. above the sea. The steepest gradient is 1 in 20, and the sharpest curve 100ft. radius.

There are two power stations, one at Douglas, and one near Laxey. The former is equipped with three Lancashire boilers, working at 120lb. pressure. Three compound side-by-side high-speed vertical engines drive, by link belts with jockey pulleys, two "Manchester" dynamos, each having an output of 500 volts, and 100 amperes, and one "Mather and Platt" dynamo of the same output. The switchboard is fitted in accordance with the requirements of the Board of Trade, with a subsidiary board for measuring the currents returning through the earth connections. The Laxey power station is similar to the Douglas station, but equipped with only two boilers and engines of the same size, and two "Mather and Platt" dynamos of similar output.

The most remarkable feature of the line is the use of accumulators. At Groudle Glen, 2½ miles from Douglas, there is a battery of 240 cells, manufactured by the Chloride Electrical Storage Syndicate. These cells have a capacity of 140 amperes for 3 hours, or 70 amperes for 9 hours; and have a level E.M.F. curve, which they maintain up to the end of discharge; they also have a very high rate of discharge. Half the cells of the battery are of the protected type, with teak separators and asbestos diaphragms, similar to those now being used on the Birmingham Tramways, and the other half unprotected. The cells are charged direct from the line or from a motor-generator of special design, which gives the required additional pressure. They serve not only the function of supplying the extra power required at times of maximum demand, but it is intended during the winter months to work the light cars, which will then be sufficient for the traffic, after the close of the tourist season, entirely from the battery, charging it only once or twice a week as occasion may require.

The conductors are on the overhead system, devised some years ago by Dr. John Hopkinson. Instead of the current being collected by a trolley wheel, as is usually the case, it is collected by two bars, each of the width of the car, and placed at each end. (See *The Electrician*, Vol. XXXII., January 19, 1894, p. 291.) They rub along the under surface of the wire

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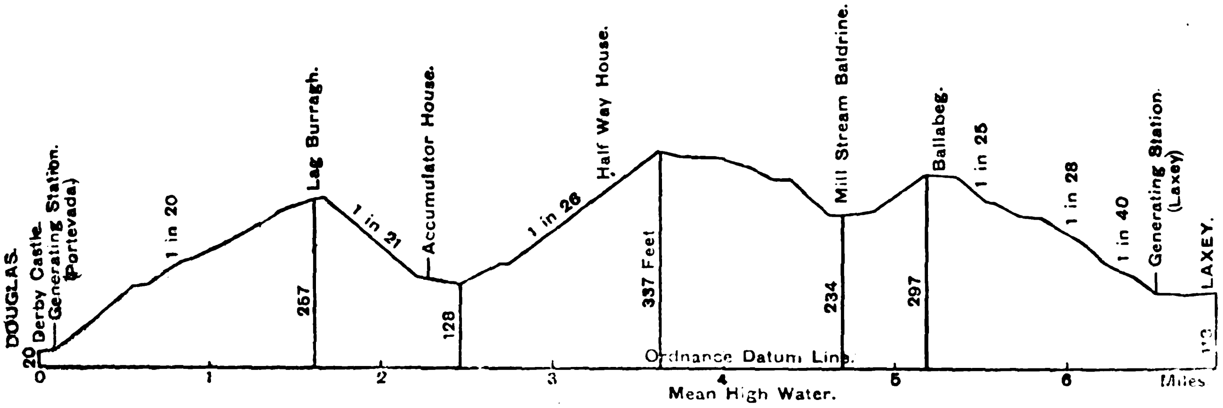
and make an excellent contact. The bars clear the insulators in passing under them by about 2in., the forward bar making contact before the trailing bar breaks contact. The collecting bars are constructed with an hinged joint controlled by a spring, devised by Dr. Edward Hopkinson, which regulates the pressure of the bar against the wire. The conductors are of hard drawn copper wire carried from insulators fixed to the cross arms of steel poles, erected with concrete bases midway between the two lines of rails. In addition to the working conductors there is a heavily-armoured Callender feeder cable of 37/14, extending about half the length of the line, and laid underground. The conductors are broken at various points and fitted with fuse boxes and connecting links, so that they can be connected and disconnected, as required by the regulations of the Board of Trade. The return is through the rails, which are bonded with copper strips riveted to the under flange of the rail.

The rolling stock consists of nine 38-passenger motor cars, and 12 open trailers. There are two 30 H.P. motors on each motor car, single reduction geared, working one on to each axle of each bogie. These motors are capable of together giving 3,000lb. tractive force at the periphery of the wheels. The motor cars with their electrical epuipment weigh 9½ tons. The trailer cars weigh 4 tons, and will seat 44 passengers; hence a fully loaded train of one motor car and one trailer car weighs 19 tons. The cars are fitted with powerful hand brakes, and also with Milnes' continuous automatic emergency brakes, which can be worked by hand or come automatically into action if a train parts its couplings. They are also fitted with Milnes' combined coupling and buffer. The nine cars can maintain a 15-minute service in each direction, and can thus provide for a traffic of some 320 passengers per hour. Since the opening of the line 30,000 passengers have been carried in one week.

The speed at which this line has been constructed and equipped with electrical plant is remarkable, although involving heavy rock cuttings, several embankments, and a massive stone bridge, it has only taken seven months to construct. The engineer is Mr. F. Saunderson, and Mr. Alex. Bruce, J.P., of Douglas, is the chief promoter and Chairman of the Company. The contract with Messrs. Mather and Platt was not let till the beginning of March, from this it will be seen that the electrical plant was designed, constructed, and erected in under five months. The whole of the electrical plant was designed by Dr. Edward Hopkinson.



PROF. KENNEDY'S PRESIDENTIAL ADDRESS TO SECTION G.

THE CRITICAL SIDE OF MECHANICAL TRAINING.

While there is no place in the kingdom more suitable for a meeting of the British Association than Oxford, and certainly no place in which it is more delightful for the members to meet, it is yet to be admitted that there are few places which have much less in common with the special work of Section G. Nominally devoted to "mechanical science," the section has for many years specially dealt with those branches of applied mechanical science which constitute the business of the engineer—to quote the well-known words of the Royal charter: "the art of directing the great sources of power in nature for the use and convenience of man." The association of this ancient and learned city with boilers and chimneys, with the noise and racket of ordinary mechanical work, seems an incongruity. Even the harmless necessary railway station is kept as far away as possible, and the very river flows with a quiet dignity which seems to shut out the thought of anything more mechanical than the most ancient and futile of water-wheels.

Naturally enough these considerations did not tend to make more easy the choice of a subject for this address, and I have come very near to agreement with a recent critic in the opinion that presidential addresses are, in fact, almost immoral in the nature of things and fit only to be abolished. Finally I decided upon taking up my present subject, as being one in which the academic rather that the technical side of our work comes to the front, while at the same time it does not lead me out of lines in which I have been able, in past years, to work myself. It is now 20 years since I first took any active part in the scientific training of engineers, and five since I ceased to do so. I have often wished that I may have been at all as successful in teaching others at University College as I was, at the same time, in teaching myself. And since I have ceased to teach I seem to have been spending my time in finding out how much better I could now do it than was possible when I was actually engaged in it. This may be pure imagination on my part; there is nothing more easy, as we all know, than to suppose that we know best how to do the things that other people do, and not the things we have to do ourselves. Indeed, I understand that this is the recognised attitude of the really superior critic. If, however, in anything which I have to say, it should seem that I am finding fault with what is now being done, I may at least point out that most of all I am finding fault with myself for not having done right when I had the opportunity—an opportunity which can now never recur. Indeed, instead of the decorous and unobtrusive heading which I have given to this address, I might have indicated its general lines almost as truly if I had entitled it "The Regrets of an Emeritus Professor"—a name which, on a suitable binding, might even have secured it a sale at the railway bookstalls.

I know well—too well—that in the present congested state of the engineering profession there are many of us who do not like to hear the word "training" mentioned at all. It seems to mean merely the preparation of more lads to struggle for a share of work that is even now insufficient to go round. There is no doubt much to be said for this point of view. But against it one must remember that all other professions are equally full, and that, after all, lads must do something. The fault is surely that there are too many lads! If our population is really to go on increasing as rapidly as at present—the benefits of which Sections D, E, and F might have a joint meeting to discuss, if not to discover—it is inevitable that demands should come for more and more complete professional preparation. The man of exceptional parts will come to the front under any conditions, training or no training, in the future as in the past. But for ordinary men—that is, for 99 per cent. of us—it is essential that no advantage should be given to a rival in the fierce competition of life, and for them, therefore, it is of an importance hardly to be exaggerated to obtain the most complete and perfect training possible. At the same time, and on purely general grounds, it can hardly be denied that to raise the standard of our

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profession is indirectly to confer a benefit on the whole community. I hope, therefore, that in making certain suggestions about the training of engineers, it will not be thought that I am desirous of increasing their number, which is really an end as far as possible from my own wishes. Whether the number increases or stands still or falls off, it is of importance from every point of view that those who come forward should be as well prepared as possible. And even the most conservative of us are compelled to recognise that the standard required in engineers' offices now is enormously higher than it was 30 years ago. This may truly be either the cause or the effects of improved training, but in either case it has made the training itself a necessity.

The particular aspect of mechanical training of which I wish to speak is its critical side. I do not know how a man should be trained to be an inventor. I would not tell anyone if I did! To be a creator in mechanical matters—which, however, is a quite different thing—is a faculty given only to a very few, and with them it is "born, not made." Many of us, however, without being either inventors or creators, have sufficient natural aptitude or inclination towards things mechanical to form a basis for the trainer or educator to work on, with some hope that he may be of service. About the sciences which should be taught to such men, or the methods of teaching them, about the extent and nature of their experience in shops or on works, I do not intend to speak. I shall confine myself to one aspect of the training only, an aspect which is perhaps not always sufficiently clearly kept in view—the aspect which I have just called the critical side of mechanical training. An engineer is a man who is continually being called upon to make up his mind. It may be only as to the size of a bolt; it may be as to the type of a Forth Bridge; it may be as to the method of lighting a city; or only as to the details of a fire-grate. But, whatever it is, once it is settled it is decided irrevocably—it is translated into steel and iron and copper, and cannot be revoked by an Act passed in another session. The time given him in which to decide may be a day, or a month, or a year, but in any and every case (so far as my own experience goes) it is about one-tenth part of the time which he would like to have. It is only in rare cases that the decision is obvious—most often there are more courses open than even the most facile politician ever dreamt of. The matters are too complex to be dealt with mathematically or even physically; even if they were not, there are few engineers who would have the special capacity to handle them. Moreover, their solutions are seldom "unique." From this point of view, the whole use of college training, of workshop practice, of practical experience, is to provide the engineer later on with the means of critically examining each question as it comes up, of reviewing systematically the *pros* and *cons.* of each method of dealing with it, of coming finally, rapidly, and positively to some defensible decision, which may then be irrevocably carried out.

In the case of a problem in pure mathematics or physics, where only one right solution can exist, that solution is arrived at by the help of a thorough knowledge of the science in question; there is little room for the critical faculty except as to method; the result is either right or wrong. With our work, on the other hand, solutions of all problems except the very simplest—in other words, decisions on all points which present themselves—can be arrived at only by a process of criticism applied to the problems, to their statement, to their condition, to all their many possible solutions. The development of the necessary critical faculty should be one of the chief aims of every teacher and every student. A scientific training cannot make a man an engineer. Perhaps it is impossible for anything to make a man an engineer unless he has grown that way from the beginning. But a scientific training may make him, or at least give him the possibility of making himself, a critic.

In the vigorous attempts which have been made to specialise the education of engineers very early, I am afraid that the idea of teaching subjects is sometimes too prominent, to the neglect of matters less obviously useful. It is, of course, one thing to know a subject from the examination point of view, and quite another to be able to think about it, and still another to be able to write about it. In particular, I have often regretted to find how little attention has been given to a matter which, perhaps, may be called literary rather than scientific, but which is all-important in criticism—I mean to the power of expression. It is not easy to overrate the importance to the engineer, as to other folk, of the power of saying clearly what he means, and of saying just what he means. I do not mean only of doing this for its own sake, but because if a man cannot say or write clearly what he means, it is improbable that he can think clearly. By the power of expression I do not mean, of course, the mere power of speaking fluently in public, a thing which appears physically impossible to some people. I mean rather the power of expression in writing, which carries with it clearness and consecutiveness of thought. It is difficult to know how this matter can be taught, but at least it can be insisted upon probably to a much greater extent than is commonly the case. A man requires to see clearly not only the exact thing which he wants to say, but the whole environment of that thing as it appears to him. Not only this, but he must see the whole environment of the same thing as it appears to the persons for whom he is writing, or to whom he is speaking. He has to see what they know about the matter, what they think, and what they think they know, and if he wishes to be really understood has got to do much more than merely write the thing he means. He has carefully to unwrite, if I may use the expression, the various things that other people will be certain to think that he means. For, after all, the great majority of people are very careless listeners and readers, and it is not for the small minority who are really exact in these matters that one has to write. Moreover, it is a great help to clearness of thought and expression to keep before one always an ideal audience of people who will certainly misunderstand every single sentence about which any misunderstanding is in any way possible, and some others as well.

In attempting to think out or to discuss any question, whether it be technical or non-technical, in fact, as long only as it is non-political, the first necessity is probably a knowledge of the question itself, and not only this, but also a proper understanding of its whole environment. This knowledge must be of such a kind as to distinguish what parts of it are important, what parts of it are unimportant, what parts can be described in two sentences, and what others may require as many paragraphs; what parts affect the result but little, however large they seem; and which ones must be considered vital, although their very existence is difficult to discover. The faculty which enables a man to handle his knowledge in this fashion may be summed up in the single expression "sense of proportion." Moreover, the knowledge, to be of real value, must be as totally free from prejudices and prepossessions as in the most rigorous branch of pure science, and as thoroughly imbued with a healthy spirit of scepticism. One is accustomed to think of engineering work as mainly constructive; but, after all, it is quite as much critical. In almost every department of mechanical work there are half-a-dozen ways of solving any particular problem. In some fashion or other the engineer must be able to judge between these various methods—methods which are often very much alike, but each of which may possess certain particular advantages and certain particular drawbacks. The arithmetical criticism which merely counts the advantages and drawbacks, and puts an equal number of the one against an equal number of the other, is common enough, but obviously useless. The very first necessity to the critic is that he should have what I have just called the sense of proportion—a sense which will enable him to distinguish mere academical objections from serious practical difficulties—which shall enable him to balance twenty advantages which can be enumerated on paper by one serious drawback which will exist in fact—which will enable him, in fact, to place molehills of experience against mountains of talk. It is perhaps a doubtful point how far this sense of proportion can be taught at all. No doubt it can only be built up upon some natural basis. I am sure that in engineering we all know men whose judgment as to whether it was advisable to take a particular course we would accept implicitly, because we know that it is based on large general criticism, in spite of the most elaborate and specious arguments against it set down on paper. Any third-year student—not to go still further back—can criticise perfectly along certain very narrow lines, just as anyone can learn the rules of harmony, and can write something in accordance with them which purports to be music. But, after all, the music may be music only in name, and the criticism may not be worth the paper it is written upon, however formal it may appear to be, unless the writer is thoroughly imbued with a sense of the proportionate value of the different points which he makes. To take the commonest possible case, I daresay we have all of us heard certain methods, mechanical, chemical, or other, stigmatised as totally wrong and absolutely useless because they contain certain easily provable errors. I am sure, too, that most of us could give illustrations of cases in which this has been said with the very greatest dogmatism when the errors of the impugned method are not one-tenth part as great as the equally unavoidable errors of observation in the most perfect method.

Probably the best special education in proportion which a man can have is a course of quantitative experimental work. I say quantitative with emphasis, as meaning something much more than mere qualitative work. Here, I think, comes in the usefulness of the engineering laboratory. We require that the training should be not only in absolute measurement, but in relative measurement, the latter being quite as important as the former. Many kinds of measurements stand more or less upon a level as a training of the faculties of observation in themselves, but no single kind of measurement is sufficient as a training in proportion. A year spent in calibrating thermometers or galvanometers might make an exceedingly accurate observer in a particular line, but it would not give the observer a knowledge of what even constituted accuracy in other directions; for accuracy is a relative and not an absolute term. In most engineering matters the conditions are, unfortunately, of a most complex kind —so complex that our problems are incapable of any solution

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sufficiently exact to satisfy the mathematician or physicist. The temptation to treat these problems as the mathematician treats those with which he deals—namely, to alter the assumed conditions in order to get an exact solution—is a very strong one. I am afraid it is most strong often in those engineers who are the best mathematicians. It is a temptation, however, steadily to be resisted. We must assume our conditions to be what they actually are, and not what we should like them to be; and if we cannot obtain an exact solution of our problem with its actual conditions, so much the worse for us, not so much the worse for the conditions. Our first duty is generally to find out the conditions; if they are disadvantageous (in fact I mean, and not merely in the problem), to alter them if they can be altered, but not to ignore them because they are inconvenient. We have, then, to find out the extent to which the known conditions permit any exactness of solution at all; and, finally, we have to keep this in view as a measurement of the highest accuracy which is attainable. To work out certain branches of the problem with such minuteness as to give us apparently very much greater accuracy than this is not only useless, but is apt to be positively misleading, as giving an impression of an accuracy which has no real existence. The relative value of accuracy in different sets of observations is in itself a matter in which a sense of proportion is wanted, and often very badly wanted. Where one has to measure half-a-dozen things, of which two are very easily measured and the remaining four are only measurable with great difficulty, it is only human nature that we should spend our energies on getting extremely accurate results with the first two, and roughly do our best with the others. It is very difficult under such circumstances to remember that the accuracy of the whole is not the accuracy of the best part of our work, but of the worst.

The extraordinary effect of a want of sense of proportion is nowhere better shown than in the absurd statements which are constantly made as to technical matters in public prospectuses, and the still more absurd statements made in those very numerous documents of a similar kind, of which some of us see a great many, but which do not finally emerge into public view. Fortunes are apparently to be made by inventions which, although doubtless ingenious, yet only concern one way of doing a thing which could be done equally well in half-a-dozen other ways. Everyone is expected to run after a piece of apparatus which is to save 50 per cent. of something, the total cost of that something, however, being so very small that nobody cares to save in it at all. I need hardly mention the all too-common case where a contemplated saving of 10 per cent. in the cost of a material works out yearly to an amount much more than equal to the whole cost of the original article. I believe that experimental work in an engineering laboratory can educate this critical sense of proportion very admirably in a number of ways. In the first place, it directs quantitative work into very varied channels, and not along one particular line. Secondly, it compels the observer to combine a number of measurements in such a way that the relative importance of accuracy in each can be seen. In the case of an engine trial, for instance, the combined results are affected by the accuracy of measurements of the dimensions of the machine, by the apparatus and methods used for measuring the water, by the indicator and by its springs, by the speed counter, by the thermometers, and so on. An error of 1 per cent. in counting the revolutions is just as important as an error of 1 per cent. in measuring the water, or in measuring the mean pressure. I am afraid that one could point to a good many cases in which this has been more or less forgotten. Then by making a series of measurements all in absolute quantities, the relative importance of each quantity to the desired total result can be seen. Thus it will be found that changes in certain quantities affect the total result to a very small extent, while changes in others affect it very largely, so that not only is the accuracy with which different quantities can be determined very different, but also the same degree of accuracy is of very different importance according to the particular quantity to which it refers. Once it is found that a final result is exceedingly little affected by a particular set of changes, it ceases to be of importance to measure or observe those changes in any extremely minute way, and of course the reverse holds equally good. Finally, and this, perhaps, is the most important matter of all, measurements in such a laboratory are made to a great extent under the complicated conditions under which the actual final result has to be obtained in practical work. They are not made under the conditions that will insure the greatest individual accuracy of each result.

It will be seen that throughout, but particularly in the last two points which I have mentioned, the work of an engineering laboratory is in intention and in essence different from that of a physical laboratory. The aim of the latter is to make its problems as simple as possible, to eliminate all disturbing elements or influences, and to obtain finally a result which possesses the highest degree of absolute accuracy. In most physical investigations the result aimed at is one in which practically absolute accuracy is attainable, although attainable only if infinite pains be taken to get it. It is the business of the physicist to control and modify his conditions, and to use only those which permit of the desired degree of accuracy being reached. In such investigations it sometimes becomes almost immoral to think of one condition as less important than another. Every disturbing condition must be either eliminated or completely allowed for. That method of making the experiment is the best which ensures the greatest possible accuracy in every part of the result. The business of the engineer, on the other hand, is to deal with physical problems under conditions which he can only very partially control, and the conditions are a part of his problem. He does not, for instance, experiment with a steam-engine so made that it can work with a Carnot cycle. It is in the nature of the case that he must experiment with a much less perfect machine. In burning fuel he does not use apparatus specially made to absorb the whole heat of combustion, but in the nature of the case has to investigate the behaviour of apparatus in which a very large part of that heat is unavoidably wasted. So one might go on through an immense number of instances. Perhaps the whole matter may be best summed up by saying that in a physical laboratory the conditions of each experiment are under the control of the experimenter, and are subservient to the experiment itself. In an engineering laboratory the conditions form part of the experiment. However much more difficult or complicated they render it, they still unavoidably form part of it—an experiment under any other conditions, or with those conditions removed, would *ipso facto* be irrelevant.

Whenever the whole matter seems to be completely mastered from one point of view, it is only to find, with a little more experience, that from another point of view everything looks different, and the whole critique has to be started afresh. Machines cannot be finally criticised—that is to say, they cannot be pronounced good or bad—simply from results measurable in a laboratory. One wishes to use steam plant, for instance, by which as little coal shall be burnt as possible. But clearly it would be worth while to waste a certain amount of coal if a less economical machine would allow a larger saving in the cost of repairs. Or it might be worth while to use a machine in which a certain amount of extra power was obviously employed, if only by means of such a machine the cost of attendance could be measurably reduced. In fact, what may be summed up in the phrase the "worth-whileness" of economies, is in itself a matter on which a whole Paper might be written. Unfortunately, the latter points which I have mentioned are just such as cannot easily be measured in laboratory work, or, indeed, in any other way whatever, except by actually using the apparatus in question. All that can be said is that a careful training in the critical measurement of comparatively simple points fits a man more than anything else to gauge accurately the importance of such other matters as I have mentioned.

Is there, then, any general standpoint from which mechanical criticism can be directed? Certain points are obvious, but probably the whole matter cannot easily be generalised. A city has to be supplied with water; there are three requisites—that the water should be of proper quality, of sufficient quantity, and that it should be brought in at a reasonable cost. But in such a case the first two are so enormously more important than the third, that the ideal is comparatively simple (of course, this is quite a different thing from being simply reached). A city has to be supplied with electric light: the essential conditions are similar. But in this case there are so many qualities which are equally proper, and there are so many different ways of bringing it in in sufficient quantity, that the third point—namely, the cost—becomes especially important. A factory has to be driven by steam power; the amount of power that is wanted can be produced by so many different types of engine and boiler—all capable of approximately equal economy, and all claiming equal freedom from breakdowns—that the choice is a peculiarly difficult one from the critical point of view. It seems almost impossible that a criticism on any one basis could meet all the three cases which I have supposed, unless that basis were that the thing supplied should be the absolutely fittest, having regard to all the conditions of each case and the relative importance of each condition. Possibly in all cases we could get at some generalisation which would show us which was the absolutely fittest, if only the necessary data were in any way complete, which they very seldom are. Perhaps in one sentence we may say that that scheme, or system, or machine, will be the absolutely best in any particular case which will the longest survive and maintain its place in its particular environment. I cannot doubt that this development of Darwinian ideas in the world of the inorganic is a legitimate one. Of course, the problem would be comparatively easy in each particular case if only the environment would stand still. It would even be comparatively easy if we knew how the environment was going to alter, but this we are unable to do. We only know that it certainly will change and will go on changing, and that therefore the things which we make now have not got to survive in the conditions in which we make them, but have got to survive through some new sets of conditions of which we know nothing. I do not think the difficulty is in any way met by the popu-

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lar method of guessing at what will be wanted 50 years hence, which generally means simply guessing at something very big. It is of no use making our ships or our engines of a type which we choose to imagine will be that of 50 years hence. If we do they will be of no use to-day, and for that very reason they will not even be in existence, useful or other, at the end of the 50 years. Sufficiently sad illustrations of this will occur to everyone in very different directions. I hope I shall not be considered churlish in saying that I do not think that the men who have worked on this principle have really been far-seeing, or have really brought us much forward. They have been men often of genius, often of great personal fascination, always of immense imagination ; but they have proceeded by methods essentially opposed to anything like the gradual evolution which must occur in technical as it does in natural matters, and in too many cases the results of their labours have not even been giants, but only monsters.

As to what causes one thing to survive rather than another we can only speak very generally. Mere survival may come about by the accident of a peculiarly tough constitution. A few engines built in the times of James Watt are still to be found at work in our own day, but can no more be taken as the fittest type than some solitary megatherium would be who, having outlived all his contemporaries, was able in after ages to look down upon his pigmy and short-lived successors. Mere length of life in such a case may be a mere accident, and is not itself a proof of fitness. We have it thrown at us every now and then that our engines nowadays do not last like the old ones, as if the mere existence of a very old machine were a proof of its virtues. It is certainly a proof of the excellence of its construction—or, as one may say, of its constitution—and perhaps also of the very small amount of work it has done in proportion to its life and its dimensions. It is sometimes, I am afraid, rather humiliating to have to remember that, to a very great extent, the question of the fittest, so far as it affects us, is a financial one. In manufacturing processes efficiency and economy tend to survival because they lead to decreased cost of production. In structures or other large permanent works those types tend to perpetuate themselves which require the least material—that is, in which the material used is disposed to the best advantage—and in which the outlay on labour is also smallest, assuming, of course, equal fitness in other respects.

I think we may fairly assume, therefore, that efficiency and economy are both legitimate criteria as to ultimate fitness, and will remain so. Moreover, they are both matters in which measurements can be made, and as to which judgment can be guided by such measurements. But there are other characteristics, not directly measurable, by which we can in some degree form an opinion as to the ultimate fitness of things or processes.

One set of considerations which has great critical importance is summed up in the word simplicity. This does not mean fewness of parts. Reuleaux showed long ago that with machines there was in every case a practical minimum number of parts, any reduction below which was accompanied by serious practical drawbacks. Nor is real simplicity incompatible with considerable apparent complexity. The purpose of machines is becoming continually more complex, and simplicity must not be looked at as absolute, but only in its relation to a particular purpose. There are many very complex-looking pieces of apparatus in existence which work actually so directly along each of their many branch lines as to be in reality simple. I believe it almost always happens that the first attempt to carry out by a machine a new purpose is a very complicated one. It is only by the closest possible examination of the problem, the getting at its very essence, that the machine can be simplified, and this is a late and not an early stage of design. If a mechanical problem is really only soluble by exceedingly complicated apparatus, it generally becomes a question whether the solution is worth having. There is no impossibility in making a machine that will do anything. But the very simplest possible form of apparatus which would wash our hands for us in a suitable manner is probably so very complicated that for many years to come at least that operation will be performed by manual labour. Very closely allied to simplicity is what I may call directness. In nearly all mechanical processes certain transformations are unavoidable. In many mechanical processes, as I have recently had occasion to mention, a very large number of transformations is at present practically unavoidable. I myself cannot help thinking that probably one of the most distinct signs of fitness is a reduced number of transformations, the bringing of the final and the initial stages as close together as possible, and cutting out altogether the apparently worthless middle processes. But any generalisation of this kind must be very cautiously handled ; these apparently useless processes are no doubt in certain cases as indispensable as is the much-abused middleman in matters economic. In a critical view of any case where similar results are aimed at by hand work and by mechanical means, it is important to recognise that the similarity of result should very seldom become identity. In the first machine, to do anything mechanically which has before been done by hand, the error is often made of trying to imitate the hand work rigorously. The first sewing machines were, I believe, made to stitch in the same way as a seamstress. It was not until a form of stitch suitable for a machine, although unsuitable for hand, was devised that the sewing machine proved successful as a practical matter.

I have endeavoured in my remarks to indicate what appears to me to be the attitude of the engineer towards a very large portion of the work which comes into his hands. In order to deal with the work it is necessary for him first of all to have a certain definite knowledge of "things"—that is to say, both of the various subjects which form part of the curricula of technical schools, and of the further matters which form as it were his professional alphabet. These last he learns not from books or lectures as a student, but by example and attempt, as does an artist. Of this part of his training I have said nothing ; it has been perhaps sufficiently talked about of late years, and there is little to say which I could have made interesting to a general gathering like this. I cannot leave it altogether, however, without dealing with one matter. Exceptional men are all-round mathematicians or physicists, still more exceptional men are both ; but for ordinary folk the study of one side of mathematics, or of a single branch of physics, is the work of a lifetime. The engineer is bound to know his own profession, by hypothesis, and it is in itself no small matter. Yet in addition he must know some mathematics, some physics, some chemistry, even also some geology, if he is to take any high rank in it. It is, therefore, surely in the very nature of things impossible that he should be a great mathematician or a great physicist, or should devote as much study to those most fascinating sciences as if they themselves were the work of his life. Therefore I beseech my friends of Section A to do what they can to modify their natural attitude of superiority—even of contempt—towards us, especially when we are students. The young engineer—I speak as a member of the great majority of the ordinary kind—would probably never have chosen his profession if he had had special aptitude for mathematical work. Having chosen it, he has to look at mathematics simply as a tool, a means to an end, not an end in itself. I cannot myself see that this point of view is one disrespectful to the parent of all the sciences, and I am confirmed by the knowledge that one or two of the greatest mathematicians in the country are of the same opinion, and have the courage to act on it—with infinitely beneficial results to the young men they have to deal with. But I know that to mathematicians in general—the physicists are not so bad—the very name of engineering student is odious, indicating only a man who wilfully refuses to make mathematics his "first subject," and who, therefore, deserves neither consideration nor quarter, to whom it is privilege sufficient that he should be allowed to pick up such crumbs as he can digest from a table prepared for his betters. I humbly protest that we deserve better treatment. It is no doubt a great misfortune to us that we cannot afford to spend our training time preparing for examinations, and that we have been compelled to choose for our future a career in which mathematics plays only a secondary part. It is our further misfortune that we have to solve 20 real live problems, each demanding a real live answer, for every single one which otherwise we would have worked out on paper. Perhaps it is also our misfortune—or it may be only our thickheadedness—to believe that in consequence of this we are quite able to judge for ourselves what units it is most convenient for us to work in, what nomenclature satisfies our requirements, and that we are as capable of getting our "g's" in their right places as even some of our distinguished critics. I venture to repeat here what I had lately an opportunity of saying before a Royal Commission—that in cases where a university or university college takes in hand the preparation of engineers—and I hope that such cases will grow in number—they should provide for them special training in mathematics, and probably also in physics, distinct from the general training in these subjects most suitable for degrees. I say this with the full knowledge that I may be accused of wishing to degrade the purity of scientific work, and at the same time with the full knowledge that I have no such wish. On the contrary, this special training is the only means by which the rank and file of us will ever know any mathematics at all. And I can say from my own knowledge that if only we can be made what I may call mathematically articulate beings, we shall be able to repay the kindness by placing before the man of pure science problem after problem of transcendent difficulty, of immense interest, and having no single drawback whatever except that its solution may really be "useful," and, after all, this need not be brought too prominently under his notice.

This digression has turned out a long one. I have only further to say that my main object in this address has been to indicate, as well as I could, the general attitude which the engineer must of necessity take up towards much of his work—the point of view from which he must look at it. I shall be extremely glad if anything which I have said should cause this attitude—this point of view—to be more clearly kept in mind in the period of training than probably has been hitherto the case.

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THE POST OFFICE AND THE NATIONAL TELEPHONE COMPANY.

In December, 1890, it became for the first time possible for the Government to purchase the telephone system of the country under the terms of the licences granted to the various telephone companies at work in the United Kingdom. Nothing, however, was done in the matter, and the opportunity then allowed to slip by will not again present itself until December, 1897. On May 27, 1892, there was laid on the table of the House a copy of a Treasury Minute which may without exaggeration be said to have announced a new era for telephony in this country. The lamb was to lie down with the lion; the Post Office and the National Telephone Company were to "co-operate in services to the public"; the former was to take over and work the trunk wires, the latter was to be given all manner of Post-Office assistance in the laudable and necessary task of improving its urban exchange system. On June 28th, a Bill giving the Post Office the needful authority to carry out the proposals of the Treasury received Royal Assent; and, on August 11th, heads of arrangement were signed by the parties concerned. To-day the public can purchase for the sum of 7½d. a mass of printed matter weighing, in London, something like half a pound, and containing, amongst other documents, a draft of the proposed agreement between the Postmaster-General and the National Telephone Company—a draft which certain members of Parliament seemed as if they would never be happy until they got it, and which, now they have it, they seem as if they never would be satisfied until they are rid of it. How it comes about that two years have been allowed to elapse between the signing of the preliminaries and the completion of the indenture, in which the two pages of the former were expanded into ten pages of legal verbiage, is not obvious on the surface, and it booteth not perhaps to inquire. The basis upon which the State was to purchase the trunk wires—viz., cost price thereof plus 10 per cent.—was settled on August 11, 1892, and though the exact delimitation of the exchange areas set forth in Schedule II. was doubtless a long business, there surely cannot have been any serious differences over a mere detail.

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The purchase price, the main thing which concerns the public, now that it has assented—too readily, as we think—to the half-way house plan of the Post Office, cannot, one would imagine, give rise to much cavilling, even on the part of the most vigilant parliamentary guardian of the public purse. It is true that the cost of the National Company's trunk wires cannot be ascertained from its books, as originally proposed, but will have to be estimated by "two experts in telegraphic engineering." The alteration is not, however, of serious moment, and, this important point disposed of, the long-winded indenture may be taken as read.

A few of the matters of detail, on the other hand, are of some interest. The date on which the transfer of the trunk lines to the State is to take place, referred to with appropriate solemnity as "the appointed day," is fixed for July 1st next. A page is devoted to setting forth the terms upon which telephone wires belonging to one party are to be maintained by the other. The arrangements with regard to the connecting up of post offices with exchanges are characteristic of the complication which this half-baked scheme gives rise to. All such wires are to be erected and maintained by the Company at its own expense; the wires and apparatus actually within the post offices, however, are to be worked by the State at its own expense, and maintained by the State at the Company's expense. The Company, whilst paying the State nothing for its labour in working the apparatus, will have to pay it a rental for the use of the post offices; and so on, and so on. Better the devastating army of postal officials conjured up by Mr. GOSCHEN in his speech deprecating the addition of the telephone legion to the Post-Office forces than this mad medley.

SENSE OF PROPORTION IN ENGINEERING.

The interesting address delivered by Prof. KENNEDY before Section G of the British Association treats of the engineer as a critic. Literary critics are of some use to the community when they boil down the contents of a new book into a paragraph or two, and thus enable their readers to judge whether the volume is worth buying; and they amuse each other, when disinclined for this useful work, by writing essays, with the intent of showing how much more clever they are than the author of the book which is supposed to be before them. Dramatic, art and musical critics write, of course, only for each other and for their friends, and are of no use whatever. It is a relief, then, to find a critic who is not expected to write, nor even to express his views articulately. The word engineer conjures up inmost minds the vision of a dirty man who either manages or makes engines or other machinery, essentially a craftsman, and a professional engineer is considered to be one who merely superintends the constructive work of contractors. Prof. KENNEDY shows that his real work lies rather in the preliminary operation of deciding how any given problem shall be solved, than in the more active task of carrying it out. Too much attention is paid to theorising on ideal examples, in which the conditions are assumed at random with an utter disregard of practical experience; or, going to the other extreme, attempts are made to teach in the lecture room matters that can only be learned in the workshop. A knowledge of theory and of actual work at the bench is essential to the engineer, both for the design of any piece of work or for superintending its execution; but Prof. KENNEDY reminds us that before even the design is begun the engineer has first to make up his mind about the particular way in which the problem is to be solved, and he points out that the considerations are too complex to be dealt with mathematically, or even physically. There are half-a-dozen ways of solving any particular problem of engineering, and any one of these may be strictly in accordance with scientific theory and the best engineering practice; but probably only one of them is really the right one. At all events, only one, as a rule, can be put into execution.

The first act of an engineer, then, is to criticise and to select the course to be taken. Whether the choice is made from his own original designs, or those of his assistant, is mere detail. A good technical training can make a good draughtsman, and with mechanical instinct and electrical knowledge he could design a first-class dynamo, and might be competent to superintend its construction; but there his duties end. It is for the engineer to decide whether the machine is suitable for the particular conditions under consideration, and his is the responsibility for selecting it. But Prof. KENNEDY points out that not only in this important initial step is the engineer called upon to make up his mind, but throughout all the details of engineering work, even to the choice of the size of a bolt, he must act as a critic, and the very first necessity to such a critic is that he should have a sense of proportion. He rightly judges that although a student may be taught to criticise perfectly along certain very narrow lines, it is a doubtful point how far the student can be systematically imbued with a sense of proportion. Like invention, which of course cannot be taught, it seems to consist in the use of a vivid imagination. The engineer must picture to himself all the different solutions of the problem, and range them before his mind's eye, criticise them, and make his selection. An inventor creates but one mental image at a time, and as he studies it he finds one improvement after another to be necessary, and sees the image gradually change as each alteration is effected. But the engineer has to place a row of such images before him, and these not necessarily of his own creation. In many cases he is actually debarred from making a single alteration. He has to confine himself to weighing advantages against drawbacks. In electrical engineering further difficulties are introduced by the consideration of such matters as the fall of volts over a network of mains, the self-induction of a coil, and other quantities of a more abstract, or, at all events, less material nature than those which concern a mechanical engineer. The other matters discussed and briefly alluded to by Prof. KENNEDY are worthy of thoughtful study—the value of quantitative experiment and the relative importance of each measurement, the "worth-whileness of economies," the balancing of the activity of a machine against its vitality, the definition of "simplicity," and the use of mathematics. On any one of these we should like to have heard him enlarge.

LIST OF THE ELECTRICAL PAPERS READ AT THE BRITISH ASSOCIATION.

The following is a complete list of the electrical Papers read and reports presented at the Oxford Meeting of the British Association:—

SECTION A.

LORD KELVIN, P.R.S., MAGNUS MACLEAN, and ALEXANDER GALT.—"Preliminary Experiments to find if Substraction of Water from Air Electrifies it."

LORD KELVIN, P.R.S., and ALEXANDER GALT.—"Preliminary Experiments for Comparing the Discharge of a Leyden Jar through Different Branches of a Divided Channel."

PROF. O. J. LODGE, F.R.S.—"Photo-Electric Leakage."

PROF. O. J. LODGE, F.R.S.—"An Electrical Theory of Vision."

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PROF. O. J. LODGE, F.R.S.—"Experiments Illustrating Clerk Maxwell's Theory of Light."

PROF. A. SCHUSTER, F.R.S.—"On a Suggested Explanation of the Secular Variation of Terrestrial Magnetism."

PROF. A. SCHUSTER, F.R.S.—"On the Construction of Delicate Galvanometers."

LORD RAYLEIGH, SEC.R.S.—"On the Minimum Current Audible in the Telephone."

LORD RAYLEIGH, SEC.R.S.—"An Attempt at a Quantitative Theory of the Telephone."

PROF. S. P. THOMPSON, F.R.S.—"On Mirrors of Magnetism."

PROF. C. G. KNOTT.—"On Volume-changes Accompanying Magnetisation in Nickel Tubes."

A. P. TROTTER —"On a Graphical Transformer."

H. STANSFIELD.—"On the Relation Between the Surrounding Gas and the Electrical Conductivity of thin Soap Films."

DR. ADOLPH SCHMIDT.—"On a New Analytical Representation of Terrestrial Magnetism."

FRANCIS G. BAILY.—"Note on the Hysteresis of Iron and Steel in a Rotating Magnetic Field."

PROF. J. J. THOMSON, F.R.S.—"On the Velocity of the Cathode Rays."

A. G. VERNON-HARCOURT, F.R.S.—"On a Ten-Candle Pentane Lamp."

DR. G. J. STONEY, F.R.S.—"How the misuse of the word 'Force,' in Attractions, Electricity, and Magnetism, may be avoided without much departure from existing practice."

DR. G. J. STONEY, F.R.S.—"On a Nomenclature for very much Facilitating the Use of Systematic Measures."

PROF. VIRIAMU JONES, F.R.S.—"Determination of the International Ohm in Absolute Measure."

PROF. VIRIAMU JONES, F.R.S.—"On Standards of Low Electrical Resistance."

R. T. GLAZEBROOK, F.R.S.—"Comparison with the B.A. Units of some Coils of Low Resistance."

J. RENNIE.—"Comparison of the Standards of the Board of Trade with the B.A Unit."

E. O. WALKER.—"Comparison of some Standards belonging to the Indian Government."

REV. T. C. FITZPATRICK.—"On the Specific Resistances of Copper and Silver."

J. TEICHMÜLLER.—"On the Specific Conductivity of Copper."

Report of the Electrical Standards Committee.

Discussion on Integrators, Harmonic Analysers and Integraphs, and their application to Physical and Engineering Problems. Opened by PROF. HENRICI, F.R.S.

SECTION B.

PROF. ROBERTS-AUSTEN, F.R.S.—"The Electrolysis of Glass."

Report of the Committee on Electrolytic methods of Quantitative Analysis.

Discussion on the Behaviour of Gases with regard to their Electrification and the Influence of Moisture on their Combination. PROF. J. J. THOMSON, F.R.S., showed experiments illustrating the connection between chemical change and electric discharge through gases.

SECTION G.

W. H. PREECE, F.R.S.—"Signalling through Space."

PROF. S. P. THOMPSON, F.R.S.—"Some Advantages of Alternate Currents."

T. PARKER.—"Continuous Current Distribution of Electricity at High Voltage, being a Description of the Lighting of the City of Oxford."

H. LEA.—"A Special Chronograph."

G. M. CLARK.—"A direct-reading Platinum Pyrometer."

SECTION I.

PROF. OLIVER LODGE, F.R.S., and PROF. GOTCH.—"Some Physiological Effects of the Passage of Rapidly Alternating Currents of Great Intensity through Nerve."

G. J. BURCH.—"On the Production with the Capillary Electrometer of Photographic Records of Currents Produced by Speaking with a Telephone."

Telephonic Communication between France and Switzerland.—An international telephone wire is at present in course of erection between Besançon, the centre of the French watchmaking industry, and the Swiss town, La Chaux-de-Fonds.

THE BRITISH ASSOCIATION AT OXFORD.

The proceedings of the sixty-fourth annual meeting of the British Association were inaugurated, on Wednesday evening last week, by the resignation of the presidential chair by Prof. Burdon Sanderson, and its assumption by the Most Honourable the Marquis of Salisbury. The presidential address was one having a many-sided interest. As a literary production it was full of terse epigram and eloquent diction. As a piece of scientific criticism from the standpoint of one whose intellectual abilities confer authority, but who confessedly stands outside the ranks of professional scientists, it demands the attention of every student of science. Physicists should be most thankful to Lord Salisbury for his frank, but perfectly justifiable, criticisms of modern atomic and ether theories. Particularly apt was his description of the ether as something "to furnish a nominative case of the verb 'to undulate.'" The sharpness of this epigram lies in its profound truth. Professional physicists are—or appear to be—content if they can refer every action to an undulation, and the medium of every action to this convenient "nominative case." But what Lord Salisbury and the rest of the intelligent world are asking is: Why undulation? Is there nothing further down than this verb 'to undulate,' with its phantom nominative case? Nor was the definition which Lord Salisbury gave to the word-labels which scientists fasten on certain sets of phenomena any less profoundly true and caustic. Physical science is not unacquainted with too many of "those indefinite words from time to time vouchsafed to humanity, which have the gift of alleviating so many perplexities and masking so many gaps in our knowledge." Time was, and not many years ago, when the major part of the map of Africa was labelled "desert." The ancients were more modest, and labelled their unexplored regions "*terra incognita.*" Many tracts of science would have their high-sounding labels removed and "*terra incognita*" substituted, if we were more willing to show the nakedness of our inward ignorance.

THURSDAY, AUGUST 9TH.

The sectional activities were commenced at various hours on Thursday, by the reading of the presidential addresses. Our readers will find in our columns the full text of the addresses before sections A and G. In the former section, Prof. Rücker directed the attention of his audience, and of the outside world, to the pressing needs of the science of terrestrial magnetism. The address was delivered in the large lecture theatre of the Museum, which was crowded to overflowing. The vote of thanks to the president was moved by Lord Kelvin, who emphasised the importance of reform in our national and international researches in terrestrial magnetism. Adjournment was then made to the lecture theatre of the Clarendon laboratory, the larger hall being required for the presidential address of another section. This smaller hall was quickly filled, the visitors included Lord Salisbury, who took great interest in the Papers which were read. The first Paper was on "Preliminary Experiments to find if Subtraction of Water from Air Electrifies It," and was read by Lord Kelvin, who occupied considerable time, and was at great pains to describe these researches. He commenced by mentioning several ways, such as by the friction of air blowing across a sandy desert, in which the atmosphere might possibly be electrified. He then described the apparatus employed by himself, together with Messrs. Maclean and Galt, to determine if the abstraction of water from air, *per se*, produced electrification. A lively debate ensued, the main point of discussion being the validity of the method of experiment. Prof. Quincke, of Heidelberg, considered that the observed electrification might possibly be accounted for by movement of the desiccating fluid in which the pumice was soaked. Prof. Lodge conceived that Lord Kelvin had attributed to condensation results which might wholly be accounted for by the friction of the air in its passage through the apparatus. Particles of dust carried over from the bellows would become electrified by friction against the indiarubber tube through which the

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current of air was forced; and the particles of moisture in the midst of the lumps of pumice might similarly be affected. Prof. J. J. Thomson threw doubts on the validity of experiments made with air rushing through tubes. Prof. Fitzgerald suggested that any electrification due to chemical action by the drying agent could be prevented by cooling the apparatus to a sufficiently low temperature. Prof. S. P. Thompson observed, that if there was any doubt as to whether the evaporation of a substance caused its vapour to become electrified, that doubt ought to be dispelled by the fact that between the positive carbon and the vapour, in a voltaic arc, there was a pressure of some forty or fifty volts—a difference of potentials which could only be accounted for on the hypothesis of actual electrification by volatilisation. Prof. Schuster pointed out that in experiments of a highly complicated nature, like those with which Lord Kelvin and his colleagues had been dealing, the validity could only be established by a careful process of elimination, and that this was exactly what Lord Kelvin and his colleagues had done. That the use of one drying agent alone, or only one form of the experiment, would warrant a doubt as to the validity of the conclusion was admitted by all; but the experimenters had been careful, by using various desiccating substances, and by varying the form of the experiment, to eliminate every one of the special marks of reasonable doubt, and had left little or no doubt that the subtraction of water from air does electrify it. Lord Kelvin, in reply, said that Prof. Schuster was quite right.

The next Paper was on "Preliminary Experiments for Comparing the Discharge of a Leyden Jar through Different Branches of a Divided Channel," and described some researches recently carried out by Lord Kelvin and Mr. Galt. In the discussion, which was very feebly supported, Prof. Lodge gave a lucid and interesting account of his theory of the alternative path in condenser discharges, and explained why it is that an iron path has a greater damping effect than a copper one. The morning session concluded with a Paper, by Prof. Lodge, on "Photo-Electric Leakage," in which the experiments of Hertz, Lodge, Elster and Geitel on the effects of ultra-violet and polarised light in the diselectrification of positively and negatively electrified surfaces were described. These researches have recently been described in *The Electrician*. The meeting then adjourned for the purpose of making a complicated tour of the neighbourhood in search for lunch. Owing to the utterly inadequate arrangements, a large number of the visitors on arriving at the luncheon tent discovered that the provisions had been wholly consumed. Returning in a vacuous state to the lecture theatre, the members proceeded to a lively discussion on thermodynamical speculations. This discussion was opened by a report, by Mr. G. H. Bryan, on the present state of his knowledge in thermodynamics, and by the reading of two Papers on the dynamics of a gaseous system.

Friday, August 10th.

The focus of electrical interests shifted, on Friday, to section B, which is usually devoted to matters relating to chemistry. Readers of the B.A. "Journal" found, on Friday morning, that a "Discussion on the Behaviour of Gases with regard to their Electrification and the Influence of Moisture on their Combination," was arranged to take place in this section. Consequently, chemists and physicists, besides a goodly number of well-known electrical engineers, mustered in force, to the detriment—at least during the early forenoon—of the attendance at sections A and G, which had temporarily coalesced. The line of discussion was mapped out by three remarkable Papers, each dealing with one aspect of a yet unexplained phenomenon, viz., the physico-chemical action of moisture on gases. The first Paper was contributed by Prof. J. J. Thomson, of Cambridge; and dealt with the resistance to electrical stress of gases in various degrees of moisture. Prof. Thomson illustrated his remarks by showing a number of experiments. Various gases in a rarefied condition were subjected to rapidly alternating electric stress; and it was demonstrated that the effect of drying the gas was, in each case, enormously to increase the potential gradient required to cause a luminous discharge. One very conclusive experiment was that in which a pair of glass bulbs, connected by a tube of glass, had been filled with rarefied gas; the connecting tube was then closed under a blowpipe flame. One of the bulbs, which contained a desiccating agent, would not glow in the same alternating electrostatic field which caused the other to glow brightly. Adverting to the potential gradient required to produce electrolytic dissociation of a single isolated molecule of water, Prof. Thomson said that a potential gradient of 30 millions of volts per centimetre length was necessary. It was hopeless to try to produce this electric stress artificially. Where several molecules were present, the influence of each on its neighbours was sufficient to exert the necessary force; which is clearly an instance where union is *not* strength and power. The two succeeding Papers showed that, in certain cases at any rate, there is a parallel between the electrical and the chemical importance of aqueous moisture in gases. For it was experimentally demonstrated by Mr. H. B. Baker that the admixture of dry ammonia and hydrochloric acid gases resulted in no chemical change, whereas the least trace of moisture in the mixed gases led to the formation of dense white ammonium chloride. Many other examples of this "chemical happy family" were exhibited; substances possessing the most intense chemical "affinity" remaining quiescent if perfectly dry. The reading of these most interesting Papers, which, undoubtedly, deal with something quite on the borderland of physico-chemical knowledge, was followed by an informal and lively discussion. Prof. Schuster said that the facts were incontestible; but as to the electrical theories which had been based upon them he could not but raise a doubt. He laid great stress on the results of experiments which, he said, ought to be made on the rarefied vapour of mercury—an elementary, monatomic gas. Mr. Baker replied that a limitation must be placed on the inferences, in so far as they related to any substances which might dissociate into atomic states before the chemical or electrical effects were produced. Prof. J. J. Thomson admitted that his interpretation required the assumption that the atom of each element might be either positively or negatively charged in the same gas or mixture of gases. He also admitted that the general extension of his theory to phenomena at high temperatures (2,000° C., for example) would make it necessary to assume that "drops" of water—*i.e.*, aggregations of molecules of water—could exist under such conditions. The chemists, generally, who took part in the discussion were inclined to doubt the hypothesis of atomic charges and interatomic stresses. They were divided in their opinion as to whether the phenomena above described depended upon aqueous moisture, *per se*, or on a state of moisture, generally, which might be caused by various compounds.

Meanwhile, the combined sections, A and G, had been taking part in a discussion on "Integrators, Harmonic Analysers and Integraphs, and their Application to Physical and Engineering Problems." The discussion, which was very poorly attended, was opened by Prof. Henrici, who exhibited and remarked upon his own ingenious instruments. By the time the two discussions, that of A and G in Keble Hall and that of B in the Museum, were over, there had taken place a very considerable change in the "balance of power," at any rate numerically. For the prospect of a lively debate on so romantic a subject as "Flight" had drawn an immense audience within the walls of Keble Hall. The discussion was opened by a lengthy speech by Lord Kelvin on the resistance of solids moving through fluids. Mr. Maxim's communication describing his machine came next; after which Lord Rayleigh ventured to ask and reply to the question: What is a flying machine?

Saturday, August 11th.

Most of the sections met for shorter or longer periods on Saturday, but the Papers on electrical matters were at a low ebb. The large number of contributions to Section A made it necessary for this section to divide; one sub-section dealing with a list of some fifteen mathematical Papers, a second considering the reports of the various committees and some physical Papers, and a third dealing with Papers having a physico-chemical nature. The mathematical sub-section found it necessary to adjourn until Tuesday, owing to the heavy list of Papers. In the physical and report sub-section Prof. Osborne Reynolds showed an interesting series of experiments on the

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boiling of water in an open vessel with a constricted tubular orifice. The character of the ebullition was shown to make four distinct critical changes as the temperature and pressure were raised. In the physico-chemical sub-section two electrical Papers were discussed; the one by Mr. H. Stansfield on "The Relation between the Surrounding Gases and the Electrical Conductivity of Thin Soap-Films," and the other by Mr. W. C. Dampier-Whetham on "The Velocity of the Hydrogen Ion through Solutions of Acetates." Meanwhile Section G had busied itself with three important Papers, including a Paper by Mr. B. Donkin on "The Most Economical Temperature for Steam-engine Cylinders."

MONDAY, AUGUST 13TH.

Whether to attend Keble College Hall, for the purpose of listening to a number of Papers on electrical engineering in Section G, or to cross over to the Clarendon Laboratory, where Section A had provided itself with a very long programme, consisting largely of electrical Papers, must have sorely puzzled the electrical individual who was anxious to make the best of his time on Monday. If his choice had fallen upon the engineering section, he would have spent the morning and the greater part of the afternoon in listening to two or three popular expositions from leading men, and he would probably have gone away with the impression that, though he had been mightily amused, he had heard little or nothing new and certainly nothing profound. Mr. Preece led off with a long Paper on "Signalling through Space," and the novice who had read his title must have wondered if it is possible to signal anywhere else but "through space." But what Mr. Preece had to say dealt with an inductive method of electrical signalling without metallic conduction between the sending and receiving stations. His Paper reviewed his researches in this method of signalling, and concluded with particulars of his most recent work on the subject, and some fanciful speculations on the possibility of signalling to Mars and other worlds than ours. It never seems to have occurred to the speculators on this topic that, even assuming the electrical possibility, there would be far less chance of being understood than if they were to signal to the polar bear at the Zoo. Mr. T. Parker's Paper on the system of electric lighting in use at Oxford received an effective fillip from the previous monologue on "Some Advantages of Alternating Currents," by Prof. S. P. Thompson. Indeed, this *pot pourri* of alternating-current information would otherwise have had little justification; but as the spicy criticisms of continuous-current practice, with especial reference to Oxford, which Prof. Thompson sprinkled over his Paper caused a lively counter-fire from Mr. Parker when his turn arrived, the audience had little cause to complain of the disconnectedness of the former Paper. Prof. Thompson's was, in fact, a typical B.A. Paper of the olden time—a number of slightly related facts grouped together beneath a sufficiently broad title; and it ranged from alternating electromagnets and motors to feeder regulation and the use of the "booster." To the adverse criticisms that were raised, Prof. Thompson made the obvious retort that his Paper was a piece of "special pleading"; and he gave one the impression that he could have made out quite as good a case had his subject been "Some Advantages of Continuous Currents." Mr. Parker's Paper described and gave some figures relating to the economy in the Oxford electric supply station, a full description of which will be found in *The Electrician*, Vol. XXIX., p. 254. At this station, the load factor for the previous year had been 5·69 per cent.; yet a coal consumption of only 6·38lb. per unit sold, costing but 0·718 penny, had been required. The energy, as metered, was only slightly over 100,000 units. A revenue of 10s. 11d. per 8-c.p. lamp had been obtained.

Had, however, the individual in quest of electrical lore elected to sit in Clarendon Laboratory, there is no doubt he would have been provided with more profound and tougher fare. Dr. A. Schmidt read a Paper on "A new Analytical Representation of Terrestrial Magnetism," which proved to be an extension of Gauss's expression enabling the internal and external components of the terrestrial force to be expanded in separate terms. Prof. Schmidt made the hypothetical assumption that an element of the force arose from an electrical displacement amounting to one-tenth of an ampere per square kilometre of surface. Prof. Schuster next read a Paper on a "Suggested Explanation of Secular Variations of Terrestrial Magnetism," which will be found in our columns this week. He showed that since the assumption either of infinite or of zero resistance of inter-planetary space led to no dissipation of energy, there must be a certain degree of conductivity at which, if the space possessed it, the dissipation and consequent retarding force would be a maximum. The maximum possible retardation, on the assumptions made by Prof. Schuster, would be so very gradual that it would be very difficult, if not impossible, to dissociate the effect from that of other retarding forces. Prof. Schuster also read a Paper giving some comparisons between the sensitiveness of galvanometers with various forms of coil-winding. In a Paper "On the Minimum Current audible in the Telephone," Lord Rayleigh showed that the degree of sensitiveness depends on the nearness of the frequency of the impulses to the natural periods of vibration in the disc, the greatest sensitiveness being obtained when the frequency of impulse was identical with the natural frequency of vibration. A number of other Papers were also read, the subjects being chiefly of minor electrical interest.

TUESDAY, AUGUST 14TH.

The climax of electrical interest was undoubtedly reached on Tuesday, when a joint discussion on theories of vision, by the physical and physiological sections, was inaugurated by some brilliant experiments and two memorable Papers by Prof. Lodge. The large lecture theatre of the museum was crowded to overflowing, among the audience there being a large number of distinguished physicists and physiologists. The proceedings commenced with a Paper by Prof. Lodge in connection with some "Experiments illustrating Clerk Maxwell's Theory of Light," in which the quasi-optical properties of electromagnetic radiation were very beautifully, very carefully, and very convincingly demonstrated. This Paper was really the prologue to the Paper on "An Electrical Theory of Vision," which immediately followed, and its direct purpose was to initiate the physiologists into the researches of Hertz, Lodge and others on this quasi-optical behaviour of electromagnetic waves. Prof. Lodge, in his second Paper, disclaimed the intention of advancing a "theory" of vision, and urged that his communication was rather in the nature of a question put to physiologists as to whether it is possible that anything resembling the action of electro-magnetic waves on a coherer could be supposed to take place in the vertebrate eye. It was difficult to know which to admire most, whether the carefully logical manner in which Prof. Lodge arranged the facts, or the modesty with which he advanced his hypothetical deductions. The gist of Prof. Lodge's hypothesis is, that a simple electric circuit consisting of a coherer contact and an otherwise closed circuit—with or without a seat of electromotive force—may be taken as an analogue, and may, *ex hypothesi*, be an enlarged model of the mechanism of vision. Just as a galvanometer in the coherer circuit will, if there is an electromotive force, be affected by electro-magnetic stimuli acting on the coherer, so the mechanism of vision may be supposed to be affected by the stimuli of optical rays. Each element of the retina—each rod and each cone—must, on this assumption, be taken as consisting of a coherer circuit which can transmit its individual impulse to the brain. The author then showed that there were two positive but opposite stimuli required, if the analogy was to be made complete. Not only was an optical stimulus necessary in order to enable the eye to perceive the element of light which falls on it; but a cancelling stimulus from within the organism was required in order to enable the eye *not* to see the visual impression when the luminous source was removed from its gaze. A coherer circuit once affected by an electromagnetic wave has a tendency to persist in its lessened resistance and increased current; and it requires some mechanical stimulus to jerk the coherer contact back to its normal state of badness. Prof. Lodge showed by an experiment that it was quite possible to limit the "persistence of vision" of the coherer circuit by arranging that the coherer should be mechanically tapped in rapid succession. The conclusion of Prof. Lodge's Paper was received with hearty and prolonged applause. In the discussion which

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followed, Lord Rayleigh, after congratulating Prof. Lodge on the ingenuity of his hypothesis, made the remark to the Physiological Section, that physicists could object neither to the Young-Helmholtz theory nor to that of Henry, provided that three *independent* variables in the system of equations was granted. There might be six variables in all, three dependent and three independent; but whatever hypothesis might be advanced, no explanation of vision could be recognised which did not postulate these three independent variables.

Prof. Burdon-Sanderson made an excellent speech, in which he said that physiologists could perceive no inherent objection to the hypothesis of Dr. Lodge; but, he said, it was useless to advance any theory of the action of the complex stimuli of vision which did not also apply to the more simple stimuli met with in other organs and in tissue of plants and animals generally. There were a number of "touch and go" stimuli, and the stimulus of the retina by mechanical means was one, where the action was functionally precisely the same as that of light on the retina. Prof. Schäfer pointed out that the vertebrate eye had a number of filamentary processes which might possibly represent a coherer; but, he added, the phenomena of vision were not confined to the vertebrate eye, but were also found in invertebrates, where a complicated retina and quasi-coherer processes were not to be found. A number of other leading physiologists added their support to the view that the morphology of the vertebrate eye very strikingly fell in with Prof. Lodge's hypothesis of a coherer circuit. Prof. Armstrong proposed that the true hypothesis of vision must account for the chemical actions which occur when light falls on the retina, and suggested that the chemical actions were the primary, and the electrical actions the secondary, cause of vision.

The section was now divided, and one portion was occupied with Papers on optics. The other division debated on Papers relating to electrical standards. Mr. R. T. Glazebrook read the formal report of the Committee on Electrical Standards. Prof. Viriamu Jones communicated the results of a "Determination of the International Ohm in Absolute Measure." Lord Rayleigh said that no method previously used for finding the ohm could compete in point of accuracy with that used by Prof. Jones.

Across the road, the engineering section had been taking a number of important Papers. The valuable report of the Committee on Dryness of Steam was submitted by Prof. Unwin, who described the work which had been done in the perfection of methods of measuring the dryness factor of steam. A useful Paper on "The Hunting of Governed Engines," by Mr. J. Swinburne, was next considered; after which a number of Papers of general engineering interest were discussed.

WEDNESDAY, AUGUST 15TH.

The publication of the *Journal* on Wednesday morning was the herald of the anti-climax. In that convenient newspaper it was announced, in respect of no less than five out of the nine sections, that "This section does not meet." Even the four sections which did meet on Wednesday, provided themselves with short programmes, and got through them as quickly as possible in order to attend a University function at the Sheldonian Theatre. This function had to do with the conferring of a number of honorary degrees upon distinguised scientists and others. In section A, five Papers were announced to be read; but as the only electrical Paper, viz., that by Prof. Newall, "On the Spectra of Discharges in Gases Without Electrodes," was withdrawn, the electrical interest in the proceedings of this section fell to zero with an impulsive rush. In the physiological section two interesting electrical Papers were read; one by Profs. Lodge and Gotch on "Some Physiological Effects of the Passage of Rapidly Alternating Currents of Great Intensity through Nerve," and the other by Mr. G. J. Burch "On the Production with the Capillary Electrometer of Photographic Records of Currents Produced by Speaking with a Telephone." The Oxford meeting of the Association terminated at the concluding general meeting which was held at half-past two, when the Association adjourned till next year when it meets at Ipswich.

The Oxford meeting of the British Association has been one on which its members may congratulate themselves; for a very much larger amount of solid, useful work and of valuable interchange of ideas has taken place, than is usual. The presence of so many distinguished scientists, both from all parts of the kingdom and from abroad, has contributed most effectively to the intellectual and educational success of the meeting. Some idea of the week's work may be gathered from the fact that no less than 384 Papers and Reports have been presented during the six days of sectional session; the number of Papers read before Section A being 80, and before Section G only 23. A striking feature of the Oxford meeting has been the number of discussions by temporarily conjoined sections; and section A, to give one example, has derived profit from its coalescence with the physiologists on Tuesday, as well as from its union with the engineers on Friday. Other sections have largely adopted this most efficient method of inducing brotherly love and catholic thought, and we trust it will be even more extensively adopted at future meetings.

By far the largest number of Papers, in any single section, was read in Section A, which may also fairly claim to have done the greatest amount of work, and to have sat for the longest time. Indeed, the pressure of work in this section has been so great that, with the instinct of a Barnum and the ambition of a Kiralfy, the section has provided a number of simultaneous side-shows, a practice which has made it quite impossible for the individual member to hear more than about one-half of the Papers. Possibly the claim to the cream of the session may justly be made by the Chemical Section, in which the chief sensation was the announcement by Lord Rayleigh and Prof. Ramsay of the discovery of a hitherto unsuspected substance in the earth's atmosphere, a substance which till recently has been confused with nitrogen, which it greatly resembles. The chemists naturally hastened to find a seat for this substance at Mendeljeef's table, if only it can show a clear claim to be considered an element.

But the British Association has done something else than serious work; it has enjoyed a full measure of recreation. The fun has even brimmed over, and leaked into the Papers and into the discussions. Mr. Swinburne's sporting Paper on "The Hunting of Governed Engines" is an example; and none the less so was the cruel fun in which Mr. Preece seems to have been indulging of driving sirens—he does not say they are not Homeric sirens—"at first slowly, then increased until a 'screech' is produced, then again dying away." Yet, after such severe treatment as this, Mr. Preece seems to evince great surprise that, do what he would, he could never get the creatures to "screech" again—after the "dying away"! A Paper on the significance of ticklishness, which was read before the anthropological section, must have showed a desire to obtain a scientific theory for all this jocularity; and the companion one on "Shoe-throwing at Weddings" showed how the British Association would rather have its joke than its man. The literature of the "new humour" must have been in the mind of the author of the communication on "The Effect of Gravity on the Circulation"; and the report of the Committee on Erratic Blocks should induce publishers to be careful that the blocks on one side of a page do not by accident improperly co-ordinate with those on the opposite side. Finally, people who have dropped into adverse circumstances may derive a crumb of comfort from "The Philosophy of Holes."

A SUGGESTED EXPLANATION OF THE SECULAR VARIATION OF TERRESTRIAL MAGNETISM.*

BY ARTHUR SCHUSTER, F.R.S.

It is a matter of great importance to ascertain whether we must consider interplanetary space to be a conductor of electricity or not. If there is an appreciable conductivity the magnetic system of the earth will, owing to its rotation, induce currents which will react on the earth in a twofold manner. There will be, in the first place, a mechanical effect tending to

* Paper read before the British Association at Oxford, Section A.

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increase the length of the day, and, secondly, a magnetic effect tending to displace the magnetic axis. It is the object of this communication to give the results of some numerical calculations referring to the magnitude and nature of these reactions.

The problem is of interest apart from any applications to terrestrial magnetism. Given a magnetic sphere rotating in a conducting medium, what are the mechanical and magnetic forces acting on the sphere in consequence of electric currents induced in the medium?

The mathematical solution is easily obtained from Lamb's equations for currents induced in spherical conductors; and, without entering into any details of calculation, I here state the principal results for the case that the sphere is uniformly magnetised about an axis not coinciding with the axis of rotation.

If the medium is either perfectly conducting or perfectly non-conducting, there will be no mechanical effect tending to stop the rotation of the sphere; but for all finite conductivities there will be a couple opposing the rotation, which is a maximum for a certain specific resistance of the medium.

If the radius of the sphere is R, the angular velocity ω, the specific resistance ρ producing the maximum retardation is given by the relation

$$\rho = 1{\cdot}4\, R^2 \omega,$$

where the numerical factor is approximate only.

For the earth: $R = 6{\cdot}4 \times 10^8$ $\omega = 7{\cdot}27 \times 10^{-5}$

$$\rho = 4{\cdot}7 \times 10^{13}.$$

The resistance indicated by this number is such that if 4·7 volts were applied to the two sides of a plate having a thickness of one centimetre there would be a current of 10^{-4} amperes per square centimetre. I do not know of any facts which would make such a conductivity an impossible one, consistently with the extreme tenuity of matter which we know must exist in space. The next point to consider is the actual value of the maximum retarding couple. In C.G.S. units, and for a sphere having the same size and magnetic moment of the earth, it is $1{\cdot}9 \times 10^{24}$. If this couple was to act continuously it would diminish the earth's rotational velocity to the extent of one second per day in 14,000 years. Early records of solar eclipses show that the earth as a timekeeper has lost time, but authorities do not agree as to how much. Two causes tending to alter the length of the day have hitherto been considered, tidal friction tending to retard it, and the contraction of the earth tending to increase it. To this we must now add a possible retardation due to the conductivity of the medium.

The maximum magnetic couple calculated above is about six times that given by George Darwin for the effect of tidal friction, and it would by itself have produced a very marked effect in historical times. But, as far as I know, we have no data giving us any information as to the allowable contraction of the earth. If the diminution of the earth's radius amounts to a foot a century, it would counterbalance the maximum effect which the magnetic couple could possibly have. It is, of course, very improbable that the conductivity of space is just that required for the maximum effect. If the conductivity is 100 times less, the couple produced would be equal to the tenth part of the maximum couple, and such a couple would be impossible to separate at present from the other effects, tending to alter the length of the day. There is, therefore, a very large range of electric conductivity, within which that of space may lie without an appreciable effect on the length of the day being produced in historical times.

Turning our attention next to the magnetic reactions, we find that these will displace the magnetic axis towards the geographical pole and round it from east to west. If the earth behaved like a steel sphere, not subjected to any shocks or changes of temperature, a certain displacement would take place once for all, but no rotation such as is required to produce the secular variation. The constantly-renewed displacement of the magnetic axis, if it is due to the suggested cause, must be produced by a continuous change inside the earth. A possible explanation suggests itself in the secular cooling of the earth, owing to which more and more of its iron becomes susceptible to magnetisation. This virgin iron will be free to adjust its magnetic axis to the magnetic forces acting on it, and a continuous displacement of the axis must result. It must be acknowledged, however, that even taking account of this possibility it is difficult to see how a rotation of the axis can be kept up for several revolutions. Some light might be thrown on the question by an experimental investigation to discover a possible effect of great pressure on the temperature at which iron loses its magnetic properties.

If the secular variation is connected with the conductivity of space, everything that affects the latter must affect the rate of progress of the variation. I have on several occasions expressed an opinion that the curious effect on the earth of an increased sun-spot activity may be due to a greater electric conductivity at times of many sun-spots. When the above explanation occurred to me two years ago I looked up the records to see whether that secular variation seemed to proceed more rapidly when the sun-spot activity was great. I found, indeed, some remarkable coincidence between the years in which the secular variation was great and marked sun-spot years; but on the whole the parallelism of the two phenomena did not seem sufficient to draw public attention to the fact. Recently, however, I found the same coincidence noticed independently (I believe by Liznar). Should it prove established on further investigation the theory of the secular variation suggested above would deserve attention. Whether there are any appreciable magnetic effects due to electric currents outside the earth may, of course, be established by an analysis of the magnetic forces on the surface of the earth. I understand that A. Schmidt and Neumayer have already made much progress with such an analysis, and I am preparing an independent calculation with special reference to the outside forces.

The results of this investigation may be stated thus:

(1) The mechanical reactions on the earth of currents induced in space, assumed to be a conductor of electricity by the rotation of its magnetic system, are insufficient to produce an appreciable lengthening of the day in historical times, unless the conductivity lies within certain narrow limits. The absence of any marked effect cannot, therefore, be brought forward as an argument against the conductivity of space.

(2) The magnetic reactions of the same current, taken in conjunction with the secular cooling of masses of iron inside the earth, tend to produce a displacement which in kind is the same as that actually observed in the secular variation. But whether quantitatively the variation can be explained in this way is very doubtful.

SIGNALLING THROUGH SPACE.*

BY W. H. PREECE, C.B., F.R.S.

Whenever an electric current rises or falls in a circuit another current is simultaneously induced in every neighbouring conductor, if it form part of a circuit and be separated from the former by some insulating medium or dielectric, such as air. This secondary current flows only during the period of rise or of fall of the primary current.

Hence, if the primary current rises, falls, or changes its direction regularly and repeatedly a given number of times per second, the induced secondary currents will alternate with the same regularity and frequency. The intensity of these secondary or induced currents, among other things, will depend upon the character, form, and direction of the circuits, and upon the distance which separates them from each other. That such secondary currents, or electro-magnetic disturbances, as they are called, existed has, of course, been known since the days of Faraday; but that they could be observed, measured, and utilised at a distance of some miles from the primary circuit was not suspected before the introduction of that marvelous sensitive instrument the telephone.

When these disturbances are rhythmic, musical sounds are produced in telephones fixed in the secondary circuits, but when they are irregular unpleasant noises alone are heard. If the sounds are preconcerted and directed, like the dots and dashes of the Morse code, then telegraphy is possible, and we have a means of signalling through space without wires. The

* Paper read before the British Association at Oxford, Section G.

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distance to which we can signal is limited only by the distance to which these electro-magnetic disturbances, in their transit through space, retain sufficient energy to actuate our apparatus, the ether is supposed to be the real medium of transmission, and not the air. The disturbances through the ether take the form of undulations or waves, and in character they are similar to those radiations which at other frequencies give us heat, light, and photography. They move with the same velocity; they are subject to the same operations of reflection and refraction; and they differ only in the number excited per second.

Thus, to deal with the subject of signalling through space, we must have a primary conductor, in which vibrating or alternating electric currents can be excited at will. They must alternate with a frequency that will pleasantly affect the ear—say about 600 per second. They must be manipulated so as to produce preconcerted signals. The primary circuit must be freely exposed in the ether; and the secondary circuit, which it is desired to excite, must not be screened from the primary by means of magnetic or conducting matter. The object of this inquiry has been to determine the best form of primary and secondary circuit, the function performed by the earth as a part of the circuit, and the distance to which communication is possible with the ordinary practical means at our disposal.

The telephone as an instrument of precision is scarcely sufficiently appreciated. The ear can be trained by its aid to measure graduations of sound as accurately as the eye determines the calibrations of engraved scales. In Hughes' induction balance we have a well-determined absolute zero of silence, and there are many well-defined nodes of sound which may be taken as fiducial points in a telephonic scale. The limit of speech where articulate sounds cease to be comprehensible is one, the limit of Morse signals where telegraphic reading becomes impossible is another. It is quite easy to determine the similar intensity of two sounds, as in photometry the eye determines the similar intensity of two illuminations. The ear, however, requires to be educated, and it is subject to fatigue; but when properly trained, and when assisted by the telephone, it can be used to observe effects with as much reliability as the eye.

My attention was first directed to the subject in 1884. In 1886 I brought it before this Association at Birmingham, and again at Manchester in 1887. In August, 1893, I reviewed, before the Electrical Congress at Chicago, the whole of my previous nine years' work. Much experimental work has been done during the past twelve months. In 1884 electromagnetic disturbances were detected between telegraph circuits and telephone circuits 80ft. apart, the former in the streets underground in London, and the latter on the housetops; but in 1885 these effects were perceptible between parallel lines of telegraph $10\frac{1}{2}$ miles apart. The permeability of stone walls and buildings to electric waves was shown by Henry in 1842, when the discharges of a Leyden jar in the top floor of his house induced sparks in a circuit in the cellar. Sonorous vibrations were reproduced in a telephone circuit in the basement of the G.P.O. in 1886 by the induction of a primary circuit excited by the voice in the upper corridor, 80ft. away. Speech was found possible between insulated coils of wire a quarter of a mile apart. Telegrams in 1893 were transmitted across a distance of 3.1 miles on the Bristol Channel. Regular communication was held last winter across Loch Ness, a distance of $1\frac{1}{4}$ miles, and recently at a much greater distance, between Arran and Kintyre, across Kilbrannan Sound. Across Loch Ness speech was maintained.

But this is not all. There is every reason to believe that we have detected distinct disturbances in our telegraphic circuits due to great electrical storms in the sun's photospere 92,000,000 miles away.

The fact that these signals across space are effects of induction, transmitted through the air or the ether as the dielectric, is beyond the region of doubt, for they were produced between isolated and insulated coils, each forming a complete metallic circuit; but the part played by the earth at short distances when the earth was used to complete the circuit was not so clear. Very exhaustive experiments were made on the sands in the Conway estuary in 1893, and again at Frodsham on the estuary of the Dee in 1894. These experiments were conducted for me by Mr. Gavey and Mr. H. R. Kempe. Further experiments were made by Mr. Gavey and Mr. Cooper on opposite sides of Loch Ness, a distances of $1\frac{1}{4}$ miles, and between the Island of Arran and Kintyre, where parallel wires four and five miles apart were available for use.

In the Conway estuary and at Frodsham squares and rectangles were formed of insulated wires, and numerous measurements were made, both with reflecting galvanometers and with telephones, of the effects due to varying currents in the primaries, and at varying distances between these and the secondaries.

At Loch Ness two parallel wires on opposite sides of the Loch were taken. Between Arran and Kintyre (Fig. 1) two parallel lines on opposite sides of the Sound, and four miles apart, were taken; and, in addition, two gutta-percha wires were laid along each coast at a height of 500ft. above the sea level, and five miles apart horizontally.

The general results and the conclusions arrived at may be briefly summed up as follows :—

The earth acts simply as a conductor, and *per se* it is a very poor conductor, deriving its conducting property principally, and often solely, from the moisture it contains. On the other hand, the resistance of the "earth" between the two earth

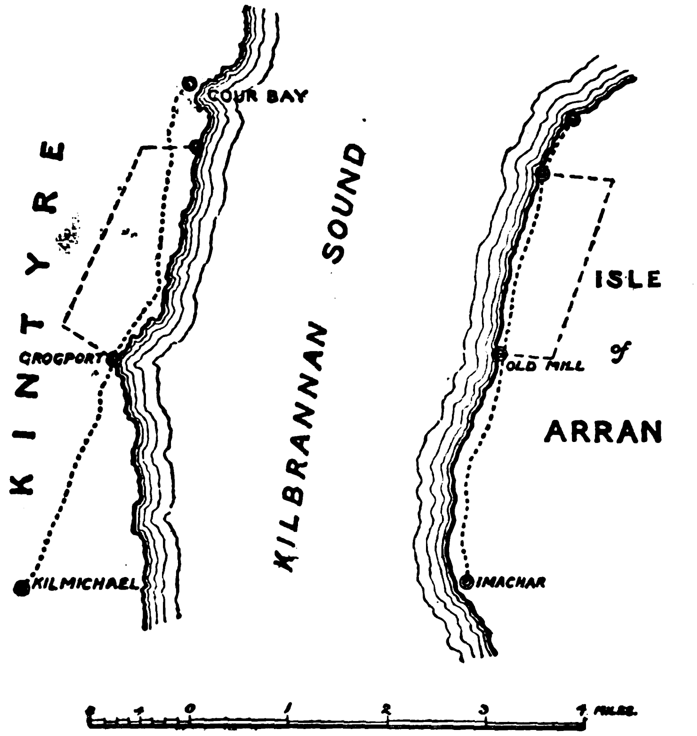

FIG. 1.

plates of a good circuit is practically nothing. Hence it follows that the mass of earth which forms the return portion of a circuit must be very great, for we know by Ohm's law that the resistance of a circuit increases with its specific resistance and length, and diminishes with its sectional area. Now, if the material forming the "earth" portion of the circuit were, like the sea, homogeneous, the current-flow between the earth plates would follow innumerable but definite stream lines, which, if traced and plotted out, would form a hemispheroid. These lines of current have been traced and measured. A horizontal plan on the surface of the earth is of the form illustrated in Fig. 2, while a vertical section through the earth is of the form shown in Fig. 3.

With earth plates 1,200 yards apart these currents have been found on the surface at a distance of half a mile behind each plate; and, in a line joining the two transversely, they are evident at a similar distance at right angles to this line.

Now this hemispheroidal mass could be replaced electrically by a resultant conductor (R, Fig. 3) of a definite form and position; and, in considering the inductive action between two circuits having earth returns, it is necessary to estimate the position of this imaginary conductor. This was the object of the experiments at Frodsham.

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If the material of the earth be variable and dry the hemispheroid must become very much deformed and the section very irregular, the lines of current-flow must spread out further, but the principle is the same, and there must be a resultant return. The general result of the experiments at Frodsham indicate that the depth of the resultant earth was 300ft., while those at Conway are comparable with a depth of 350ft.* In the case of Frodsham the primary coil had a length of 300ft., while at Conway the length was 1,320ft., At Loch Ness and between Arran and Kintyre, where the parallel lines varied from two to four miles, the calculated depth was found to be about 900ft. The depth of this resultant must, therefore, increase with the distance separating the earth plates, and this renders it possible to communicate by induction from parallel wires over much longer distances than would otherwise be possible.

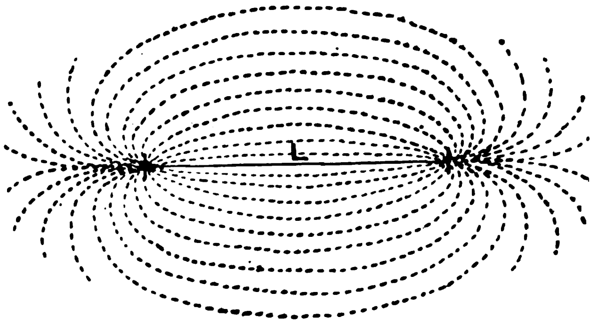

FIG. 2.

The first and obvious mode of communicating across space is by means of coils of wire opposed to each other in the way familiar to us through the researches of Henry and Faraday. All my illustrations of the principles involved in effecting this object have consisted in opposing two similar coils of wire having many turns, the one coil forming the primary current and the other coil the secondary circuit.

Vibratory or alternating currents of considerable frequency were sent through the primary circuit, and the induced secondary currents were detected by the sound or note they made on a telephone fixed in the secondary circuit.

The distance to which the effective field formed by a coil extends increases with the diameter of the coil more than with the number of turns of wire upon it. A single wire stretched across the surface of the earth, forming part of a circuit completed by the earth, is a single coil, of which the lower part is

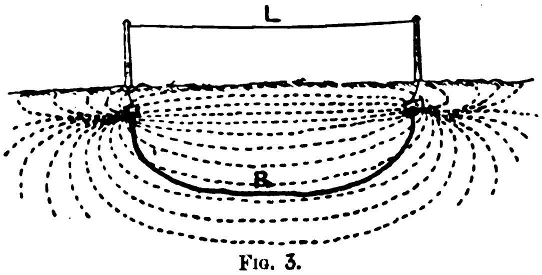

FIG. 3.

formed by the resultant earth return, and the distance to which its influence extends depends upon the height of the wire above the ground, and the depth of this resultant earth.

In establishing communication by means of induction there are three dispositions of circuit available, viz., (*a*) single parallel wires to earth at each extremity; (*b*) parallel coils of one or more turns; (*c*) coils of one or more turns placed horizontally and in the same plane.

The best practical results are obtained with the first arrangement, more especially if the conformation of the earth admits of the wires being carried to a considerable height above the sea, whilst the earth plates are at the sea level. By adopting this course the size of the coil is practically enlarged, and even if it be necessary to increase the distance between the parallel wires to effect this object the result is still more beneficial. In a single wire circuit we have the full effect of electrostatic and electro-magnetic induction, as well as the benefit of any earth conduction, but in closed coils we have only the electro-magnetic effects to utilise.

In one experiment two wires of a definite length were first made up into two coils forming metallic circuits, then uncoiled and joined up as straight lines opposed to each other, with the circuit completed by earth. The inductive effects, and the distance between which they were observable, was very many times greater with the latter than with the former arrangement.

Incidentally some extremely interesting effects of electro-magnetic resonance were observed during the experiments in Arran. A metallic circuit was formed partly of the insulated wire 500ft. above the sea level, and partly of an ordinary line wire, the rectangle being two miles long and 500ft. high. Wires on neighbouring poles, at right angles to the shorter side of the rectangle, *although disconnected at both ends*, took up the vibrations, and it was possible to read all that was signalled on a telephone placed midway in the disconnected circuit.

I have not succeeded in determining satisfactorily the general law which regulates the distance to which one can speak, and I scarcely hope to do so. There are so many disturbing elements introduced, geological as well as electrical. In practice we have to deal with two complete circuits of unknown shape and in different planes. We have obtained some remarkably concordant and accurate results in one locality, but we have met with equally discordant results in another locality. I fear we are beyond the reach of the mathematician. In the appendix I have shown the formulæ that gave the most reliable results.

The mechanism of the mode of signalling across space is not difficult to follow. Its analogue is a flash of light seen at a distance. Energy is expended, say, in a lighthouse on some dangerous rock, or in a gun firing some warning signal, or in a bonfire on some mountain top. The energy assumes the luminous form exciting the ether to undulate with a frequency of many millions per second, which, acting upon the retina of the eye, produce the sensation called light. The burning of the oil-lamp of the lighthouse is the primary source of energy; the rapid undulations of the ether propagated in straight lines at a velocity of 186,000 miles per second are the radiations, transmitting this energy in a wave form to the distant ship; the eye is the apparatus which transforms the energy of the light-waves into a form which excites consciousness in the brain.

In our electrical experiments the primary energy is in the current form, the comparatively few alternations per second excite waves in the ether of a few hundreds per second only. But these oscillations of the ether or electric waves are of the same character as those of light, they move with the same velocity, and when they fall on a sympathetic secondary conductor, they excite in that conductor currents of electricity of the same frequency; and if a telephone be inserted in that circuit and applied to the ear, sounds and musical notes are distinctly heard which by preconcerted measures, such as the use of the Morse code, can be utilised for the transmission of messages. Thus messages were sent across the Bristol Channel between Penarth and Flat Holm Island, 3·1 miles away. Speech was maintained in the Highlands across Loch Ness, 1¼ miles broad, and telegrams were transmitted from Kintyre to Arran, across distances of four and five miles, and thus we could readily communicate between England and France, or between outlying islands and the shore, when the conditions admit of the erection of the necessary circuits.

A somewhat fascinating branch of this subject is the possibility of signalling across planetary space. Signalling between one planet and another is merely a question of degree. Magnetic storms and earth currents have some intimate connection with the sun, although Lord Kelvin has questioned the reality of the fact The great storms and sun spots of March 30 and 31, 1894, were accompanied by very marked and peculiar sounds in telephones inserted in our long telegraph circuits (*v.* Appendix II.) The storm of July 20th was not so distinguished Strange, mysterious, weirdlike sounds are frequently heard on long lines of telegraph in the calm stillness of the night, but whether due to terrestrial or to cosmic causes remains to be discovered

* These figures are obtained from the use of the formula $Q = K\left\{\log\left(\frac{D^2}{d^2}+l\right)\right\}$ which is given in Appendix I.

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The sun's photosphere when disturbed by spots may be subject to violent electrical storms and those vast crouds of incandescent hydrogen that flame up with terrible velocity may excite electrical oscillations through etherial space of such a frequency as to influence our terrestrial circuits. We may thus hear on earth the electric storms of the sun. But this is mere speculation, and the evidence before us at present is not sufficient to justify positive deduction. We shall continue to watch and record, and it is hoped that observers in other parts of the world will assist by making use of the telephones and telegraph lines at their disposal.

The practicability of this method of effecting communication is now solved, but the subject possesses great scientific interest from the views it imparts of the mechanical character of electrical waves, of the molecular theory of electricity and of the great distances at which electromagnetic disturbances are perceptible.

Appendix I.

The following are the formulæ on which the foregoing calculations are based :—

Let A B (*a*) (Fig. 4) be an infinitely long wire, and *b* and *c* be two wires forming parallel sides of a rectangular circuit,

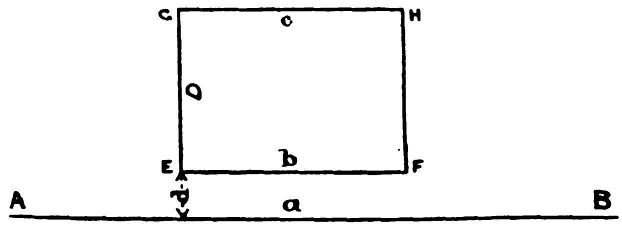

Fig. 4.

E F G H; then, if a current be set up in A B, the lines of force cutting E F and G H will cause a momentary current to be set up in the rectangle, so that

$$Q = K\{\log(D+d) - \log d\} = K \log \frac{D+d}{d},$$

where Q is the quantity induced.

K is a constant depending on the length of the sides G H, E F of the rectangle in centimetres, the current strength in amperes in the wire A B, and the total resistance in ohms of the rectangle.

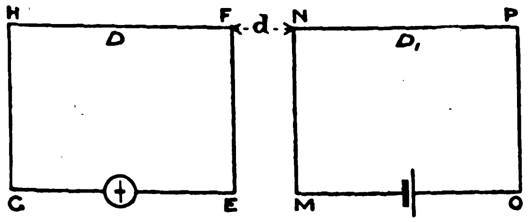

Fig. 5.

Within certain limits this formula is approximately correct, even if the wire A B is not infinitely long, but makes one face of a second rectangle similar in form to the induced rectangle E F G H, and set either in the same plane with, or at right angles to, the first rectangle ; but in such cases the formula has to be corrected to allow for the influence of the second face of the inducing rectangle as follows :—

With two rectangles in the same plane (Fig. 5) the total effect produced by the two faces, M N, O P, of the inducing rectangle is

$$Q_1 = K\left\{\log\frac{D+d}{d} - \log\frac{D_1+d+D}{D_1+d}\right\}.$$

If the two rectangles are at right angles to each other (Fig. 6) and l is large compared with D, then the formula becomes

$$Q_2 = K\left\{\log\frac{D+d}{d} - \tfrac{1}{2}\log\frac{D_1^2+(D+d)^2}{D_1^2+d^2}\right\}.$$

Again, if the two rectangles are parallel and equal (Fig. 7) and l is large compared with D, then

$$Q_3 = K\left\{\log\left(\frac{D^2}{d^2}+l\right)\right\}.$$

These formulæ take into account the effects on the wires in the secondaries which are parallel to the primaries, but not the effects of those at right angles to them. The latter oppose the

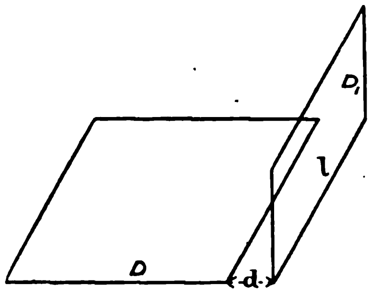

Fig. 6.

main induced current, so that in practice this current diminishes more rapidly with the distance than the log law indicates.

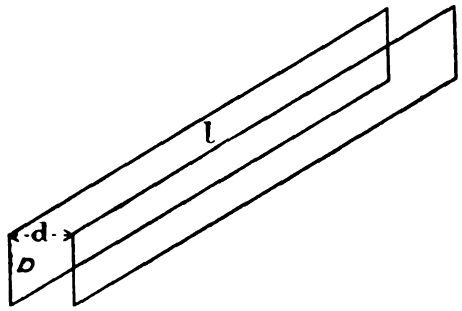

Fig. 7.

The problem is very intricate, but Mr. Kempe, to whom I am indebted for the formulæ, still hopes to obtain a final and accurate solution.

Appendix II.

The following letter appeared in *Nature*, April 12, 1894 :—

Earth Currents.

The Astronomer Royal was kind enough to show me the permanent photographic records of earth currents during the great magnetic storm on February 20th-21st, and they indicated so unmistakably such rapid and violent alternations, that I supplied our principal relay stations with telephones and with instructions to insert them in circuit whenever they observed indications of disturbances. This happened on March 30th-31st, during the display of the Aurora Borealis. Mr. Donnithorne, in Llanfair P.G., Anglesea, reports :—" At 2:0 a.m. (Saturday) the telephone receiver was again tried, and then 'twangs' were heard as if stretched wire had been struck, and a kind of whistling sound. The strength of the earth current was 17·7 milliamperes." Mr. Miles, in Lowestoft, reports :—" Noise on 408 (Liverpool-Hamburg) wire seemed like that heard when a fly-wheel is rapidly revolving," and " sounds in telephone appear like heavy carts rumbling in the distance." Mr. Scaife, in Haverfordwest, reports : " March 31st, 2:5 a.m. Earth currents on all wires ; wires completely stopped. . . . Peculiar and weird sounds distinctly perceived, some highly-pitched, musical notes, others resembling murmur of waves on a distant beach. . . . The musical sounds would very much resemble those emitted by a number of sirens driven at first slowly, then increased until a 'screech' is produced, then again dying away. Duration of each averaged about 20 seconds." These experienced observers, situated at three distant points, and perfectly acquainted with the ordinary inductive disturbances on telephone circuits, simultaneously observed and independently recorded their own impressions of peculiar sounds exerted in telephones by very rapid alternations or pulsations of currents which accompanied, or were consequent on, sun spots, earth currents, and the Aurora Borealis.

W. H. Preece.

G.P.O., April 9th.

A GRAPHICAL TRANSFORMER.*

BY A. P. TROTTER.

This instrument is intended for the expeditious re-plotting of a curve with transformed ordinates without calculation or scaling. It consists of a rectangular frame and a curved template or cam, and is used in conjunction with a straight ruler.

Let the scale of one system of ordinates be set off upwards along the edge of one of the perpendiculars, and the scale of

* Paper read before the British Association at Oxford, Section A.

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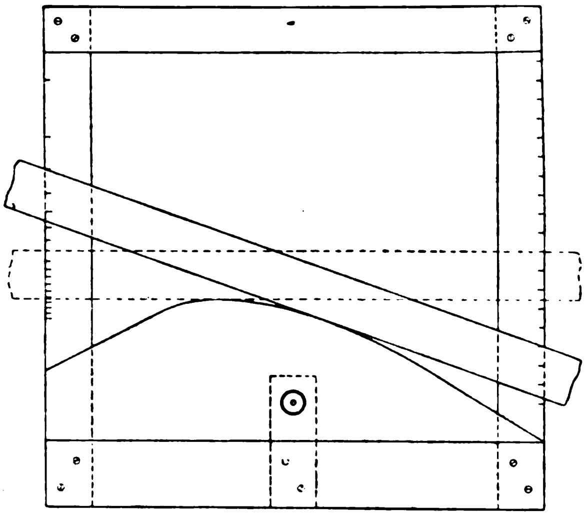
the other along the edge of the other perpendicular, but downwards. Join the corresponding points on the scale by straight lines. The envelope of this system of lines may be thus drawn, and to this curve a cam is cut in thin wood or ebonite.

To transform any ordinate, set the frame against a T square, adjusting the edge to the ordinate, and the zero to the zero of the scale. Set a needle at the extremity of the ordinate; bring a straight edge to touch the needle and the cam; prick off a point at the intersection of the straight edge with the other edge of the frame. This point determines the length of the new ordinate.

The illustration represents an instrument provided with a logarithmic cam. With this instrument the product or quotient of two curves can be found by adding or subtracting the logarithms of the ordinates; or the logarithms of a series of observations can be plotted. Cams for other functions can be easily made; but it must be remembered that the action of the instrument is, as it were, arithmetical rather than geometrical, for a cam is useful only with reference to its own scale.

This instrument not only enables transformations of a definite and known character to be made, but is equally applicable for transforming in an empirical manner. The curve drawn by a



recording voltmeter or ammeter may thus be re-plotted for estimation of area, or other graphical analysis, without any knowledge of the law of the particular instrument. In other words, a correction can be applied to a curve.

The cams are easy to make, and even if carelessly cut, cannot possibly give rise to cumulative errors. It is convenient to use the upper edge of the ruler instead of the edge which rolls on the cam. The curve must in this case be set out with the ruler, and used with the same ruler, or one of the same width. The rolling of a straight edge on a cam has been used in a photometer, invented by Mr. W. H. Preece and the author,* for the automatic calculation of the squares of the displacements of a lamp.

THE FRENCH PRESS AND THE BRITISH SUBMARINE TELEGRAPH COMPANIES.

[Communicated].

The French Press has again started, with the view of raising the national spirit in favour of French submarine cables, an agitation which is looked upon as the forerunner of applications to the Government for subsidies to assist the French telegraph companies in distress. Nothing need have been said about it had not the promoters of that campaign thought proper to attempt to strengthen their case by unfounded statements as regards the action of several English telegraph companies. The *Journal des Débats* took the lead in the matter in publishing a series of articles signed "Harry Allis," purporting to correctly state the present position of submarine telegraph matters in France, which, besides many unjustifiable assertions, contains certain charges against some English companies in their past and present relations with France, obviously put forward with the purpose of prejudicing the French Government and public against them. The following corrections show that these statements have no foundation whatever.

In the first place, it is impossible to accept the opinion that there is no country geographically situated under such favourable conditions to be the centre of telegraphic communications between Europe and America, as France; and it only requires a look at the chart of the Atlantic Ocean, to recognise that France is situated at a much greater distance from the American islands or the American shore, than Ireland or the point of Cornwall, involving, as a consequence, the use of longer and more costly cables, with a lower speed of transmission, as is shown by the respective lengths of 2,717 and 2,281 nautical miles of the existing two cables between Brest and St. Pierre, compared with the 1,847 miles length of the Anglo-American cable just laid between Valentia and Heart's Content. Nor has experience shown that this southern route is more free from accidents and interruptions. If, moreover, due account be taken of the fact that the proportion accruing to France proper in the telegraph traffic between Europe and North America is only 12 per cent. of the whole, whilst Great Britain's proportion is 61 per cent., the statement that one of the Atlantic companies ever intended to land in France their two original cables, is seen to be wholly unsupported by reliable evidence.

The part which relates to French concessions granted to English companies suggests the following observations and refutations: The concessions referred to for the 1883 Senegal cable was given to Count d'Oksza, who sold it for a consideration to an English Company. The same has practically happened as regards the contract of 1885 for the French possessions of Rio Nunez, Grand Bassam, Porto-Novo and Gaboon. At all events, it does not concern in any way the African Direct Telegraph Company, whose cables are only worked under an English contract and land only in British or Portuguese territories. But it is mainly in respect of the two contracts made with the Eastern and Eastern Extension Companies, that the charges proffered in the articles referred to assume an obviously prejudiced character. As regards the concession of 1883 for the Tonquin cable, it is not true that the Eastern Extension Company's cable between Hong Kong and Cochin China was out of order, and that it has since been superseded by the Tonquin cable for the Company's service. That cable, after ten years' service, since then elapsed, is still in good working order, and performing all the Company's service. Moreover, it is absolutely untrue that the cable used for Tonquin was "*en détresse*," and previously made for Japan. The cable was quite new, and expressly constructed in execution of the contract. The Government subsidy to the Company amounts to £10,600 per annum; but the proceeds of the local traffic between Cochin China and Tonquin belongs to the French Administration, which fact the writer judged proper to pass over in silence, and that traffic has now so much increased that it entirely fills up the capacity of the cable, which has thereby become of hardly any use for the Company.

Respecting the Obock cable, a similar denial must be unconditionally given to the statement that the cable was an old one which the Company had for several years carried about in their repairing ships. It was a new cable expressly manufactured in execution of the contract, which fact can be clearly established by documents of undoubted authenticity. It is not in this way that the Eastern and its associated Companies could build up the world-wide reputation which they undoubtedly possess.

As regards subsidies, there is no common sense in the mode of calculating them by summing up the yearly amounts for the whole duration of the contracts, without taking into account maintenance and repairing expenses, nor the fair proportion chargeable in respect of each cable to the expenses of the respective repairing ships, which are kept in readiness to re-establish the communication whenever interrupted.

The yearly annual cost of maintaining submarine lines depends not only on the length of a cable, but also on the risk of interruption and facilities of repairs; it will, therefore, be easily

* *Proc.* Inst. Civ. Eng., Vol. CX., p. 81.

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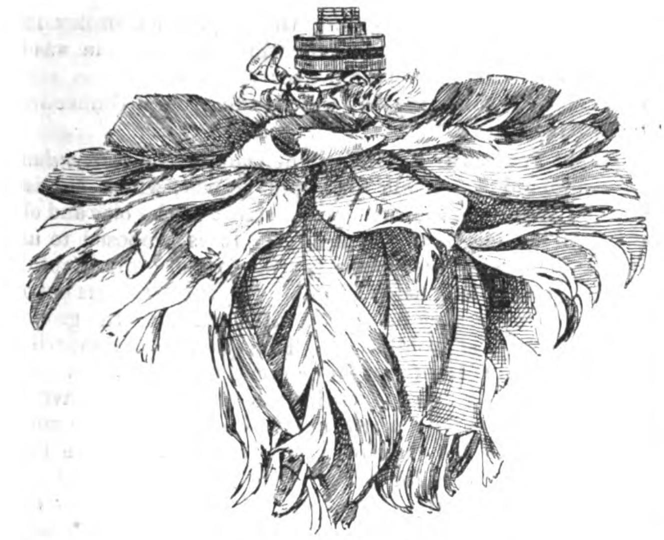
understood, for instance, that in the case of a short cable like that to Obock, laid across the Straits of Bab-el-Mandeb, where accidents to cables and interruptions are of almost daily occurrence and where expeditions for repairs are so costly, the subsidy of 37,500fr. is not out of proportion to the length and position of the cable.

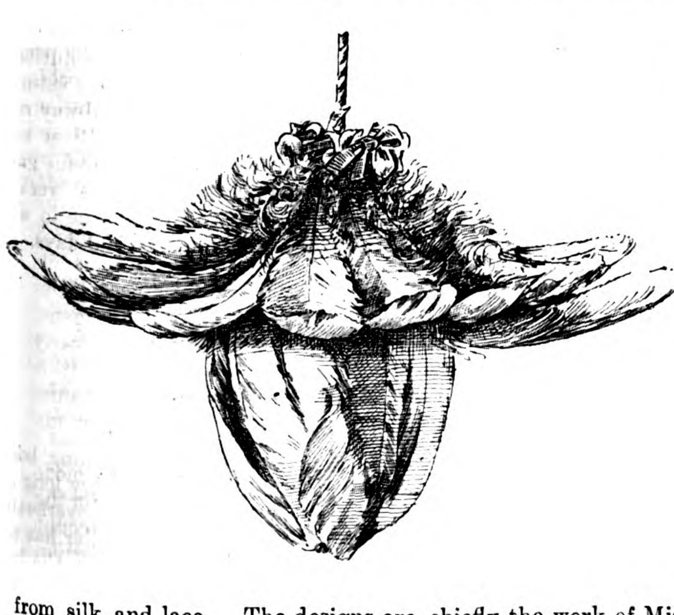
As a conclusion, it may safely be asserted that both Companies have every reason to believe that the French Government is quite satisfied with the terms of the above contracts and the way they are carried out. Also that there is good reason to assume that, owing to the increased cost of submarine telegraph lines, neither could now be contracted for on as good or better terms.

NOVEL LAMP SHADES.

Some pretty feather lamp and candle shades, for use with the electric light, are being introduced. The shades are composed of a specially-selected description of natural feathers



dried in various shades of colour, and arranged in artistic shapes and combinations, both of colour and design. The effect made by these shades is quite different to that obtained



from silk and lace. The designs are chiefly the work of Miss Beatrice Devonport, who has done the work for the Plume Company, for whom Messrs. Chas. Ingle and Co., of High Holborn, London, W.C. are the wholesale agents for the United Kingdom.

SHALL WE COME TO THE DOUBLE TROLLEY AT LAST?*

BY NELSON W. PERRY.

Much has been said and written of the damage done to underground conduits by electrolytic corrosion, and many have been the remedies proposed. Without doubt the most important Paper on this subject thus far has been that by Mr. I. H. Farnham, read before the American Institute of Electrical Engineers.† Certainly the damage that has been done by this agency has been far more extensive than appears at present, for in most cases it has only been discovered when it has become so extensive as to require the digging up of the pipes where they have been almost totally corroded through. It was years before this corrosion was discovered at all, and it may yet be years before its full extent will be realised in the almost total destruction of our water and gas mains. No one, I take it, will assume that this insidious enemy has confined its operations to the localities where its work has been discovered, nor will anyone probably believe that its mere discovery has stopped its work. It is certainly going on now, for instance, all over Brooklyn, though its action has been so slow or the time so short that little damage has as yet been disclosed.

The remedies that have been suggested from time to time, though they seemed to have worked well in some cases, have signally failed in others, and even when a success has been claimed it has not infrequently happened that the claimant was mistaken and that a failure was recorded instead of a success. Mr. Farnham, in his very exhaustive and carefully prepared Paper, for instance, claimed that the method adopted in Boston, that mare's nest of experiments, the evil had been practically remedied, and he was certainly honest in his claims, and his reasoning appealed to his audience as logical. The writer, however, has had a long interview with a former employé of high rank, of the West End road, who views the situation through entirely different spectacles. This gentleman was certainly qualified to speak, as he was one of those connected with the attempt of his Company to control the earth currents from its lines. His statement was to the effect that whatever remedy was tried seemed merely temporary and local, the effect being to drive the demon elsewhere. He estimated that the West End road had probably put quite as much copper underground as it had overhead, and still the trouble continued. Of course, if the electrolytic action were practically stopped at one point and removed to another or distributed over a greater area, it might take years to make itself manifest in those new areas; but the conclusion he comes to is that at best the trouble is only mitigated.

Now here is the testimony of two reputable men who contradict each other. That does not imply dishonesty on the part of either, for we well know that two reputable witnesses of the same event often contradict each other on material points.

Much faith is pinned to the welded rail as a panacea for the evil of electrolysis, but it has not been proved that the welded rail is practicable. There are strong hopes that it will prove so, but in the only extensive experiments thus far tried, viz., those in Johnstown and Boston, the rails have failed to withstand the contractions due to the rigours of winter. In both cases the rails stretched and stretched until they could stretch no longer, and then they broke. In Boston the breaks numbered about 6 per cent. of the welds. That is to say, that when winter had come on there were about 10½ breaks to the mile—absolute breaks which were worse than a faulty bond. Other experiments are now under way on a very large scale, but both of these have yet to stand the winter, and if they withstand the stretching of 4ft. or 5ft. to the mile, which would be due to the average decrease of temperature, they will still have to withstand the following summer heat, which may mean buckling and warping to such an extent as to require the relaying of the track. The question of whether or not the continuous rail is practicable cannot be definitely settled until more than a year from this date; but supposing, as I sincerely hope, it will pass both ordeals safely, the trouble from electrolysis is still not settled. Its evils would, doubtless, be mitigated, but not eradicated. We are too apt to think, and the statement has frequently been carelessly made, that electricity will follow the easiest path. This is not true. It will divide itself up among *all* the paths to which it has access in proportion to the conductivity of those paths.

A 70lb. rail has about the same conductivity as a copper conductor of 1,000,000 cir. mils (0·8 sq. in.), and the two rails will be the equivalent of 2,000,000 cir. mils, probably a far greater carrying capacity than the combined feeders to the trolley wire. They could, therefore, easily carry far more current than the feeders, and would at first sight seem to be ample for the return, and so they would be if they were insulated, but they are not and cannot be. Supposing we should lay alongside of these another

*From the *Street Railway Gazette.*

†See *The Electrician*, May 4, p. 16, and June 1, p. 134.

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conductor of equal capacity, the rails would part with half their current, and this would still be true if the conductivity of the rail were tenfold what it was, providing that the parallel conductor were increased tenfold also. Now the gas and water mains, especially the latter, have a much greater conductivity usually than even the heaviest rails that are laid, and the resistance of the earth between two parallel conductors continuing parallel for such distances as the track and pipes often do, becomes almost negligible, so that the two must necessarily divide the current between them, and, notwithstanding every precaution of bonding or welding of the rails, the pipes may still carry even the greater portion of the current.

This course of reasoning—and it is correct electrically—would seem to indicate that all attempts to prevent electrolysis while the rail is used as a return must be abortive. The only alternative left seems to be to keep the current away from the rails entirely—to use the double trolley. There is a popular prejudice against the double trolley which it does not wholly deserve, for, in fact, in many respects it is superior to the single trolley, and it certainly does not cost any more than the latter when the earth return is properly provided for. The double trolley is scarcely known outside of Cincinnati—in fact, I do not know of a single instance of a road thus equipped in any other city, but there it reigns almost supreme. With something like 200 miles of road electrically equipped there is but one road, consisting of about four miles of double track, that uses the single-trolley system. Probably part of the prejudice against the double trolley originated in the early experience in Cincinnati. In the first place, the manufacturers discouraged it, knowing that it would be more difficult to get consents of property holders to the stringing of two wires over a track than one. In this they were right, and they feared to let it get a foothold, lest in its being insisted upon in subsequent franchises their own business would be injured. It cost about one-third more than the single trolley as roads were constructed then. They wanted to make about 200 per cent. profit on their equipments, and if they put up the double trolley the cost would be prohibitive if they still insisted upon the usual profit. So for this and other reasons no electrical company could be found, except the Daft, which was then on its last legs, that would erect a double-trolley equipment at any price. They would sell the apparatus, however, and let the railroad company put it up as it chose. The Cincinnati Street Railway Company being closely allied, through its stock holders, with the local telephone company, decided upon the double trolley as a protection to the telephone service. They therefore bought apparatus from the Thomson-Houston Company, and erected it themselves on about 3½ miles of their road. Having started with the double trolley, all extensions were of necessity constructed in the same way, and so with the connecting lines crossing the river to Covington and Newport.

The first double trolley consisted of a single mast arm forked at the top, having a trolley wheel on the end of each fork. The wires were stretched 18in. apart, and this trolley worked particularly badly going around curves, on account of the radii of the curves that had to be described by the two wheels. In fact it worked badly everywhere, and gave the double trolley a black eye at once. Two distinct masts, each similar to those now used on the single-trolley roads, were substituted, and with this change and some change in the overhead structure, the system worked well, and works well to-day.

During a lawsuit brought by the telephone company against the single-trolley road to compel it to cease interfering with its service, the single-trolley road attempted to prove that it could not operate with the double trolley. The double-trolley road was called in to prove that it was really the better system. Among other questions that arose was the relative expense of operating by the single and double trolleys, and both companies were obliged to bring their books into court. A comparison showed that the double trolley was operated at less expense than the single trolley, the reason being, as we know now, that the former had at all times as good a return circuit as the outgoing, while with the single trolley the ground return was a very uncertain quantity.

The greatest objection to the double trolley lies in the complications in the switches and cross-overs. This trouble is both mechanical and electrical. When two roads cross each other there is difficulty in insulating the positive from the negative, since in this system they must necessarily cross each other, whereas in the single trolley the two crossing wires are both positive and presumably at the same potential. In the double trolley, too, at a crossing there are *four* intersections, whereas in the single trolley there is but one. It is also evidently more difficult to insulate the positive and negative sides of the circuit when they are but 12 or 13 inches apart, as in the double trolley, than when they are so far separated, as in the single trolley; but, as an offset to this, the cars on the double trolley are entirely independent of the condition of the track, since it forms no part of the circuit. As a result of all this the double trolley in suburban districts where it does not intersect other wires has proved itself superior to the single trolley, but in centres where many lines cross and radiate it is at a great disadvantage, both on account of the mechanical and of the electrical difficulties attendant upon the many intersections. These difficulties are not insuperable, however, as in Cincinnati there is one centre—the intersection of two streets—Fifth and Broadway, where two lines run east and west, two run north and south, and there are four curves connecting these four lines together, and on Fountain-square the situation is still more complicated, yet these are the busiest car centres in the city. The complication of wires—trolley wires, span wires and pull-off wires—at these points is most unsightly and greatly to be deplored. A perfect stream of cars, however, is continually passing these points, and doing it apparently without trouble. But the water and gas mains are safe, and I believe this is the only way to make them so. There may be other partial remedies which will postpone the day of reckoning, but this seems to be the only radical cure.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *August* 6, 1894.

Strikers and Trolley Lines.—The Electric Street Railway in Youngstown, O., for some time has been having trouble with strikers, which resulted in the road being tied up several times, the last expedient adopted by the strikers to this end being a novel one. During the night the trolley line was grounded, and the manner in which it was done was so skilfully concealed that traffic over the system was suspended until late the following day before the ground connection could be discovered.

Rapid Transit in Boston.—The people, by a *referendum* vote, have adopted a scheme for rapid transit, which consists of a subway under the most congested street of the city and elevated railways leading from the termini. It is proposed to use electricity for the motive power in the former; but Capt. Meigs, whose system has been adopted for the latter, is opposed to the use of electricity on the elevated roads on the ground that its cost would be prohibitive. The question submitted to the people was the Meigs system or none, though it has never yet been practically tried. Owing to the great disfavour with which underground electric systems are viewed by politicians on account of the lack of spoils, the people were given no opportunity to vote for it.

Chicago Exhibition Wire Tests.—The results of tests by four professors on commercial electric insulated wires have been published, only three of ten wires tested receiving favourable reports. The tests were of three kinds—a breakdown test, with an alternating current of high pressure, and two soaking tests, in one of which a current of 6,000 volts pressure was sent through the wire until the insulation broke down. Chicago hydrant water and four solutions were used in the two latter, two of which were 10 per cent. solutions of sulphuric acid and ammonia respectively, another a saturated lime-water solution, and the fifth a solution of subway refuse or scrapings from Chicago subways and Chicago River water. The samples of wire, equivalent to No. 16 Birmingham gauge, with $\frac{3}{32}$in. insulation, were tested at least once a week for resistance. In the simple soaking test the least time in which the insulation showed serious deterioration was 100 days.

CORRESPONDENCE.

THE MAXIM BOILER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Some years ago I made a very rapid steaming boiler, exceedingly light and effective. The tubes were very long and thin, and in order to prevent them from becoming overheated, I employed a forced circulation of water. This boiler has now been in use for some years, and there never has been the least thing happen to it. The boiler without any casing, burner or smoke stack weighs about 800lb., and on many occasions it has been made to develop more than 350 H.P. It is still intact.

A scientific gentleman—Mr. Pilcher—in speaking of the remarkable performance of this boiler before the meeting of

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the Naval Architects, described the means which I employed for preventing the tubes from overheating by a forced circulation, and he said that *without* this forced circulation it was found that the tubes would overheat. As a matter of fact someone who has since made a similar boiler without the forced circulation did find that the tubes became overheated, and were ruined.

In the last number of *The Electrician*, however, you make Mr. Pilcher say exactly the reverse of what he really did say. Is this fair?—Yours, &c., HIRAM S. MAXIM.

August 9, 1894.

[The discussion was reprinted on p. 396 of our issue of August 3rd as it was reported. We regret that the report should have been inaccurate.—ED. *E.*].

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have just seen your issue of August 3rd, and your account of the discussion which took place on Mr. Thornycroft's Paper read before the Institute of Naval Architects. You have reported me to have said precisely what I did not say. I said that Mr. Maxim, by using a forced circulation in his boiler, obtained by the feed-water squirting down the downtake leg with considerable force, through a specially-constructed valve, had succeeded in being able to force his boiler to an extraordinary extent without overheating the tubes; but that he was of opinion that he would not be able to force the boiler nearly so hard without this forced circulation.

I shall be much obliged if you will publish this letter.—Yours, &c., PERCY S. PILCHER.

August 11, 1894.

FLY-WHEEL ACCUMULATORS FOR ELECTRIC TRACTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As the question of employing high-speed flywheels as accumulators of energy for electric traction has been raised in your columns by Mr. Archibald Sharp, perhaps I may be allowed to point out that in Vol. CXII. of the *Proceedings* of the Institution of Civil Engineers for June, 1893, in the correspondence on Dr. E. Hopkinson's Paper on the South London Railway, I called attention to this very point, and suggested the advantage of employing for traction purposes engines of the steam turbine type, running, say, at about 4,000 revolutions per minute, fitted with solid cylinder fly-wheels, say 3ft. diameter and 3ft. wide, and weighing about six tons.

A single fly-wheel of this description would store sufficient energy to maintain 66 H.P. for two minutes with a 5 per cent. variation in speed, and, of course, a proportionally greater horse-power when the periods of variation between the maximum and minimum loads were less than two minutes, or, again, where a larger variation in speed than 5 per cent. was permissible.

A 3ft. wheel, running at 4,000 revolutions per minute, would have a peripheral speed of about 666ft. per second, but if of solid steel, would, I believe, be quite safe, as I understand that considerably higher speeds are actually used with the similar fly-wheels employed for propelling the Howell torpedo. In any case, absolute safety could be obtained by employing several wheels of smaller diameter arranged all upon the same axis.

No properly-designed hydraulic power system is nowadays constructed without its accumulator, and, the conditions as to rapidly-varying load with very short periods of maximum demand being analogous, it seems that plants for electric traction, as also perhaps those for electric welding, should be similarly equipped. For these, high-speed fly-wheels on the engines or dynamos seem to be the most convenient arrangement for this purpose.—Yours, &c., A. A. C. SWINTON.

66, Victoria-street, S.W., August 11, 1894.

BOOKS RECEIVED.

"Chats on Invention." By John Martin. Price 1s. (London: Offices of *Invention*.) 1894.

"Construction des Lignes Électriques Aériennes." By A. Boussac. (Paris: Gauthier-Villars et Fils.) 1894.

LEGAL INTELLIGENCE.

Edison-Bell Phonograph Corporation (Limited) v. Smith and Mansfield.

In the Chancery Division, Mr. Moulton, Q.C., applied on behalf of the plaintiff Company for an injunction to restrain the defendants from infringing the plaintiffs' rights in a phonograph patent. His clients wanted some protection. This was a serious matter, and there were altogether about thirty actions. His clients had issued writs, because they believed they had established their patent, and if they did not take this course it might be a point of objection. It was even now pressed upon them that they did not deserve an interim injunction because they knew of the infringement, and did not bring the action sooner. His Lordship said he thought he ought not to make any order beyond this, that this action be consolidated with the other, and both to come on together. The motion would stand over accordingly, the costs to be costs in the action.

Edison-Bell Phonograph Company (Limited) v. M'Kinnon.

In the Court of Session, Edinburgh, Lord Trayner sat to hear an application by the Edison-Bell Phonograph Company (Limited), of London, to have David M'Kinnon, of Kilmarnock, interdicted from infringing letters patent which the complainers hold. The complainers averred that the respondent was at present using and exhibiting machines or apparatus which constituted an infringement of their patent. In reply, the respondent stated that the patent was invalid, in respect that it was not new at the date of the patent, especially in regard to the use of wax and the method of engraving or cutting records. He also averred that the invention which forms the subject of the patent was anticipated as regards all the claims, in respect that it was published by an article in a French periodical called *La Nature*, dated May, 1879, and subsequently by the publication in an issue of *Engineering*, dated April 18, 1879, of an article entitled "A Sixpenny Phonograph"; by the publication in *The English Mechanic*, April 25, 1879, of an article entitled "A Sixpenny Phonograph"; by the British specifications of Edison's patents published in 1878 in the Patent Office Library; by the U.S.A. specification of a patent by Christopher C. Reynolds in 1883, published in the Patent Office Library; and by the U.S.A. specification of another Edison patent published in the British Patent Office in 1879. The respondent also averred that the complainers had frequently applied in an English Court for interdict against the users of phonographs or apparatus similar to those described in the specification, but had failed to obtain such interdict or injunction, these having been uniformly refused, and in actions which were still in dependence the validity of the petition was being seriously disputed. The respondent's agent undertook that an exact account would be kept of all gains and profits derived from the use or exhibition of the machines.

His Lordship refused an interim interdict.

Alabaster v. Harness.

Mr. Justice Hawkins gave judgment on Friday last in this action. Plaintiffs are the proprietors of the *Electrical Review*, and defendant was manager of the Medical Battery Company. Plaintiffs were successful in an action which was brought against them by Dr. Tibbits for libel; but they were unable to recover their costs, and they now sued Mr. Harness, alleging that he was really maintaining Tibbits in his action.

His Lordship, in summing up, said that it was contended for the defendant that such maintenance was not unlawful nor actionable, inasmuch as he had a common interest with Dr. Tibbits in bringing it, or at least that he honestly believed, on reasonable grounds, that he had such interest. Light was thrown upon the circumstances under which maintenance becomes innocent by certain paragraphs in "Hawkins's Pleas of the Crown" dealing with acts of charity, mere neighbourly acts, and cases of "common interest." It could not be seriously suggested that the maintenance of Mr. Harness was due to a neighbourly or charitable spirit. There remained, therefore, the question whether Mr. Harness had, or upon reasonable grounds believed that he had, a common interest with Dr. Tibbits in the result of his action. Many cases were to be found in which persons have been held justified in contributing to the expenses of suits brought or defended by others with the object of defending or enforcing a common right in which all were interested; but there was no case in which a person has been held justified in maintaining a suit in which he was not interested in "the thing in variance," nor any in which such a claim of common interest as this has been even suggested. In this case the article complained of Dr. Tibbits contained also libellous imputations upon Harness and his institute, but these did not form any part of the cause of action, nor was there any issue as to his character or conduct. In the action brought by the Medical Battery Company against Alabaster and others, the defendant Harness had a full opportunity of completely vindicating not only the character of the Company, but his own. That action he abandoned some months before Tibbits's action was tried, preferring to shelter himself under the wing of Tibbits. By acting as he did the defendant saved himself from liability as to the then defendant's costs, and he (the learned Judge) was of opinion that he merely availed himself of Tibbits's action to save himself from the risk of liability for the then defendant's costs; and that his conduct in all these respects was unlawful. The verdict must be entered for the plaintiffs for the amount of the taxed costs of their defence as between party and party.

Stay of execution was granted in view of an appeal, but only on condition that the defendant paid into Court the £500 which was claimed.

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TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

TENDERS INVITED.—The Dundee Gas Commissioners invite tenders for the supply of a steam engine and dynamo machine in connection with their electric supply scheme. Copies of the specification and form of tender can be obtained of Messrs. Urquhart and Small, 17, Victoria-street, Westminster, S.W., to whom tenders must be sent on or before Thursday, the 30th inst. Some further particulars appear in our advertisement columns.

TENDERS ACCEPTED.—The Electric Lighting Committee of the Cheltenham Town Council have received nine tenders for transformers as follows :—

Brush Company	£394	15	0
Crompton and Co.	450	0	0
Electric Construction Company	455	10	0
Johnson and Phillips	468	0	0
Slade, Templeton and Co.	500	0	0
Swinburne and Co.	522	0	0
C. A. Parsons and Co.	606	12	0
Siemens Bros. and Co.	677	0	0
John Fowler and Co.	783	5	0

On the recommendation of the Council's electrician the Brush Company's tender was accepted. The report of the Committee containing these figures was adopted at the last meeting of the Council.

SALES BY AUCTION.—The important sale of plant and machinery by Messrs. Fuller, Horsey, Sons and Cassell, at the works of Messrs. Latimer Clark, Muirhead and Co., Regency-street, Westminster, which was announced to be held on Tuesday, Wednesday, and Thursday, the 4th, 5th, and 6th prox., has been extended to four days, *i.e.*, Tuesday, Wednesday, Thursday, and Friday, the 4th, 5th, 6th, and 7th prox. The sale will commence at 11:30 precisely each day.

APPOINTMENTS.—The Bolton Corporation have appointed as electricians for the new works in Spa-road, Messrs. E. W. Dickinson, of Wigan, and W. J. Pilling, of Bolton, the commencing salary in each case being £110 per annum. Fifteen applications were received.

AGENCY.—Messrs. W. F. Dennis and Co., of 11, Billiter-street, E.C., have been appointed sole agents for the United Kingdom for telephones and other electrical apparatus manufactured by the Antwerp Telephone and Electrical Works.

LIQUIDATIONS.—Creditors of the Gülcher (New) Electric Light and Power Company (Limited) are reminded that particulars of their claims must be forwarded to Mr. C. Fitch Kemp, liquidator, 73, Lombard-street, E.C., by the 24th prox.

BANKRUPTCIES.—A first and final dividend of 3⅞d. in the £ has been declared in the bankruptcy of Arthur H. W. Radcliffe, electrical engineer, of Clare House, Claremont-road, Handsworth.

——— In the case of Newington, Priddle and Co. (Edward Percival Oliver), of 50, Great Sutton-street, E.C., the liabilities are given at £96. 6s. 10d. and the assets nil. The principal creditor is Mr. W. Mackie (£80).

——— M. L. Ross, electrical engineer, formerly of Queen-street, Cheapside, E.C., was examined at an adjourned first meeting of his creditors, held before Mr. Cooper in the City of London Court last week. The debtor failed about twelve years ago, when carrying on business at Boston, U.S.A. He closed the offices at 90, Queen-street, in 1892, having lost about £6,000 in the business. Since then he has been engaged in the development and sale of various patents, and he attributes his failure to delay in the completion of certain contracts. He denies that he is insolvent, but does not estimate the value of his assets in his statement of affairs ; his debts he returns at £1,954. 10s. The meeting was again adjourned to August 29th, at noon, for a scheme of arrangement to be submitted to the creditors and reported upon by the Official Receiver.

——— A. F. St. George, electrician, of Bermondsey and Earlswood, had a receiving order made against him in June last. It appears that the gross debts are £1,033, of which £529 is unsecured, and that there are no assets. In 1883 he petitioned the court for liquidation, and paid 1s. 6d in the £ on debts to the amount of £3,741. He was adjudicated bankrupt in November, 1886, his debts being £4,504, and no dividend was paid. He has not received his discharge under those proceedings. He attributes his failure to the non-success of his patents (which include patents for manufacturing artificial india-rubber) and to his liability for money borrowed to work them.

——— A summary has been issued of the affairs of George Forrest and Son (Limited), incorporated in 1886, with a nominal capital of £50,000, to acquire the business of engineers and brass founders then carried on by George Forrest and Son at New-street-square and Nevill's-court. The liabilities to creditors amount to £14,207, of which £12,311 is expected to rank, and there appear to be no available assets. As regards contributories, a total deficiency of £39,346 is disclosed. The Official Receiver reports that no dividend has ever been paid by the Company.

ELECTRIC LIGHT FITTINGS.—A new catalogue, containing a number of new and most effective designs of electric light fittings, has just been issued by Messrs. Benham and Froud (Limited), of Chandos-street Works, London, W.C. The contents include full particulars of the revised and reduced prices of these fittings, and in addition give a large number of illustrations of both arc and incandescent varieties. The catalogue is especially strong in pedestal and pendant designs, and includes amongst the former several artistic arrangements for music stands. The prices given show in many cases a large reduction on previous charges, and bring many of the popular designs within the reach of all. There is nothing more noticeable in the progress of electric lighting than the endeavours made by firms like Messrs. Benham and Froud to meet the growing demand for cheap, good and artistic electric light fittings. Copies of the catalogue can be obtained by trade buyers post free on application.

CHLORIDE STORAGE CELLS.—On Saturday last the Goring-on-Thames regatta was held, and the new electric launch "Aphrodite" was used by the Thames Conservancy for clearing the course during the day. The boat was built in Mr. Saunders' boat yard at Goring, and measures 35ft. over all by 5ft. 3in. beam, and, although built for comfort and not for speed, satisfactory results have been obtained in the latter respect. The arrangement of the electrical details have been carried out by Mr. H. A. Earle, of Messrs. Mather and Platt's Westminster branch. The novel feature consists in the employment of a battery of chloride cells for the first time on the Thames, and the launch has been specially built to demonstrate the superiority of these cells for this class of work, their large capacity for a given weight enabling distances and speed to be run without recharging previously impossible. The cells with which the "Aphrodite" is fitted are capable of being discharged at a very high rate, and on the measured mile a speed of nine miles per hour has been obtained, and this rate can, it is stated, be continuously maintained for about three hours. At slower speeds, namely, 6½ miles per hour, which is the usual rate of travel, and which is said to be considerably above the average speed of electric launches of this size, a day's run of nine hours can be undertaken, inclusive of the time taken in passing the locks. The battery power with which the launch is provided is capable of covering a distance of approximately 110 miles without recharging. The chloride cells are manufactured by the Chloride Electrical Storage Syndicate (Limited), 16, Victoria-street, S.W.

THOMSON-HOUSTON PATENTS.—The Laing, Wharton and Down Construction Syndicate (Limited) have purchased the patent rights and privileges of the Thomson-Houston system of lighting, traction, and power transmission in the United Kingdom, and will in future manufacture the plant and apparatus in England. The name of the Syndicate has been altered to the "British Thomson-Houston (Limited)," under which style the business of the Corporation will in future be conducted.

INCOME TAX.—In reference to a note in our last issue, it would appear that there are rival organisations for protecting the public against overcharges for income tax by the Inland Revenue Department. We are desired by the Income Tax Repayment Agency to remind income tax payers that there are two important claims which they should make without delay. The first is for repayment, if the profits of the past year have not reached the amount of the assessment, the second is one in respect of any loss incurred during the year. In both cases a refund of the tax can be obtained, and may possibly bring the balance of income-tax within the limit of exemption or abatement.

ABERDARE.—A public meeting has been held to arrange for the electric lighting of the centre of the town. Mr. J. C. Howell, of Llanelly, explained to the meeting the steps that had been taken to obtain the Provisional Order, and this having been secured, the meeting was asked to make such arrangements as were necessary to secure the carrying out of the Order. An influential Committee was appointed to visit Pontypool, and to report to a subsequent meeting. It is probable that a local Company will be formed to carry out the provisions of the Order.

ARUNDEL CASTLE.—The electric lighting of Arundel Castle was commenced last week. Our readers are referred to *The Electrician* of July 27th, page 371, for a full account of the installation.

BALLINA (IRELAND).—The Board of Guardians have unanimously agreed to consent to the Irish Electrical Supply Company introducing the electric light into Ballina and district on the condition that this permission involve the Board in no expense whatever.

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BOMBAY.—The Crawford markets and municipal offices are now lighted by electricity, sanction having been given for an expenditure of 700 rupees per mensem up to the end of the current financial year to defray the cost.

BRECHIN.—A special meeting of the Police Commission is to be held to discuss the applications made by the Scottish House-to-House Electricity Company and the Northern Electric Light Company for the sanction of the Commission to their applications for Provisional Orders to supply electric current to the district. Both companies agree to supply electric current at 6d. per unit.

BRIDGEND.—At the last meeting of the Local Board questions were asked as to what was being done with the subject of electric lighting. The Clerk said that the Board were awaiting a report from the Electric Lighting Committee, the Chairman of which said that several members of the Board objected to the expenditure of £200 in the obtaining of a Provisional Order, but he felt sure that had it not been for this expenditure the ratepayers would have been paying 4s. 6d. per 1,000 for gas at the present time. They had, therefore, made up for any expenditure on the electric lighting Order by the reduction in the price of gas, even assuming it were decided to take no further steps.

BRISTOL.—The sanction of the Local Government Board has been obtained for the borrowing of an additional £24,000 for electric lighting purposes, and the money is to be obtained from the Bank of England and to be repaid in 50 half-yearly instalments at 3¼ per cent. interest on the amount remaining unpaid from time to time.

BROMSGROVE.—A public meeting is to be held to discuss the application of Messrs. Hemming and Co., of Birmingham, for permission to erect machinery and plant in this town for the purpose of supplying electric current throughout the district.

BURY ST. EDMUNDS.—The Local Board have been notified by the Board of Trade that the local Electric Lighting Company had applied for the time required for lodging their deposit to be extended. The Local Board decline to take any responsibility in the matter.

CARDIFF.—The National Telephone Company have in contemplation a considerable extension of their telephone system at Cardiff, and a discussion arose at the last meeting of the Public Works Committee of the Corporation as to the arrangements to be entered into with the Company, with special reference to the placing of the telephone wires underground. Some discussion ensued as to the rent to be charged by the Corporation for this privilege. Mr. Gaine (the Manager of the Company) stated that he could not agree to pay anything approaching the sum of £5 per mile as proposed by the Corporation; the Company were willing to pay a nominal rent, but beyond that would not go. The extensions would cost the Company from £4,000 to £5,000 if overhead wires were used, whereas placing the wires underground would cost £20,000. The Company had to pay £75,000 to the Post Office to compete, and for that performed a great public service. After some discussion it was arranged that an agreement should be drawn up by the Chairman of the Committee, associated with Mr. Johnson, the Town Clerk, and the Borough Engineer, and it is understood that the Committee have decided that a rent of. £1 per mile per pipe of 3in. diameter shall be charged.

CARLISLE.—The Town Council having decided not to follow up their application for a Provisional Order, the Brush Provincial Company has given notice of its intention to apply for an order to supply the city with electric current.

CHARGE OF THEFT.—Harry Henderson Owler, electrician, was charged at the Oxford City Police-court with stealing from his employers, Messrs. Baker, Hall and Co., electrical engineers, of Oxford, a quantity of electrical apparatus, &c. The firm were carrying out an electric lighting installation at Wadham College, from which place it was alleged the prisoner had taken the articles which were the subject of the charge. After evidence had been given, the magistrates said that the prosecutors were justified in bringing the charge against the prisoner, who had, in their opinion, brought the trouble entirely upon himself by the course he had pursued. They, however, decided to dismiss the case.

CHESTER.—The Town Council have referred to the Improvement Committee the question of the desirability of acquiring a portion of the site of the old county gaol for the purposes of an electric lighting station.

CRANBROOK (KENT).—The outlying districts of Cranbrook, Sissinghurst, Biddenden, and Frittenden are now being placed in telephonic communication, the work being carried out under the superintendence of Sergeant Campbell, R.E.

DUNDEE.—Messrs. Lowdon Brothers have just completed an installation of the electric light upon the exterior of the extensive premises occupied by Messrs. Clunas and Harrison. Six 2,000-c.p. arcs are used, the current being taken from the Corporation mains.

ELECTRICAL EXHIBITION.—The Ealing Local Board intend holding an exhibition of electrical appliances in Victoria Hall, Ealing, commencing on the 3rd prox., and continuing open till the 13th. This exhibition is held in connection with the forthcoming opening of the Local Board's electric lighting station, and manufacturers and others desirous of exhibiting can obtain information as to space, &c., on application to Mr. C. Jones, C.E., Public-buildings, Ealing, W.

FACTORY LIGHTING.—The new factory just completed for Messrs. Mardon, Son and Hall, at Temple Gate, Bristol, is being fitted throughout for the electric light by Messrs. F. W. Ball and Co. 500 16-c.p. incandescents will be used, and arrangements made to allow for an additional 120 lights later on. The plant includes an Edison-Hopkinson 350-ampere machine. The consulting engineer for the work is Mr. E. J. Tongue. This installation, when completed, will be the largest in Bristol.——The contract for lighting the new stay factory of Messrs. C. Bayer and Co., at the Oldlands Common, near Britton, has been secured by Messrs. A. McTavish and Co., of Bath. 120 16-c.p. incandescents will be used, and the contract includes the supply of the necessary plant.

FAREHAM.—The Local Board have adopted an amendment modifying the resolution passed in June last for the purchase of the Fareham Electric Light Company's undertaking for a sum not exceeding £5,000. By the amendment a valuation is to be made of the Company's property and undertaking before purchase.

GRANGE (LANCS.).—The Local Board have discussed a report on the electric lighting question presented by the Town Clerk, and have decided that inquiries should be made as to the probable cost of lighting the district before deciding on the advisability of applying for a Provisional Order. The application made by the Windermere Company for the Board's consent to their application for a Provisional Order has been referred to the Electric Lighting Committee for consideration.

HALIFAX.—The recent strike of joiners is estimated to have delayed the work in connection with the Corporation's electric lighting station for about a week; but, notwithstanding this delay, progress has been sufficiently satisfactory to warrant the opinion that the works will be ready for opening early in November. Already orders have been received for about 2,000 out of the 5,000 lights for which plant is being put down, the customers including banks, the principal business houses, and several places of worship.——By a small majority it has been decided not to light the Town Hall by electricity. The proposal involved an expenditure of £500, and, after considerable discussion at the last meeting of the Finance Committee of the Town Council, a negative motion was approved.

HAMPSTEAD.—Power has been granted to the Electric Lighting Committee to engage such staff as may be necessary for working and tending the plant of the central electric supply station. Mr. R. A. Chattock, the recently-appointed chief electrical engineer to the Vestry, commences his duties on September 3rd, and the machinery and mains are to be thoroughly tested before October 1st, the date fixed for turning on the light.

HEREFORD.—The Lighting Committee of the Town Council have reported that they have had encouraging replies to their circular asking for support for the electric lighting scheme, and Mr. Alderman Shelley, in moving the adoption of the Committee's report, said that they had trebled the number of applications on this occasion to those previously received when a similar circular was issued. There was no doubt that the electric light would receive the support of the principal tradesmen and householders in the district.

HOTEL LIGHTING.—Messrs. Rashleigh Phipps and Co. are fitting out Limmer's Hotel, Conduit-street and George-street, W., for the electric light, and have also received a contract for the lighting of the Howard Hotel, Norfolk-street, W.C., the latter installation requiring 450 16-c.p. incandescents.

HUDDERSFIELD.—The Electric Lighting Committee of the City Council have decided to lay an additional main along Victoria-street, and have adopted a system differing somewhat from that originally selected. A sub-committee has been appointed to consider the desirability of reducing the price per unit, and of adopting a graduated scale. They will also consider the question of reducing the meter rents.

ISLINGTON (LONDON, N.).—The Vestry have received from the Board of Trade a communication giving a provisional approval to the system of electric lighting adopted by the Vestry.

LANCASTER.—The trustees of the Palatine Hall have decided to light the building by electricity. Mr. Barnard, the borough electrical engineer, has prepared the necessary specification, which has been adopted by the trustees.

LEICESTER.—The sum of £250 is to be expended in the wiring and fittings for lighting the principal apartments at the Assembly Rooms, the current being taken from the Corporation mains.

MIDDLESBROUGH. In criticising the result of the past year's working of the local gas works, the *Daily Gazette* points out that the good dividends earned are largely owing to the fact that coal is

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very cheap in the district, and that the introduction of the electric light is, therefore to some extent retarded. The journal points out that in the northern districts water power of considerable magnitude is now running to waste, and might be profitably utilised for electric lighting purposes. The initial outlay would be heavy, but the ultimate result would be a great saving in the cost of lighting, both public and private.

Mill Driving.—The London *Daily News* states that the city of Bremen is shortly to be in possession of an ever-revolving "windmill," and that the firm of Schuckert and Co. have been commissioned to build and erect an electric motor in the extensive mill owned by Herr Oscar Wolff, Ausgaruthor, the motor to be so arranged that the mill can be controlled at will, the current to be supplied from the city mains.

Mill Lighting.—Messrs. J. H. Holmes and Co. have secured the contract for lighting the extensive mills of Messrs. Joshua Smith (Limited), at Cornholme, the alterations and extensions to which have cost between £20,000 and £30,000.

Monmouth.—The Town Council are to discuss, at a special meeting this week, the report from Messrs. Bramwell and Harris on the drainage and the electric lighting scheme.

Montrose.—A private meeting of the Electric Light Committee of the Police Commission was held last week to again consider the question of lighting the district by electricity. A lengthy discussion took place, but no definite resolution was come to, the principal point being whether the Scottish House-to-House Company should be allowed to obtain a Provisional Order to proceed with the lighting of the town, or whether the Commissioners should themselves apply for an Order. A special meeting of the Council is to be held on the 10th prox. to finally decide this question. The subject has been before the Commissioners for three years.

Newcastle-on-Tyne.—Messrs. J. H. Holmes and Co. have secured the contract for fitting up the extensive premises of Messrs. Galloway and Co., wholesale confectioners, in Clayton-street, with the electric light.

North Riding (Yorks.).—The Electric Lighting Sub-Committee of the County Council have discussed a proposal from the Caledonian Electric Supply Company for taking over the Provisional Order obtained by the Corporation. It was finally decided that the Borough Surveyor obtain information from towns which have adopted the electric light, and submit the same at the next meeting of the Committee.

Perth.—The Town Council have refused to consent to applications made by the Municipal Electric Light and Power Corporation (Limited) and the Caledonian Electric Supply Company (Limited), under the Electric Lighting Acts.

Pontypool.—It has been decided to light the recently completed market by electricity.

Radcliffe.—The Electric Lighting Committee of the Local Board have resolved to request Mr. Bennett to state upon what terms he is prepared to provide the plans and estimates for an electric lighting station plant and all necessary appliances and accessories, and to give all engineering assistance required, up to and including the obtaining of a Provisional Order to light the district by electricity, and also the terms upon which he is prepared to carry out the works from the obtaining of the Order to the completion.

Stirling.—The Police Commission met to-day (Friday) to make the necessary arrangements for applying for a Provisional Order for lighting the district by electricity. Notice has been given by the Caledonian Company and the Scottish House-to-House Company of their intention to apply for Provisional Orders to light the burgh.

Stowmarket.—An important meeting was held last Wednesday in the Institute Hall to consider the desirability of adopting the electric light at Stowmarket. The meeting was attended by the principal tradesmen of the town and many of the chief private residents. Mr. Napier Prentice gave the meeting some statistics on the subject. Subsequently Mr. Prentice and Mr. C. R. Dewhirst were appointed as a Committee to approach the local gas company with a view of inducing them to supply the town with electricity. In connection with the meeting there was an exhibition of domestic electrical appliances for cooking and heating.

Taunton.—At the meeting of the Town Council, on Tuesday, the electrical engineer, Mr. H. W. Couzens, stated that during the past quarter the improvements and alterations at the electric lighting station, which has been suggested by Dr. Fleming, had been completed and examined and approved by him. The Electric Lighting Committee have insured the electric lighting station machinery and plant for £6,000, at 4s. per cent.

United States Tariff Bill.—The Bill has now finally passed, and iron, coal, and other items of large consumption have been placed upon the free list. The reductions under the new law do not materially affect the electrical industries.

Walthamstow.—The Local Board, having arranged to build a new Fire Brigade station, have decided to fit out the principal thoroughfares in the town with street calls, &c. The work has been entrusted to the Private Wire and Telephone Installation Company, whose standard fire alarms are to be fitted up, and communication is to be established between the new fire station and the firemen's dwellings.

Waverley (New South Wales).—The Town Council a short time back passed a resolution that the police had been provided with portable electric lanterns similar to those in use in New York. It is stated that the suburban police in the district are unprovided with lanterns of any kind.

Wednesbury.—The Gas and Water Committee of the Town Council have had under consideration the electric lighting question, and Mr. Griffiths, in presenting the report of the Committee, said it had come to the conclusion that an electric lighting scheme was "too big an order" to be entertained at present.

Windermere.—The Windermere Electric Light Supply Company have written the Local Board a lengthy document setting out the conditions under which they propose to light the district by electricity. The Company point out that they have an authorised capital of £50,000, and that they are supported by the Brush Electrical Engineering Company of London. It is proposed to use water power, and the Company have obtained this from the rivers Leven and Troutbeck. The new Company has been amalgamated with Messrs. R. H. Fell and Son, and an assurance is given to the Local Board that overhead wire will be entirely dispensed with, and nothing done to detract from the beautiful scenery of the lake district. The Company undertake to supply the whole of the Windermere district with electric current. The Company's scheme is an extensive one, and it is pointed out that it is only by such an arrangement that an area so thinly populated can be worked economically. The Company propose to supply accumulators for the launches on the lake, and to make a feature of supplying current for domestic purposes. The Company's application is to be further discussed at the next meeting of the Board.

York.—The extensive premises of Messrs. Cotts and Falconer, of this city, are being installed throughout with the electric light by Mr. Edward B. Pym, of Scarborough. The plant includes a 9-kilowatt machine and Otto gas engine.

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by Mr. J. C. Chapman, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

August 4, 1894.

14,987. W. L. Wise. London. Improvements in or relating to the separation of caustic alkalies from the liquors obtained by the electrolysis of alkaline salts (Solvay and Co., Belgium).

14,988. W. L. Wise. London. An electrolytic table (E. Solvay, Belgium).

15,000. H. Soifrank. London. An improved wind motor for driving electric machinery, and other purposes.

15,004. G. Ritter. London. Improvements in telephonic installation.

August 7, 1894.

15,034. W. Thomson (Baron Kelvin). Glasgow. Improvements in instruments for measuring electric currents.

15,051. R. Middlemass. Scarborough. An improved grip to be employed in laying electric cables.

15,065. E. Tyer. London. Apparatus for making electrical contact by passage of a railway train.

15,070. W. J. Brewer. London. Improvements in overhead conductors for electric railways and tramways.

15,082. E. Tilmann and C. K. Lenow. London. Improvements in magneto-electric machines for cycles or other vehicles and driving gear for the same.*

August 8, 1894.

15,129. A. Malignani. Manchester. An improved process for evacuating incandescent lamp bulbs.

15,170. J. J. Rathbone and A. Chester. London. Improvements connected with arc lamps.

August 9, 1894.

15,219. E. Müller. Liverpool. Improvements in the method of and means for preventing undue reciprocal influences between telephonic lines, or between telephonic and telegraphic or other electrical lines.*

SPECIFICATIONS PUBLISHED.

Note.—All Specifications can now be obtained at the uniform price of 8d. each.

1893.

14,130. Hargreaves and Bird. Electrolysis of iodides, bromides, &c.

14,131. Hargreaves and Bird. Electrolysis of chlorides, iodides, &c.

15,485. Mann and Hopwood. Glow lamps and holders.

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17,197. Crompton and Brunton. Dynamo-electric machinery.
17,341. Kapp. Alternate-current dynamos.
17,348. Bowden and Boby. Electrical transformer street-surface boxes.
17,645. Grenfell and March. Distribution and regulation of electric current.
10,866. Schöffer, L. W. and G. E. W. Electric accumulators.
17,972. Mills. Electric bells, fire and burglar alarms, &c.

1894.

433. Elieson. Electric switch.
5,572. Fearnley. Elastic ear-cushion for telephone receivers.
8,218. Jones and Collier. Electric signalling.
8,585. Conner. Electric conductors.
10,199. Naughton. Electrotyping.
10,386. Fritz. Clocks for operating electrical alarms.
10,851. Lake (Beattie). Electric railway signals.
11,100. Denison. Electric dental motor-apparatus.
11,861. Lake (Miles). Electric belts.

COMPANIES' MEETINGS AND REPORTS.

Crompton and Co. (Limited).

The sixth annual general meeting of this Company was held on Monday at Cannon-street Hotel, Viscount Emlyn (Chairman) presiding.

The SECRETARY (Mr. Francis R. Reeves) read the notice calling the meeting.

The CHAIRMAN: Gentlemen, as you will have noticed, the statement of accounts show a slight reduction of gross profits as compared with the statement laid before the shareholders at the meeting in July last year. But there are, notwithstanding this, several matters on which, I think, we may fairly congratulate the shareholders. First of all, the amount of business done exceeds the turnover of the previous year by just £22,000. And, secondly, by careful economy, and watchfulness over items of expense, we have been able to reduce the item in the Profit and Loss Account, which is headed, "Trading and Office Expenses, Salaries, &c," by a sum of £3,000. The accounts before the meeting, I should say, show a diminution of £4,000; but the difference is occasioned by the fact that the Directors, this year, have taken the interest on bankers' loans from the Profit and Loss Account, and placed it in the Revenue Account, which is, in our opinion, the more correct way of dividing the expenses. Although the accounts then show a difference of £4,000 the net result is practically a saving of £3,000 in the expenses of the year. The Directors have under consideration further economies, which they are proposing to effect and have begun to effect, by re-arranging some of the departments of the Company. It is hoped that by these economies we shall show a still further satisfactory reduction in the expenses, next year, under this head. It will be observed that the item of "Depreciation of Plant and Machinery," has increased by £900. This is partly accounted for by the previous year's increase in the respective items dealt with in the Depreciation Account, but it is also due to the desire of the Directors to err rather on the side of over-caution in dealing with the Company's accounts, than to submit a statement to the shareholders of too favourable a character. You will see, by continuing the examination of the figures in the published statement of accounts, that there is an apparent further increase in the item of Subsidiary and other Companies. This increase is due, mainly, to the fact that an additional item in respect of the Chelmsford Electric Lighting Co., has been transferred from trade debtors to Investment Account, and also to the fact that the Company has had to take a considerable amount in debentures of the Australian Company, instead of cash, in part payment of the debt owing by that company to us. This need not be regarded as an investment absolutely. Practically it is, but it is only the result of an arrangement which has been made to take over these debentures until the Australian Company is in a position to pay us cash. It is not, in any way, a permanent investment, although it appears, for the present, as an addition to the amount we hold in subsidiary and other Companies. Both these items have been transferred from the trade debtors to investments; but, notwithstanding these transfers, the item of trade debtors shows a slight increase over the amount of the previous year. The stock-in-trade shows an apparent decrease on last year; but this is in consequence of separating the item "work in progress" on contracts, from "stock in trade." Practically there is hardly any alteration in the amount of stock carried. We have only divided them, as we thought by doing so we should make them clearer. There is another matter which you will expect me to say something upon, and that is with respect to the depreciation and the proposed writing off of assets. In reply to some questions addressed to me at our meeting in January last, I explained that no contracts whatever had been accepted by the Directors for several years—between three and four years—under which the Company was bound to take payments in shares and securities, instead of receiving cash for work done. During the past year, unfortunately, some of the securities taken in former years as part payment have, in our opinion, depreciated, and on looking carefully into them we felt they should not stand in our books at the amount credited to them. The Directors, therefore, applied to Mr. Crompton and Mr. Albright, the Managing Directors, and placed before them the desirability of reducing the amount at which the securities stood. They met us in the fairest manner, and undertook to surrender whatever Ordinary shares were necessary to clear any doubtful securities from the Company's books. Taking advantage of this offer, we have carefully examined the whole of our assets, and have endeavoured to wipe off our books any that appeared at all doubtful, and if we have erred I feel sure it has been on the side of writing down the account very severely, for the amount we propose to write them down by is no less than £20,000. I should explain, —although perhaps it is not necessary to the meeting, but for the benefit of those outside—that this is merely, so far as the assets are concerned, a bookkeeping transaction. The assets are still available for what they are worth as previously; and if they should eventually improve in value, the improvement, whatever it is, will be to the advantage of the shareholders generally. At the conclusion of our business it is proposed that we should make the meeting special for the purpose of passing a special resolution which will enable us to carry out this agreement. It will be necessary to hold a further meeting to confirm the resolution, and then an application will be made to the Court of Chancery to sanction the cancelling of the capital in question. Not only the shareholders, but the Directors also, owe a debt of gratitude to the Managing Directors, for the way in which they have assisted the Company in dealing with this matter in the manner I have described. Since our last meeting the Manager of the Company's works at Chelmsford has resigned, owing to his having accepted another engagement. The Directors have placed Mr. Brunton in the position of Manager, and they have every confidence that under him the works will be carried on well. The result of the past few months have fully justified the view we took of Mr. Brunton's ability. I hope Mr. Crompton will say a word about this matter, as he is specially interested in the works at Chelmsford. Last year mention was made of the prospects of the Australian Company, and I then said that there were signs that the business in Australia was likely to improve. I am glad to be able to tell you that the result has justified that statement. The orders from the Australian Company at present on the books amount to a very considerable sum; and we learn from the latest mail from Sydney—last week's mail—that the contracts in hand, which were practically secured at that date, amounted to about £40,000. That will give you some idea of the development of the Australian Company. Now, in a great deal of the work we do we have to compete closely with many other companies; but there are one or two departments in which we have specialities, and these, we hope, will bring us a large amount of business. I think I referred the last time I addressed you to the arc lamp department. I am glad to say that is going on well, and I hope we have in that a valuable property. The other department comprises the cooking and other domestic appliances. That, too, is going on very well, and bids fair to prove of considerable value. We hope it may develop with some rapidity. The City of London Electric Lighting Company have opened a show-room in Queen-street, Cheapside, where they are exhibiting some of our cooking stoves and other appliances. As these inventions become better known, and the cost of manufacturing them is reduced, owing to increased demand, we shall be able to sell them at a cheaper price, and we then anticipate that a large business will be done in this department. The Vestry of St. Pancras have issued a number of circulars recommending the electric stoves and cooking appliances of our Company. That is a good example, and we hope it will be followed by others. At any rate it is a testimony to their value, and shows how much these things are appreciated by those who understand them. Well, gentlemen, of course I should have liked to have told you that we were going to pay the full Preference dividend. The net profits would have allowed of the payment of a larger dividend than we recommend, and we could have had recourse to the reserve fund, and in addition to that there is the balance we propose to carry forward, which could have been applied to the payment of a dividend. After careful inquiry, however, we thought that the best interests of the shareholders would be consulted by paying a moderate dividend now. We deem it advisable to increase the amount set aside for contingencies to £1,000, and the balance of net profits to be carried forward to next year's account, after paying the dividend, will be slightly over £1,000. And this, I may point out, will be available for dividend next year. At our meeting in January last it was explained to the shareholders why the Directors had not declared an interim dividends, the reason being that although the Company had earned a moderate profit the indebtedness to the Company's bankers had become such a large item that it was felt inadvisable to declare a dividend at that time, or until the proposed new issue of debentures, with respect to which we held that meeting had been placed. The Directors are still in the face of the same difficulty, inasmuch as the response of the shareholders and debenture-holders to the Directors' invitation to take up the new debentures has only been met to the extent of £32,000. The Directors feel that they cannot urge too strongly upon the shareholders the necessity which exists for subscribing to the new debenture issue, so as to place the Company on a firm footing. It is not, as I explained before, a satisfactory position for a Company to be in to owe such a large amount to its bankers as we owe now, and, besides, the want of ready money cripples us in dealing with such matters as we have to deal with in a business of this kind. It prevents us from buying in the cheapest market, and hampers us in many other ways. We hope the shareholders will appreciate the manner in which we have dealt with the affairs of the Company, as shown by the balance-sheet, and that they will show that appreciation by accepting our assurance that we believe the Company to be thoroughly sound, and assisting us to put it on a firm footing by endeavouring to take up the debentures we have offered. I shall be glad to answer any questions shareholders may wish to ask, and in the meantime to place myself in order, I beg to move:—

"*That the report of the Directors and audited statement of accounts to March 31, 1894, be, and the same are hereby received and adopted.*"

Mr. R. E. B. CROMPTON (one of the Managing Directors) in seconding the motion said: I continue to feel myself very largely responsible to you for the conduct of the Company's business, and therefore I presume you will wish to hear something from me personally. I can only corroborate everything your Chairman has said with regard to the past year's working and the future of the Company. Without doubt the past year has been adversely affected by the competition of new firms that have

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entered the field to manufacture electric appliances without a full knowledge of what they were doing, and this has had the effect of reducing market prices to such an extent that it has been a very hard matter indeed to fill our order sheet with profitable orders. We believe, however, that there are signs that this period of extremely low prices, based on erroneous estimates, is coming to an end. It must necessarily work out its own cure. The weaker firms will be gradually weeded out as they find such contracts as they have made cannot be carried out in a paying fashion, so that we may look forward, as one of those firms who will continue, to having better prices and better times in the future. As regards the change in the management at Chelmsford I can only confirm what the Chairman has said. Mr. Brunton, your present Manager, is the best man I could possibly have selected. In our opinion the Company is now in a better position than ever it was before to meet the severe competition of the present day by manufacturing goods as cheaply and economically as possible. I do not believe that at any time our manufacturing department was in better order. With regard to prices, I hope, as I have just said, the tendency will be rather to increase than to diminish; but if the low prices of the past year continue during the present year, I feel convinced that we are at least in as good, and probably in a better, position for meeting such a state of affairs by manufacturing at an extremely low rate than any other firm I know of in England. Consequently we may be able to take contracts which will yield us a profit, whereas they would not be profitable to our competitors.

The motion was then carried unanimously without discussion.

The CHAIRMAN then proposed—

"*That a dividend at the rate of 3s. per share be declared and paid on the Preference shares of the Company.*"

Mr. J. ALBRIGHT (joint Managing Director with Mr. Crompton) seconded the resolution, which was passed.

Mr. CROMPTON moved the re-election of the Chairman as a Director. Mr. TUFNELL, Sen., seconded, and it was unanimously agreed to.

On the motion of Mr. TUFNELL, Sen., seconded by Col. JAMESON, the auditors (Messrs. J. H. Duncan and Co.) were reappointed.

At an extraordinary general meeting, which was held at the conclusion of the annual meeting,

The CHAIRMAN said: I beg to move—

"*That the capital of the Company be reduced from £300,000 to £280,000 by cancelling paid-up capital which has been lost, or is unrepresented by available assets, to the extent of £20,000; by cancelling 4,000 Ordinary fully paid-up shares of the Company, numbered 2,785 to 6,784 inclusive, which have been issued.*"

I have already explained the reasons for this resolution. The Board believe that it embodies the best course we can pursue in dealing with the depreciation on certain securities, as we do not think we should keep any on the books which are of doubtful value.

Mr. OSBORNE seconded the resolution, which was unanimously carried.

On the motion of Col. JAMESON, seconded by Mr. TUFNELL, sen., a vote of thanks was accorded to the Chairman, after which the proceedings terminated.

Liverpool Overhead Railway Company.

The twelfth ordinary half-yearly meeting of the proprietors of this Company was held on Tuesday, in the Law Association Room, Cook Street, Liverpool, Sir Wm. B. Forwood presiding.

The CHAIRMAN, in moving the adoption of the report (which appeared in our issue of the 3rd inst.) and statement of accounts, said he was glad to think that the report which the shareholders had before them was of a very satisfactory and encouraging character. During the past half-year the traffic on their line had increased to an extent which ought to give them all great encouragement for the future. As in all new undertakings, it was difficult to get figures for the purposes of comparison. For instance, if they compared the traffic of the past half year up to the end of June with that of the preceding half-year, they would be comparing the traffic of a summer half-year with the traffic of a winter period, and if they took the winter half-year they would be comparing it with a broken half-year, for the line was opened in the month of April last year. During the half-year ended June 30th they carried 2,851,437 passengers, as against 2,475,639 in the half-year ending December 1893, or an increase of 391,0CC. It was impossible to compare these figures with those of the previous half-year, as the latter was a broken period; but he had some figures which would give an indication of the increase of traffic at the present time. During the last half-year they carried 15,300 passengers per day, and during the corresponding period they carried 11,810 per day; and taking the traffic from April 30th to June 30th last year and comparing it with the same period this year, they found the receipts for the former period, nine weeks, to be £5,890 as compared with £8,045 for the corresponding nine weeks this year, showing an increase of £2,155. That was a very gratifying increase, and since the close of the half-year with which they were dealing the increase in traffic had been kept up. During the six weeks that had elapsed since June 30th they had received £1,100, which he considered as very satisfactory. They opened the Seaforth Sands station on April 30th, and their traffic from that station had been everything they expected it to be. It was a valuable feeder to the line. During the half-year they had opened two new stations—one at Nelson Dock and the other at Huskisson, the latter being a removal from the Sandon Graving Dock, and on Wednesday they proposed to open another new station at the Langton Dock, which experience had shown to be necessary. With these three stations the line would be complete, and he might say that it would be an omnibus line, and that passengers would have no complaint to make on the ground of distance between the stations. He would also direct the attention of the shareholders to the fact that the Company had made an arrangement with the Tramway Company, by which they had secured the co-operation of that powerful Company. It was an arrangement which would be advantageous to both, and to which he looked forward in the hope of a considerable increase in traffic. Turning to the revenue account, he found that they had received for the half-year £20,044. 7s. 6d., showing an increase of £1,696 on the previous half-year. That figure might be disappointing to them, seeing the increase in the number of passengers, but as that increase was due to the cheap workmen's tickets in the early morning they would understand why the increase in the revenue did not average much more than one penny per extra passenger carried. The Directors were pleased with the development of the early workmen's trains, and thought they were getting very well compensated for the work done. Coming to the expenditure, they had spent £14,947, being an increase on the corresponding half-year of last year of £1,215. That was made up of two or three items, including £425 on the ventilation of carriages and other alterations; and an additional sum of £873 on traffic expenses, which was largely made up of the cost of the new stations and the cost of running the 22,000 extra miles. They had also had an increase in the rates of £255, and the law charges were somewhat heavier than the previous half-year. On the other hand, they had effected a saving of £910 by taking over the generating station into their own hands. The total receipts were then £20,000, and the working expenses £14,947, leaving £5,097 to be dealt with. They had paid interest of debentures and calls in advance £2,639, leaving £2,457, which by the addition of the balance from last year of £2,598, gave £5,066 available for dividend. The Directors recommend the payment of 5 per cent. dividend on the Preference, and 1 per cent. on the Ordinary shares, leaving £1,010 to be carried forward. As regards the future, they were fully alive to the importance of the extension of the system, and but they wished to see the present undertaking a little further developed, and they would not do anything without obtaining the sanction of the shareholders. They believed that there was a large field for traffic awaiting them at the south end. Their claim against the Dock Board had not yet been adjusted, but they hoped soon to effect an amicable arrangement. He paid a tribute to the work and ability of the engineer, Mr. S. B. Cottrell, and referred to the interest taken in their work by the servants generally, among whom existed a splendid *esprit de corps*, and for whose benefit the Company had recently opened an institute at Seaforth Sands station.

Mr. RICHARD HOBSON seconded the motion, which was agreed to.

A vote of thanks to the Chairman and Directors closed the proceedings.

Birmingham Central Tramways Company.

The thirteenth annual meeting of this Company was held on Wednesday at the Queen's Hotel, Birmingham, Mr. J. Ebbsmith presiding.

The CHAIRMAN, in moving the adoption of the report (which appeared in our last issue), referred to the recent decision of the House of Lords upon what was known as the purchasing clause of the Tramway Act, a decision which was adverse to the contention of the tramway companies affected and favourable to the local authorities. There was a great deal of misapprehension with regard to the effect of that purchasing clause, and therefore it would be satisfactory to many shareholders when he stated that that decision had no injurious effect upon the position of the Company. In Birmingham the Central Company's lines were divided into two classes—first, those which were held directly from the Corporation within the city, upon a lease which expired at the termination of twenty-one years, so that they were not affected at all by the decision; and, secondly, by the lines outside the city, in respect to which they were subject to the statutory conditions. In 1888 the constructive value of their lines was taken, and it was that value which appeared in their books now. Dealing with the accounts, the chairman said the new engines referred to at the last meeting had been received and were working admirably. It was satisfactory to find that upon those engines a saving of close upon three farthings per mile was effected in the consumption of fuel alone, and he was hopeful that the saving would be more marked during next year. The horse department was what it had always been—a difficulty, and a blot upon their accounts. In the cable department there had been a most satisfactory increase of working profit. They could not have their profit at both ends, and he was glad to know that the profit on the cable department far outweighed any corresponding loss upon the horse department on the southern routes. The electric department was one of mingled difficulty and hope. The shareholders were aware that the Corporation had not met the Directors as they had a right to expect in the hope of establishing another and more economical form of traction; but the Directors had turned their attention to two alterations of detail in the present system, which gave them distinct reason to believe that the electric department had seen its worst days, and that it would now show a steady if unsatisfactory improvement. He said "unsatisfactory," because he considered it was unsatisfactory that they should be compelled to work that form of traction which could be replaced by one of equal advantage to the public and much more economical to the Company. He was quite sure if the Corporation had permitted the experiment of overhead lines to be tried in the Bristol-road, the inhabitants of that thoroughfare would in three months have warmly supported a continuance of the system, and the profit to the Company would practically have equalled the loss which they now sustained. The £550 paid to the late Managing Director (Mr. Carruthers Wain) was a proportionate payment made upon the determination of his agreement, which expired at the end of last year. He had done his work of organisation, and done it well. His retirement necessitated a reorganisation of the management, and as their traffic manager (Mr. Herring) about that time left the district they requested Mr. Holmden, in whose ability, probity, and assiduity they had profound confidence, to act as manager as well as secretary. The effect of the reorganisation of duties had been to diminish the standing

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charges by £1,100 per annum. The shareholders would be called together at a special meeting to consider the question of a proposed reduction of capital.

The report having been adopted, Mr. J. Booth and Mr. J. Ebbsmith were re-elected Directors, and Mr. J. T. Mantle was appointed a Director in place of Mr. Martyn J. Smith, who retired.

Cuba Submarine Telegraph Company (Limited).

The following is the report of the Directors for the half-year ended 30th June, to be presented at the forty-sixth ordinary general meeting to be held at the offices, 58, Old Broad-street, London, E.C., on Wednesday next, the 22nd inst., at noon :—

The gross receipts amount to £24,703. 9s. 0d., and the gross expenditure to £5,133. 8s. 1d., leaving a sum of £19,570. 0s. 11d., which, added to the balance brought from the last account, £2,259. 5s. 0d., leaves £21,829. 5s. 11d. at the credit of revenue account. Of this, the sum of £1,000 has been set aside as a further reserve against any loss from the deposits with banks. In view of the reserve fund having shortly to bear the cost of the new cable referred to below, the sum of £8,000 has been added to it, making the fund £113,000. The dividend on the Preference shares will absorb £3,000, and leave £9,829. 5s. 11d., out of which the Directors recommend the payment of a dividend on the Ordinary shares at the rate of 8 per cent. per annum, free of income tax, the balance £3,429. 5s. 11d., being carried forward to the current half-year.

The cables have continued in good order throughout the half-year. A contract has been entered into with Hooper's Telegraph and India Rubbber Works (Limited), for the manufacture and laying of a new cable between Batabano and Cienfuegos, to replace the original 1870 one, which, as mentioned in last report, gave out at the end of the year. This cable will be laid in the beginning of next year and its cost charged to the reserve fund.

The Company's suit against the Spanish Government at Madrid has made progress, but no decision has been given.

The Director who retires from the Board at this time is Mr. Alexander F. Low, who, being eligible, offers himself for re-election, as does also Mr. John Gane, the Auditor.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1894, pages 274-300, *&c., &c.*]

EDMONDSON ELECTRICITY METER SYNDICATE (LIMITED).—This Company was registered on August 10th, with a capital of £2,000, in £1 shares, to acquire the patents and patent rights for the manufacture of electricity meters, invented and patented by Joseph Edmondson, of Bradford, Yorks., electrician, either alone or in conjunction with Joseph Oulton, of Bradford, clock maker, to manufacture and deal in electricity meters, and all apparatus, appliances, materials, and things connected with the measuring of electricity, or with the generation, accumulation, supply, distribution or employment of electricity, and generally to carry on the business of electricians and mechanical engineers. The subscribers include Joseph Edmondson, Heath-avenue, Halifax, electrician ; Frederick Priestman, J.P., Pierremont, Bradford ; Edward Priestman, Moorfield, Bradford ; and Joseph Cooper, Ilkley, Yorks.

BRITISH THOMSON-HOUSTON, LIMITED (formerly the Laing, Wharton and Down Construction Syndicate, Limited).—An agreement, dated June 27, 1894, with the Thomson-Houston International Electric Company, of New York, provides for the allotment, as fully paid to that Company, of 3,010 shares (Nos. 4,727 to 7,736 both inclusive). By a special resolution, passed July 11 and confirmed on July 26th, the name of the Syndicate was changed to the British Thomson-Houston (Limited), and the permission of the Board of Trade for such change of name was granted on August 2nd. The annual return, made up to July 25th, was recently filed. Out of a nominal capital of £100,000, in £10 shares, 7,526 have been taken up, and of these 4,140 have been issued as fully paid. The full amount has been called on 2,660 shares, £5 per share on 329 shares, and a call of £2. 10s. per share has been made on 397, resulting in the receipt of £29,237. 10s.

HEAD, WRIGHTSON AND CO. (LIMITED).—The annual return of this Company, made up to July 7th, has been filed. The whole nominal capital of £210,000, in £5 shares, was taken up, and the full amount called and paid. The total amount of shares for which share warrants are outstanding, comprising 98 of 20 shares each, 140 of 10 shares each, 200 of 5 shares each, and 489 of 1 share each, is £24,245, while share warrants, comprising 5 shares have been surrendered since last summary.

HOOPER'S TELEGRAPH AND INDIA RUBBER WORKS (LIMITED).—The statutory return of this Company, made up to August 7th, has been filed. The capital is £50,000, divided into 2,500 Preference and 2,500 Ordinary shares of £10 each. 2,000 have been taken up, and the full amount called on 1,496 shares, while a call of 2s. per share has been made on the remaining 504 shares, resulting in the total payment of £15,010. 8s.

LONDON AND HAMPSTEAD BATTERY COMPANY (LIMITED).—The annual return of this Company, made up to June 19th, has been filed. Out of a nominal capital of £50,000, divided into 7,000 Preference and 3,000 Deferred shares of £5 each, 830 Preference and all the Deferred have been taken up, and the latter were all issued as fully paid. Upon the 830 Preference shares the full amount has been called, resulting in the total payment of £4,150.

CITY NOTES.

CHARING-CROSS AND STRAND ELECTRICITY SUPPLY CORPORATION (LIMITED).—The Directors have declared an interim dividend for the half-year ended June 30th, at the rate of £4 per cent. per annum on the Ordinary share capital of the Corporation (£150,000), and carried forward £1,335, after payment of £5 per cent. per annum on debentures.

CITY AND SOUTH LONDON RAILWAY.—The traffic returns of this Company for the week ended August 12th were £897, as against £829 in the corresponding period of 1893, being an increase of £68. The total receipts for the half-year amount to £5,203, as against £5,066 for the corresponding period of 1893, an increase of £137.

DENIAL.—We are informed that there is no truth in the announcement that subscriptions are being privately invited for the shares of the Brockie-Pell Electric Lighting Company (Limited), which was stated by a financial contemporary to have been registered with a capital of £80,000. Consequently the statement that the Company is to pay to the vendor £55,000 for the patents, and a royalty of 5s. per lamp, is also at variance with the facts.

GREAT NORTHERN TELEGRAPH COMPANY.—The coupons falling due on September 1st next on the Debentures of 1883, Series B, should be presented for payment between the hours of 11 and 2, at the office of Messrs. C. J. Hambro and Son, 70, Old Broad street, where lists may be obtained. Coupons must be left three clear days for examinations.

GULCHER (NEW) ELECTRIC LIGHT AND POWER COMPANY (LIMITED) (*in liquidation*).—At the meeting called yesterday (Thursday) to confirm a resolution passed on the 1st instant, that Mr. C. F. Kemp (the liquidator) be authorised to enter into an agreement with Messrs. Easton, Anderson and Goolden (Limited) on terms set out in our issue of the 27th ult., page 379, was confirmed, and Mr. Kemp now proposes to pay in cash the first mortgage debenture-holders, and hopes to be in a position eventually to pay all unsecured creditors.

W. T. HENLEY'S TELEGRAPH WORKS COMPANY (LIMITED).—This Company have, during the current week, invited applications for £50,000 Four and a-Half per Cent. Mortgage Debenture Stock at par in multiples of £10. The authorised capital of the Company is £100,000, and the subscribed capital £98,370, £30,000 Preference and £68,370 Ordinary. The prospectus states that the increase in the Company's ordinary business (as distinct from laying submarine cables), and the prospect of extending the business in new directions, render it advisable to increase the capital of the Company, hence the issue of this Four and a-Half per Cent. Debenture Stock. This issue is to be secured by a trust deed, and to be a first charge upon the Company's property and undertaking. For this purpose a sinking fund is to be created, to commence with the year 1900, for which will be set aside out of the profits a sum of £1,000 annually for the purpose of redeeming the stock. £20 is to be paid on application, £20 on allotment, and the balance by December, 1894 The prospectus contains a waiver clause as to contracts and agreements, and must be referred to for other particulars.

SOUTH METROPOLITAN GAS COMPANY.—Mr. George Livesey, at the meeting of this Company on Wednesday last, referred to the very considerable income derived from the penny-in-the-slot gas meters of which the Company has now 20,000 in use. He referred to the profit-sharing system adopted by the Company, under which the officers and working staff have benefited to a very material extent. As to the purchase of the Metropolitan Gas undertakings by the London County Council, Mr. Livesey is of opinion that such a scheme would result in a much more expensive system of working, and would not result in any benefit to gas consumers. A dividend at the rate of 13 per cent. per annum was declared.

A. AND J. STEWART AND CLYDESDALE (LIMITED).—A half-yearly interim dividend at the rate of 2½ per cent. per annum has been declared, payable August 31st.

STOCK EXCHANGE NOTICES.—Application has been made to the Stock Exchange Committee to appoint a settling day in and to grant a quotation to £150,000 Four and a-Half per Cent. First Mortgage Debenture Stock of the Metropolitan Electric Supply Company (Limited).

TRAMWAY COMPANIES' DIVIDENDS.—The *Financial News* of the 14th inst. contains an interesting article on the subject of tramway company dividends as affected by the recent decision of the House of Lords, with special reference to the reserve funds of these undertakings. In regard to this subject Mr. W. S. Graff-Baker points out that in cases similar to that of the Dublin United Tramways Company, it is unnecessary that a reserve fund of any magnitude should be created, as the Company have built their line under an Act from the Privy Council of Ireland granting the use and enjoyment of the lines to the tramway company in perpetuity, under which arrangement no question of the purchase of the undertaking by the local authority can be considered without the consent of the tramway shareholders.

VICKERS, SON AND CO. (LIMITED).—The Directors of this Company have declared an interim dividend of 5 per cent. per annum on the Preferred stock.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended August 10th (after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited), were £2,219.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share	Last Dividend.	Name.	Previous Week's Price, Aug. 8.		Price Wednesday, Aug. 15.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Aug. 15.	
			TELEGRAPHS.					£ s. d.		Highest	Lowest
£1,012,880	Stock	10/0	Anglo-American	37	40	38	41	5 9 9	Jan., Apr., July, Oct.	40½	40
£2,933,560	Stock	20/0	Do. Preferred	70	72	74	76	5 18 5	" "	74½	71½
£2,933,560	Stock	5/0	Do. Deferred	6½	6¾	6½	7	..	" "	6¾	..
£184,500	100	4%	African Direct Teleg. 4% Deb. (Reg. & Bearer)	101	104	101	104	3 16 11	January and July	..	..
130,000	£10	3/0	Brazilian Submarine	12½	12¾	12½	13	5 0 0	Mar., June, Oct., Dec.	13	12½
£18,700	£100	5%	Do. 5 per Cent. Bonds	..		..		..	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	107	111	107	111	3 16 11	June and December	..	—
10,000,000	$100	$1½	Commercial Cable Capital Stock	139	143	139	143	4 17 11	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	12½	13½	12½	13½	5 18 6	February and August	..	..
6,000	10	10%	Do. Preference 10 per Cent.	19½	20½	19½	20½	4 17 7	" "	..	..
12,931	5	1/7½	Direct Spanish (£4 paid)	4	4½	4	4½	4 8 11	April and October	..	—
6,000	5	10%	Do. Preference 10 per Cent.	9½	9¾	9½	9¾	5 2 7	" "	..	—
£30,000	Stock	4½%	Do. 4½% Debentures of £50 each	103%	106%	103%	106%	4 4 11	" "	..	..
60,710	20	2/0	Direct United States Cable, 1877	8	9	8	9	6 13 4	Jan., Apr., July, Oct.	8¾	8¾
400,000	10	5/6	Eastern	15½	15¾	15⅝	15⅞	4 1 11	" "	15⅞	15⅝
70,000	10	6%	Do. 6 per Cent. Preference	16½	16¾	16½	16¾	3 11 8	" "	16⅞	16½
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	116	119	115	119	3 7 3	May and November	117½	116½
£102,100	100	5%	Do. 5 per Cent. Debentures, 1899	105	109	105	109	4 11 9	February & August	..	..
250,000	10	2/6	Eastern Extension	15⅝	15⅞	15⅝	15⅞	4 8 2	Jan., Apr., July, Oct.	15¾	15⅝
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	114	117	114	117	3 8 5	February & August	..	..
£62,700	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103	106	103	106	3 17 3	January and July	..	..
£95,100	100	5%	Eastern and S. African 5 p. Cent. Mor. Deb., 1900	103	106	103	106	3 17 3	" "	104	..
£300,000	100	4%	Do. 4% Mortgage Debentures, 1909 (regd.)	103	106	103	106	3 15 6	February & August	..	—
£200,000	£25	4%	Do. 4% Mauritius Sub. Debs.	107%	110%	107%	110%	3 12 9	May and November	..	..
180,227	10	2/6	Globe Telegraph and Trust xd	8¾	8⅞	8½	8¾	5 2 10	Jan., Apr., July, Oct.	8¾	8⅝
180,042	10	6%	Do. 6 per Cent. Preference xd	15⅝	15⅞	15½	15¾	3 16 2	" "	15¾	15⅝
160,000	10	5/0	Great Northern	20	20½	20	21	3 17 0	Jan., April, and July	20½	20½
£190,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	105	108	105	108	4 12 7	March & September	—	—
17,000	25	37/6	Indo-European	44	46	45	47	5 6 5	May and November	..	..
37,548	10	5/0	London Platino-Brazilian	5	7	5	7	..	" "	46	45½
£100,000	100	6%	Do. 6 per Cent. Debentures	108	111	108	111	5 8 1	March & September	11¾	..
£100,000	£100	4%	Pacific European Tel. 4% Guar. Debs. "Red" 1942	102	105	102	105	3 16 2	..	..	—
11,839	8	4/0	Reuter's	3	5	3	5	..	April and October	..	..
3,381	£100 Cert.	25/0	Submarine Cables Trust 6 per Cent.*	108	113	108	113	5 6 2	" "	..	..
15,609	10	5/0	West African Telegraph	3	5	3	5	..	January and July	..	..
£249,900	100	5%	Do. 5 per Cent. Debentures	102	105	103	105	4 15 3	March & September	103½	..
30,000	10	2/0	West Coast of America	2½	3	2½	3	..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	96	101	96	101	7 18 5	June and December	..	..
88,321	10	9d.	West India and Panama	1	1½	1	1½	..	..	1½	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10	10½	10½	10¾	5 11 7	May and November	10⅝	10½
4,669	10	6%	Do. 6 per Cent. 2nd Preference	9	10	9	10	6 0 0	" "	..	..
£80,000	100	5%	Do. 5 per Cent. Debentures, 1917	107	110	107	110	4 5 7	June and December	108½	..
64,242	15	7/6	Western and Brazilian	6¾	7¼	6¾	7¼	..	May and November	7⅛	7
33,129	7½	7/6	Do. 5 per Cent. Cumulative Preferred	5¾	6¼	5¾	6¼	..	..	—	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	1¾	2¼	1¾	2¼	..	..	..	..
£171,900	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	105	108	105	108	5 11 1	February & August	..	..
£214,800	100	6%	Do. 6% Mort. Debs., Series "B" 1910	105	108	105	108	5 11 1	" "	..	..
$1,211,000	$1,000	7%	Western Union 7% 1st Mort. (Building) Bonds	115	120	115	120	5 16 8	May and November	—	..
£166,900	£100	6%	Do. 6 per Cent. Sterling Bonds	100	104	100	104	5 15 5	March & September	..	..
			TELEPHONES.								
44,000	5	10/0	Chili Telephone (fully paid)	1	2	1	2	..	..	..	—
224,850	10/0	2½d.	Consolidated Telephone Const. & Maintenance	¼	½	¼	½	..	May and November	..	..
171,504	£1	6d.	Oriental Telephone and Electric (fully paid)	¼	⅜	¼	⅜	..	Yearly	..	..
484,597	5	3/4	National	4¾	5	4¾	5¼	4 17 7	June and December	5	4⅞
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	14	15	14	15	4 0 0	" "	14½	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	13½	14½	13½	14½	4 2 9	" "	..	..
119,234	5	3/4	Do. 5% Non-Cumulative 3rd Pref.	5¾	5⅝	5¼	5¼	4 6 11	..	5⅜	5¼
1,000,000	Stock	4½%	Do. Debenture Stock, 4½%	109	112	109	112	4 10 0	January and July	..	..
58,000	5	1/0	United River Plate	1	2	1	2	—	" "	..	..
£146,733	Stock	5%	Do. 5 per Cent. Debenture Stock	85	95	85	95	5 5 3	" "	..	—
			ELECTRICITY SUPPLY COMPANIES.								
40,000	£10	..	City of London Electric Lighting (fully paid)	12½	13½	12½	13½	..	..	13½	13½
40,000	10	6,0	Do. 6% Cumulative Pref. (fully paid)	14	14½	14	14½	4 2 9	..	14½	14½
19,900	£5	..	Electricity Supply Co. for Spain	..		..		..	..	..	..
£30,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp. xd	4½	5½	4½	5½	3 12 7	—	..	..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	..		..		..	..	..	..
8,322	£5	..	House-to-House Electric	..		..		—	—	..	—
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	..		..		—	..	..	—
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..		..		—	January and July	..	—
45,000	£5	2/6	Liverpool Electric Supply (fully paid)	6½	6⅞	6½	6⅞	—	..	..	—
111,000	5	..	London Electric Supply	¾	⅞	¾	⅞	—	..	..	—
49,900	£10	5/0	Metropolitan Electric Supply (fully paid)	8½	8¾	8½	8¾	2 17 2	..	8½	..
£150,000	Stock	4½%	Do. 4½% Debs. (Bonds of £10, £20, and £40)	3	5 pm	4	6 pm	1 4 11	June and December	..	..
6,452	£10	..	Notting Hill Electric	4½	5½	4½	5½	—	..	..	—
19,930	£5	2/0	St. James and Pall Mall	7	7½	6¾	7½	..	..	7½	—
20,000	£5	7%	Do. 7 per Cent. Preference	8½	9	8½	8¾	4 0 0	—	8⅝	..
59,000	5	2/0	Westminster Electric Supply (fully paid)	6	6½	6	6½	3 9 3	—	6⅛	6½
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
90,000	3	1/6	Brush Electrical Engineering	2¾	3	2¾	3	6 0 0	..	2⅞	2⅞
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	2¼	2½	2¼	2½	4 16 0	..	..	..
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	110	113	110	113	3 19 8	March & September	..	..
20,000	5	2/6	Crompton and Co., 7 per Cent. Cumulative Pref. xd	2	2½	2	2½	—	January and July	..	..
12,139	5	..	Edison and Swan United	—		—		..	..	—	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	..		..		..	..	—	..
120,000	2	..	Electric Construction	¾	¾	¾	¾	—	—	—	—
12,845	2	..	Do. 7 per Cent. Cumulative Pref.	1½	1¾	1½	1¾	..	—	—	..
91,195	2	10/0	Elmore's Patent Copper Depositing	1	1½	1	1½	..	—	—	..
20,000	5	..	Fowler-Waring Cables (fully paid)	½	1½	½	1½	—	..	..	..
50,000	10	10/0	India Rubber, Gutta Percha, &c., Works	23	24	23	24	5 4 2	February & August	..	—
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103	105	103	105	4 5 9	March & September	—	—
15,993	£10	6/4	International Okonite Ordinary	..		..		—	—	23¾	23½
16,000	£10	..	Do. 8 per Cent. Preference	—		—		—	December and June	—	—
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid)	—	½	—	½	—	..	—	..
78,949	5	3/6	Swan United (£3 10s. paid)	..		..		..	May and November	..	..
37,350	12	12/0	Telegraph Construction and Maintenance	40	42	40	42	5 14 3	March and July	41½	41
£150,000	100	5%	Do. 5 per Cent. Bonds	102	105	102	105	4 13 6	January and July	..	..
37,514	£5	—	Woodhouse and Rawson Ordinary (£3 15s. paid)	—		—		..	..	—	—
41,098	£5	—	Do. Preference (fully paid)	—		—		..	—	—	..
£63,870	10	10/0	W. T. Henley's Telegraph Works Ordinary	7	8	7	8	6 5 0	..	..	..
£30,000	10	..	Do. Preference	..		..		..	..	..	..
			RAILWAYS AND TRAMWAYS.								
£630,000	Stock	1%	City and South London Railway xd	36	38	36	38	1 16 2	May and November	37½	..
7,000	10	5%	Do. 5% Perpetual Preference xd	12½	13½	12½	13	3 16 11	May and November	—	..
£67,130	Stock	4%	Do. 4% Perpetual Debenture	121	122	121	123	3 5 1	..	—	—
37,500	£10	1%	Liverpool Overhead Railway	8½	8⅝	8⅛	8⅛	1 3 11	..	..	—
6,295	10	5%	Do. 5% Preference	13	13½	13	13½	3 14 1	..	..	..
£125,000	Stock	4%	Do. 4% Debenture	111	113	111	113	3 10 10	January and July	..	..

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

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NOTES.

As will be seen by a note in another column, the strenuous opposition of a handful of members has induced the Postmaster-General to defer the signature of the agreement with the National Telephone Company until next session. What can be gained by this delay, except loss of time, it is difficult to see, since by the Telegraph Act of 1892 and the Treasury Minute which heralded it, Parliamentary sanction was given to a certain course, a mistaken one as we think, and no measurable deviation from that course can be made without something approaching a breach of faith. Parliament apparently rather enjoys agreeing in haste and repenting at leisure.

This week we begin to reprint the two important Papers on the Liverpool Overhead Railway, by Mr. Greathead and by Mr. Thomas Parker, which were read before the Institution of Civil Engineers in February last. Not only is this railway of great interest because it is the first permanent elevated electric railway, but because it is a thoroughly practical and financial success. It is, moreover, an example of sound English engineering. Not the smallest hint, so far as we are aware, has been taken from American tramways, though the fact that the carriages are mounted on bogies, and that there is a passage from end to end, has been quite sufficient to start the idea that the whole concern has been copied from American work. If there is a line in America or elsewhere that can be compared with the Liverpool road for completeness, solidity, first cost, or working expenses, we should be interested to hear of it. An attempt was made during the Chicago Exhibition to run a so-called "intramural" railway; but it was only a big side-show, and no figures as to financial success, or even as to cost of working, were ever published. The great glory of it was the colossal dynamo of 2,000 h.p. It may be remembered that soon after the City and South London Electric Railway was opened, numerous designs and schemes for New York lines of exactly the same type were suggested. The estimate for the electrical equipment of the Ninth Avenue Railway of New York, based upon certain experiments made in 1889, was probably deliberately intended for political or other business purposes to mislead; but a comparison with the actual cost of the Liverpool line is amusing, for the six miles of that line has cost little more than 5 per cent. of the estimate for the Ninth Avenue line of five miles.

An interesting example of the mutual help which experiment and calculation afford one another was furnished in Prof. J. J. Thomson's Paper "On the Velocity of the Cathode Rays," which was read before Section A of the British Association. As our readers are probably aware, the medium of the cathode ray has been a matter for considerable debate; one view taken being that the ray is a phenomenon of the ether, similar to electromagnetic radiation, the alternative view being that the ray is produced by molecular streaming. The behaviour of the ray in a magnetic field, however, as Prof. Thomson observes in his Paper, requires that if the ether hypothesis is adopted the ether must be invested with altogether new and startling properties. And, indeed, before the physicist can feel justified in adopting such a modified ether, he must have very conclusive evidence that the cathode ray is not the product of molecular motion. In order to determine whether a stream of electrically-charged gas particles could account for the phenomenon, Prof. Thomson has worked along two distinct lines of investigation, and compared the two results. The first line consisted in experimentally determining the velocity of the cathode ray in the rarefied gas; the second, in calculating what that velocity ought to be if the ray is due to a stream of electrically-charged gas particles urged down a potential gradient. The observed velocity, in the case of a discharge passing through the so-called hydrogen vacuum, was $1{\cdot}9 \times 10^7$cm. per second; and the calculated velocity, under the same conditions, came out at $2{\cdot}0 \times 10^7$cm. per second. The agreement is astonishingly close, and, as Prof. Lodge remarked during the discussion, tends strongly to support the view that this velocity is approximately correct. More than this, the agreement would seem to give great strength to the hypothesis of molecular motion, as contrasted with the ether hypothesis.

We are still, however, face to face with Prof. Schuster's important criticism, namely, that what Prof. Thomson had been directly measuring was the rate at which the cathode ray discharge establishes itself along an axis in space, and not the actual velocity of the molecules past any fixed point on that axis. At first we were inclined to believe that this criticism, if justifiable, must weaken the arguments on Prof. Thomson's side. For there is an obvious difference between the value of measurements made in the initiatory stages of a phenomenon, and those made when the phenomenon is steadily established. In the case of a stream of electrified particles moving down a fixed potential gradient, however, the movement of the very

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first particle would be exactly repeated by every succeeding particle. In this case, therefore, the conclusions might equally well be drawn from measurements at the initiatory stage as at any later stage. Indeed, the fact that such measurements do agree with the calculated velocity turns Prof. SCHUSTER'S criticism into a further argument in favour of the view that the cathode ray consists in a stream of gas particles projected along a path under steady electric stress.

SHOULD waves of a particular length be known by their predictor's, or by their discoverer's, or, indeed, by any human name? This point was raised by Prof. LODGE during his remarks, at the British Association, upon "Experiments Illustrating Clerk Maxwell's Theory of Light." Prof. LODGE ventured to express his opinion that if HERTZ were alive he would be the first to discourage the appellation "Hertzian" in connection with the electromagnetic waves discovered by him, and would be foremost to advance the claims of MAXWELL to the adjectival vacancy. Maxwellian waves—that was the just and right name by which they should for ever be known. This brought the learned German, Prof. BOLTZMANN, to his feet to utter a loud and emphatic protest against any attempt to poach on HERTZ'S preserves by taking advantage of his modesty. HERTZ was a modest, retiring man, and might too willingly yield the palm to MAXWELL; but MAXWELL had never turned a brand new wave out of his laboratory, while HERTZ had. We confess to a feeling of pleasure when Prof. LODGE decided that the phrase "Hertzian waves" must go, and a compensating feeling of pain when he put "Maxwellian waves" in its place. Why should a particular range of wave-lengths be stamped by any human name? Will not the practice lead to great inconvenience when the entire orchestra of ether waves is filled up? What if we had to call the middle octave in musical instruments the "Jubal notes," or ocean waves of a certain length by the name of some famous warship which they will set synchronously rolling! To do honour to MAXWELL, we may sufficiently recognise his splendid theory and affix his name to it; to pay tribute to HERTZ, we may use his name as an adjective for the particular methods and apparatus which he invented to excite ether waves. But the waves themselves should be hampered neither by the name of the mathematician who predicted them, nor of the experimenter who first produced them, nor, indeed, by any human name.

GLASS apparatus is now being so largely used in some branches of electrical research; and the electro-chemical influence of the constituents of some kinds of glass is of such importance, and so liable to vitiate the results of the experiments, that the information which was afforded on various occasions during the British Association meeting at Oxford as to the electro-chemical properties of glass must have proved useful to many who heard it. In the chemical section Prof. ROBERTS-AUSTEN read a Paper on "The Electrolysis of Glass" in which he showed that some metallic bases, *e.g.*, sodium, may be passed through glass at as low a temperature as 200°C. under electro-chemical stress. During the discussion of Prof. J. J. THOMSON'S Paper on "The Behaviour of Gases with regard to their Electrification, &c.," it was pointed out that the chemical nature of the rarefied gases in the glass apparatus employed in Prof. THOMSON'S experiments might be affected by constituents of the inner layers of glass. Prof. SCHUSTER came forward with a remedy, which had the advantage that he had actually tried it and found it effective. His remedy consisted simply in electrolysing the basic constituents away from the inner surface of the glass, leaving a surface of pure silica. This was done by passing a continuous current from the inner to the outer surface of the glass. The transparency of the glass suffers to some extent, of course, but not sufficiently to interfere with the observations of electrical discharges taking place in the interior.

THE letter from Mr. STEINMETZ, which will be found in our Correspondence columns, is sufficient, for the present, to answer the foolish comments in one of our American contemporaries on our recent notes on the disadvantages of sine curves in alternate-current work. When certain experiments now in progress are completed, we hope to return to the subject.

Cable Interruptions.—No interruptions are recorded this week.

London, Walthamstow and Epping Forest Railway.—The Bill giving the necessary powers for constructing this line has passed both Houses of Parliament.

Cobwebs.—An obscure country newspaper has distinguished itself by discovering an entirely new and original objection to the electric light. It informs its readers that "there is always a large amount of cobwebs where electricity is in use."

Durham College of Science.—Particulars of the courses of instruction in electrical and other branches of engineering, at the Durham College of Science, at Newcastle-on-Tyne, will be found in our advertising columns this week. The mechanical and electrical equipment of the laboratories at this college appears to comprise several useful machines. The session will commence on September 24th.

Postal Telegraph Statistics.—In the recently-presented report of the Postmaster-General it is stated that an addition of 425 telegraph offices at post offices and 248 at railway stations has been made during the year. There are now 9,210 offices from which telegrams may be despatched. The number of messages of all kinds showed an increase of 1·4 per cent. over the business of the previous year.

Long-Distance Telephony.—The Belgian Government has, it is stated, decided to open negotiations with the English Government for the construction of a direct telephone line from London to Brussels viâ Ostend, it being understood that should the negotiations be successful the authorities at Berlin have signified their willingness to consent to a connecting telephone line from Brussels to Berlin.

Electric Lighting Provisional Orders.—In a Parliamentary Paper just published the Board of Trade report that they have granted 24 Electric Lighting Provisional Orders since the date of their Report last year, bringing up the total number of operative orders to 190, of which 118, or 62 per cent., are at present in the hands of municipal authorities. Something like 44 local authorities either have electric lighting stations in operation, or shortly will have.

Artificial Diamonds and the Electric Furnace.—A correspondent of the *Engineer* questions the morality of artificial diamond making by the Moissan process. He is afraid it may lead to "severe injury to individuals, and to South Africa." Patenting would be useless, "as the patent would be infringed in a wholesale manner." Neither could the process be worked secretly, for "the operators would be likely to disappear mysteriously!" All this seems very dreadful, and we sincerely hope M. Moissan will not allow anything so immoral to happen.

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Electrical Utilisation of the Waters of the Loue.—An agreement has been signed between MM. Ritter et Magnin and the municipal authorities of Besançon by which that town may before long be expected to be blessed with an electric supply at a price 22 per cent. less than that of gas. MM. Ritter et Magnin's concession will be exploited by an influential Franco-Swiss syndicate, and 3,000 H.P. will be electrically transmitted to Besançon, the power being derived from the River Loue between its source and Mouthier, 7,500 H.P. being available on an average, and 3,750 H.P. during the driest season.

Fire at Siemens and Halske's Chicago Factory.—The Chicago factory of the Siemens and Halske Electric Company, of America, was destroyed by fire on the night of August 1st. It is estimated that the loss will amount to £60,000; the insurance was about £22,000. The destruction of the building was complete, and a large amount of machinery which the Company was constructing was utterly ruined. The generators designed for the Toronto Street Railway Company were destroyed. The Company was fortunate in saving its books, drawings, and patterns. The plans of the Company are not announced, but it has not cancelled any of its contracts.

Electrical Utilisation of the Gohna Lake.—According to the latest telegrams the waters of the accidentally formed reservoir in the Himalayas known as the Gohna Lake have now reached within 50ft. or so of the top of the natural dam. The length of the lake is now 4½ miles, its average width ½ mile, and its average depth may be taken at about 500ft., which is also, we believe, about the height of the dam, which is well-nigh vertical. We do not know what could be done with the power if generated; but enthusiasts are not likely to overlook this opportunity of proposing to electrically utilise this heaven-sent reservoir, which contains, roughly speaking, a store of some 25×10^7 H.P.H.

Motor Predetermination.—At a recent meeting of the *Société Internationale des Electriciens*, M. J. Rey described a 720-H.P. electric motor built in the workshops of MM. Sautter, Harlé et Cie., and intended to propel the submarine boat "Gustave Zédé," the motor being a 6-pole machine, with two armatures coupled in parallel, keyed to a common shaft. M. Rey pointed out that the commercial efficiency of the motor, as tested by a modification of the Hopkinson method, came out at 92·44 per cent., the calculated efficiency being 92·15 per cent.; and he laid stress on the fact that in no other branch of engineering would it be possible to predetermine the output of a machine to within less than 1 per cent

Capetown Electric Light Scheme.—The action of the Municipal authorities of Capetown regarding the electric lighting engineer about to be appointed is meeting with some criticism, as will be seen from the following extract of a letter written to a local paper by a Capetown taxpayer:—"I have seen the Municipality's advertisement asking for a triplicate engineer; namely, hydraulic, electric, and steam, competent to control the works now going on for electric light. The result, as was to be foreseen, is that no *bona-fide* applicant has turned up. We shall get the young man from home, of course, at some date. Meanwhile the contract under execution, costing the town £60,000 or over, wants no controlling!"

Islington.—The Vestry of Islington recently appointed a committee to make exhaustive inquiries as to the relative cost of gas and electricity, especially with regard to street lighting. The committee now report that they have been unable to obtain any definite data from actual experience of the relative cost of lighting public streets by the two illuminants. They, however, say they have come to the conclusion that the lighting with arc lamps of the route from the Angel to Finsbury Park —namely, High-street, Upper-street, Holloway-road, as far as the Nag's Head, and thence along Seven Sisters-road to the park—which is projected as a commencement, would cost little (if any) more than the present cost of gas. We hope that this conclusion may be realised, and shall be interested to learn the data on which it is founded.

Books.—Before leaving England Mr. Kapp handed in the final proofs of the fourth edition of his work on the "Electric Transmission of Power" to Messrs. Whittaker. The work has been brought up to date, both as regards theory and practice. Examples of the most recent installations of power transmission by continuous current, including the series arrangement of a number of machines for working at extra high pressure, have been added to or substituted for the examples in the third edition. The theory of continuous current generators and motors has been further developed in accordance with latest investigations, and several new chapters have been added dealing with the transmission of power by simple and multiphase alternating currents. The theory and construction of alternators, transformers, and alternating current motors, has been added, as well as examples of large alternating current plant successfully at work on the Continent. The book contains many illustrations and full particulars of dynamo-electric machinery made by the best English and foreign engineers.

The Paris Municipal Central Station.—In recent issues of *La Lumière Electrique* M. G. Claude has been describing, at infinite length and with infinite pains, the latest phase of the Paris Municipality's central lighting station, which has met so far with but very qualified success. Although Belleville boilers are used it seems that the kilowatt hour cannot be *generated* with an expenditure of less than 10lb. of such coal as they get in Paris; a long way off Mr. Crompton's ideal of 2½lb. of Welsh coal per unit *sold* and his actual of under 5lb. The presence of a storage battery in the station, and the curious use which is made of it, may perhaps supply a clue to this lack of economy in fuel. Electric energy is first of all generated at the rate of 1 kilowatt hour per 10lb. of coal, and stored in accumulators which, according to M. Claude, have a maximum efficiency of 60 per cent. On leaving the accumulators the current passes to a Hutin-Leblanc "panchahuteur" or transformer, where it is converted into a current of the high-pressure alternating species, finally reaching the lamps after the usual losses in the line and step-down transformers. The transformers, according to M. Claude, are so inefficient that the substitution of improved apparatus would lead to an annual saving of £2,100.

"La Lumière Electrique."—We have received the following communication from the editorial office of our Paris contemporary:—Founded on April 15, 1879, *La Lumière Electrique*, a universal journal of electricity, has been for fifteen years the most complete and authentic organ of the science to which it was devoted. It has not hesitated to make any sacrifices to insure its utility, and each year it has resulted in an average loss to its proprietor of more than 70,000 francs, and at the present moment the journal is in difficulties. Two solutions have been considered by the managers: (1) To increase the rate of subscription, and to open the columns of the paper to commercial advertisements; (2) to suspend the publication for a sufficient period to permit of financial reconstruction. The first solution was immediately discarded. *La Lumière Electrique* has never sought pecuniary gain, and it will remain a journal of pure science, and a stranger to all commercial promiscuity. The second solution has therefore been adopted, and it is hoped that subscribers, remembering the past, will be faithful to it in the future, and that they will accept patiently this momentary stoppage. Those subscribers who do not adhere to this proposal will be good enough to communicate with Counsel, M. Francis I. Delasalle, Advocate in the Civil Tribunal of the Seine, 19, Rue d'Alger, Paris.

Electric Welding.—At the Manchester meeting of the Institution of Mechanical Engineers Mr. B. A. Dobson read a Paper on electric welding. As the results of some experiments conducted at the author's works, a number of interesting facts have been arrived at. It has been found that electric welds may be bent cold without giving way, not more than one out of 500 welds proving defective in this respect. The question of cost, which of course is of importance to commercial engineers, has not been alluded to in detail. The author admits, however, that the payment of royalty, the cost of horse-power, and the depreciation—which on electrical apparatus is heavy—together bring the cost considerably over the net cost of the ordinary smith's hearth work; while the actual payments in wages and so on are considerably less. The loss in weight of iron is about one-twentieth only. It may be taken that on straightforward welds the total cost will be between 10 and 15 per cent. more than the ordinary smith's work; whereas, in

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delicate work and difficult operations such as have been alluded to, the cost will probably be one-third of the smith's work. But the real advantage of the apparatus, at any rate as at present arranged, is not so much an economy as a method of securing an absolutely reliable result, and occasionally saving considerable expenditure by its special adaptability. The amount of power required to effect a large electric weld is very considerable, but the time during which this power is required for each weld is very small. A 2in. wrought-iron bar required from 55 to 59 H.P. for from 243 to 246 seconds, neglecting the power expended in the mains and machinery. A 1in. wrought-iron steam pipe required from 15 to 25·5 H.P. for from 61 to 86 seconds.

The Liveing Explosive Gas Indicator.—In the course of his four Cantor lectures on "the Detection and Estimation of Gas or Vapour in Air," delivered before the Society of Arts, early this year Prof. Clowes briefly described the Liveing indicator. As this ingenious electrical instrument may not be generally known to our readers, the following may be of some interest. The Liveing indicator depends upon the principle that when a mixture of gas and air is passed over an incandescent wire, the wire glows more brightly. In the Liveing apparatus one wire is enclosed in an hermetically closed tube containing pure air, and the other is enclosed in a tube open to the atmosphere to be tested. When an electric current is passed through the wires they will be of equal brilliancy if the atmosphere being tested is pure. The two wires are compared by means of a photometer arrangement, which enables the percentage of fire-damp to be read off on a scale; and the necessary current is generated by means of an electro-magnet arrangement driven by hand. Taking the light of the enclosed wire as unity, the light of the exposed wire has been found to be equal to 1·24 when ¼ per cent. of fire-damp is present; 1·65 with ½ per cent.; 2·78 with 1 per cent.; 5·10 with 2 per cent.; 22·0 with 3 per cent.; and 64·0 with 4 per cent. Mr. James Grundy, of Bolton, who has made a series of check tests with this apparatus, finds that it does not give sufficiently steady results until the proportion of fire-damp has reached 1 per cent.; and he also finds that with use the wires undergo change unequally. The exposed wire increases in electrical resistance, while the other remains practically constant. As this causes the enclosed wire to glow more brightly it becomes necessary to take the instrument into pure air from time to time, in order to readjust the photometer scale. Indeed, in some of his tests Mr. Grundy found that the zero mark upon the scale was, by this change of resistance, shifted beyond the distance between the two wires. The change was curiously fitful in some wires and in others it was rapid, but when it had once taken place the wires could not be brought back to their original condition. There is one other objection to the apparatus, and that is that to get constant results there must be a constant current passing through the wires, which cannot be obtained with a hand-driven generator. It is quite possible, however, that the apparatus may be improved, and one of the most apparent improvements is the introduction of a proper storage battery.

The Government and the National Telephone Company.—The Postmaster-General and the Chancellor of the Exchequer were subjected to considerable "heckling" last week with regard to the proposed agreement with the National Telephone Company. Mr. A. C. Morton asked whether the intention was still to meet, as far as possible, the telephonic views of the municipal authorities, and if so, having regard to the fact that the proposals had only just been circulated, Mr. Morley would postpone until next Session the completion of the agreement, so as to give the municipal authorities an opportunity of expressing their views on it. Mr. Henniker Heaton asked the Postmaster-General whether he would consider the propriety of referring the Treasury minute to a Committee of business men chosen from Members of the House. Mr. A. Morley replied that the Committee which sat in 1892 recommended that the details of the arrangement should be carried out by the department. The agreement did not require the confirmation of Parliament. It merely carried out the policy which had already received Parliamentary sanction, and in connection with which large sums had already been expended. The telegraph estimates would afford an opportunity for any discussion that it might be desired to raise. He was not prepared to assent to the postponement of the matter until next Session. Later on Mr. A. C. Morton asked the Chancellor of the Exchequer whether he intended to force through the draft agreement with the National Telephone Company. So long ago as last November the Postmaster-General promised that a copy of the draft should be circulated before the Government agreed to it, not only amongst members but amongst the municipalities of the country, so that there might be ample opportunity of considering it. If the agreement were concluded, it would be a distinct breach of faith. The Chancellor of the Exchequer replied that if the Government found there was a well-founded opposition to the agreement they would consider whether it could be postponed. Mr. Benn assured the Chancellor of the Exchequer that the feeling on the London County Council with regard to the agreement with the Telephone Company was very strong. They strongly objected to the absence of opportunity for examining its provisions. Mr. Cohen said that, as far as he knew, there had been no expression of opinion by the County Council. Mr. Storey said that many large municipalities would be affected by the agreement. They desired ample time to examine the agreement critically. Mr. A. Morley, in deference to the views expressed by various members, agreed to the postponement of the subject.

The French Press and British Submarine Cables.—In our last number a flat contradiction was given to statements of the French Press, mainly in the *Journal des Debats*, about the action of English telegraph companies in their relation with the Government and the public in France. The *Soleil* of the 13th inst. reproduces the same attacks, and adding further charges with the object of throwing discredit on the Companies' services. "Everywhere," says the writer, "telegrams from French agents reach Paris after long delays and mutilated; the English Press circulates false and prejudicial news before rectification is possible; orders sent from Paris to the French Government agents, to the commanders of French forces, are deciphered, tardily transmitted, and previously communicated to our adversaries. Likewise, as regards the conflict between Siam and France, pending which all the news interesting us were received through English channels and our Government being only informed twenty-four hours after London newspapers." The general remarks embodied in the above are absolutely incorrect, and the Companies oppose a flat denial to the special charge referring to the delay in transmission of messages to France during the difficulties between France and Siam. The Eastern and Eastern Extension Companies, from the commencement forwarded instructions to every station under their control to give their most careful attention to the prompt and accurate transmission of French correspondence, and those Companies may credit themselves with having had those instructions most successfully carried out by their staff as regards the telegraph service on their own lines, as may be fully substantiated by the traffic returns and also as has been fully acknowledged by the French Government itself. It may be pointed out that neither Company has stations in Siam, where the service is performed on one side by French land-lines in connection with Cochin China, and on the other through the Government of India land-lines, as far as Bombay. A large portion of the Government correspondence with Siam was forwarded as far as Hong Kong through the Great Northern Company's lines, which is a Danish Company, and received by the same route. But the Eastern and Eastern Extension Companies affirm, and claim that they can justify the statement, that all French traffic has been transmitted with the utmost speed and the greatest accuracy from the moment it was placed in the hands of their officials until it was delivered at Marseilles to the French telegraph authorities. As the Chairman of the Companies named has frequently said in public "telegraphy knows no politics," and obviously as a matter of business it is to their interest to do their best for all their customers regardless of nationality. The Companies referred to have concessions from and carry telegrams for almost every European Government and people; but it is from France alone that complaints of unfair treatment come.

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ELECTRIC MOTIVE POWER.*

BY ALBION T. SNELL.

(*Continued from page 387.*)

Dip pumps (*see* Fig. 115), should invariably be driven by series-wound motors if continuous currents be used. Centrifugal pumps have generally a limited use in mines on account of requiring to be "primed" before they will suck water, and also because there is always a risk of the pump ceasing to act if air gets into the suction pipe; in fact, they require frequent attention. These pumps are not suitable for working against higher heads than 28ft. or 30ft. of water unless special precautions are provided for starting. They are suitable for a low head and a large volume, and will be found useful in cases where the water is too "dirty" for a force pump. A usual arrangement is shown in Fig. 116.

Fans, either main or auxiliary, should also be driven by series motors, if run off a continuous-current circuit. The electric motor is peculiarly adapted for running fans, and it is somewhat surprising that this has not been recognised more fully. The author designed a 25-H.P. main fan plant for a tin mine at Eger, in Bohemia, in 1889, the dynamo being driven by water power at a distance of about half a mile from the motor.

Coal cutters and rock drills have hitherto, with few exceptions, been run on continuous-current circuits. In order to avoid "racing" when running light both differential compound and shunt windings have been tried with indifferent success—comparative regularity of speed has been gained at the expense of torque. After numerous experiments, the author has found series-wound motors to give the best results for driving coal getters and drills. He prefers to control the speed by an external resistance. Other workers in this field have arrived at the same conclusions. But the success attained has not been sufficient to warrant the hope that coal will be got largely in the future by machinery driven by continuous-current motors.

The future appears to lie with the polyphase systems. The polyphase motor, having neither collector nor brushes, obviates the danger from sparking at the brushes—a difficulty always present with continuous-current motors. And, since the speed can never exceed that of synchronism with the generator, racing is impossible. The regulation of polyphase currents can be accomplished in a small space by means of impedance coils with *no possibility of sparking*, for no part of the circuit need be opened or shunted, as is necessary with a continuous-current resistance regulator.

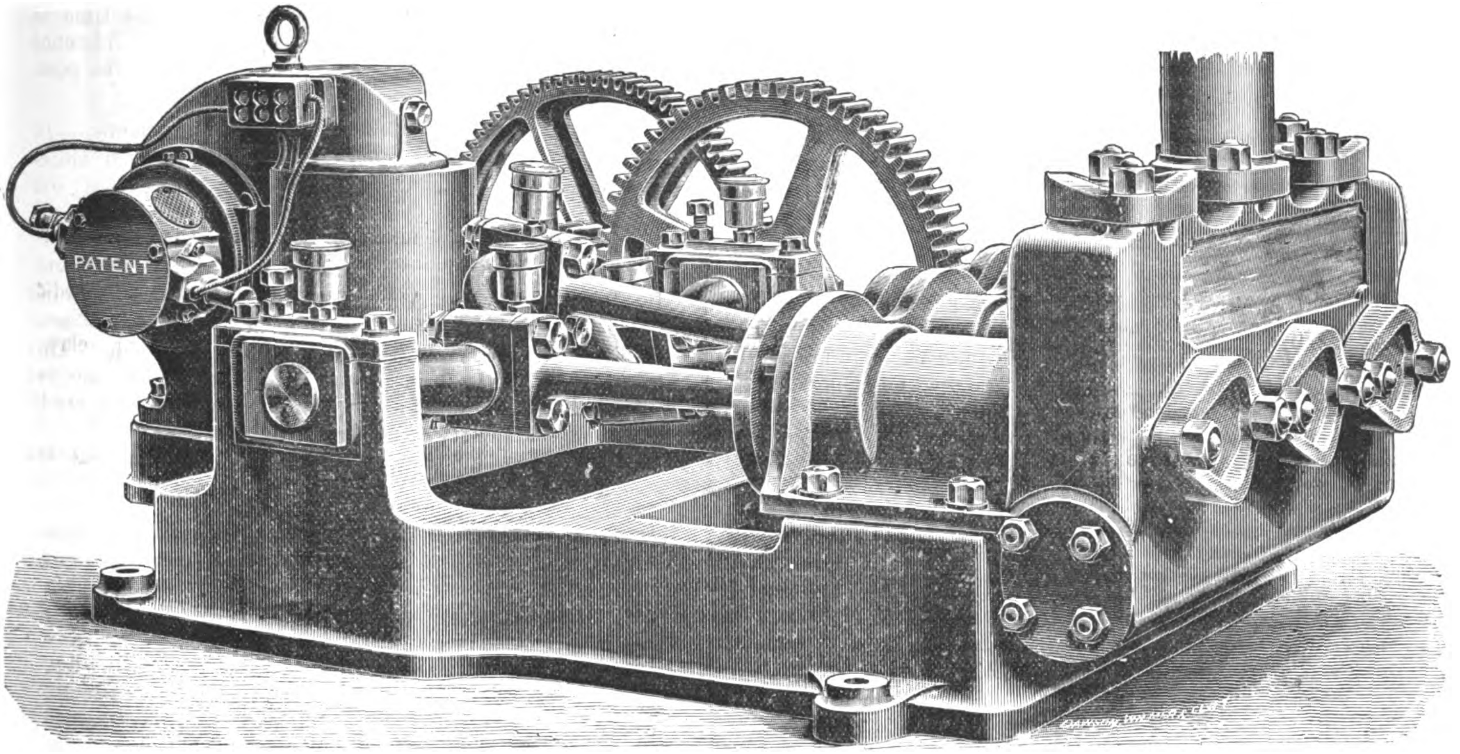

FIG. 115.—Goolden Three-Throw Dip Pumps with Safety Motor, suitable for mounting on a Trolley.

The sole point on which continuous-current motors are superior to polyphase ones, and then only with series winding, is as regards the *starting* torque. From this point of view they are undoubtedly the best and most efficient motors that can be built. The ordinary three-phase motor at starting is roughly comparable to a shunt motor—neither better nor worse.

It is usually possible, however, to start a motor before coupling it to the load if the initial torque be too great for the maximum motive effort. With drilling machines the drill can be slacked if necessary, and with coal-getters the initial torque of the motor can be made sufficiently great to start the cutter against the friction of the debris, which is all that is necessary. A "fall" should be cleared away by hand.

In driving large pumps and hauling gear, it will generally be advisable to use friction clutches, through which the load can be gradually applied after the motor has acquired its proper speed. The clutch does not entail extra expense in most cases, since its use is generally advisable and often absolutely necessary even with continuous-current motors.

Safety Motors.

Attempts have been made to design a continuous-current motor perfectly free from the risk of firing gas from sparks at the commutator, or from short circuits in the coils. It is admitted on all sides that so long as brushes and commutators are used (sliding contacts) it is impossible to work without sparks which, under certain conditions, may fire explosive gas. It is, indeed, found experimentally that the small blue sparks occasionally seen on even the best continuous-current motors are able to fire gas if the metal of the commutator become heated, as it will at times. It is, therefore, necessary to confine the explosion area to as small a space as convenient, in order to limit the effects and prevent communication to the outer air.

The first crude attempts were made in the direction of enclosing the entire motor in a metal case. It was soon found, however, that the quantity of air enclosed was too great to be safely fired, and the method was abandoned. The next obvious course was to inclose only the armature, commutator, and brushes. By suitable arrangements this can be done in a very effective manner, and the space so enclosed can be made small enough to limit an explosion to the protected area. But other

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difficulties are introduced. The design of the brush gear is complicated, and the adjustment of the brushes is rendered exceedingly difficult, especially to unskilled hands. The author has built motors for coal cutting in this manner, and Messrs. Easton, Anderson and Goolden have patented various devices with a similar object.

In Fig. 117 is shown a perspective view of the excellent safety mining motor made by Messrs. Easton, Anderson and Goolden. The general arrangement is easily understood. The armature, commutator, and brushes are encased in a metal compartment, the free space of which is small. The makers say that an explosion of gas within it cannot be communicated to the outer atmosphere. The author has had no opportunity of testing this important statement, but from his knowledge of the motor it appears to be correct, always assuming the casing is in good condition and the inspection doors properly fastened.

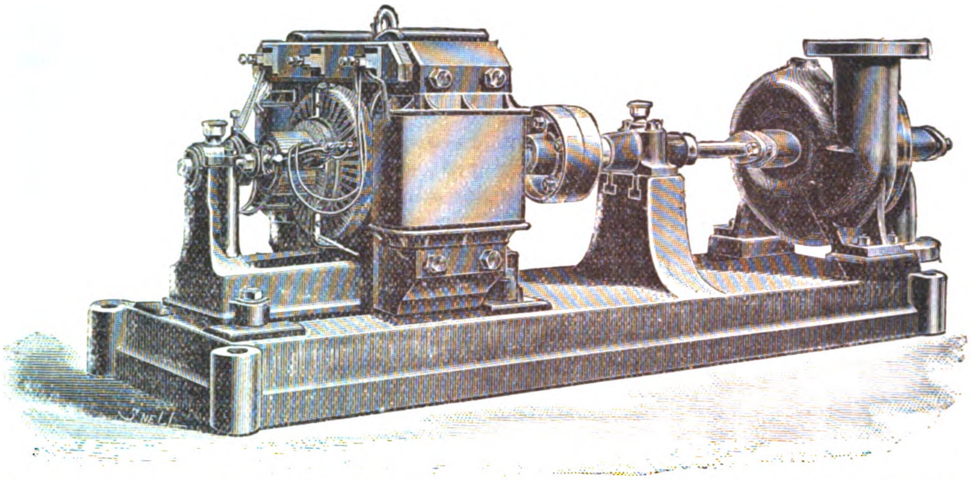

Fig. 116.—General Electric Power and Traction Company's Centrifugal Dip Pump, suitable for mounting on a trolley.

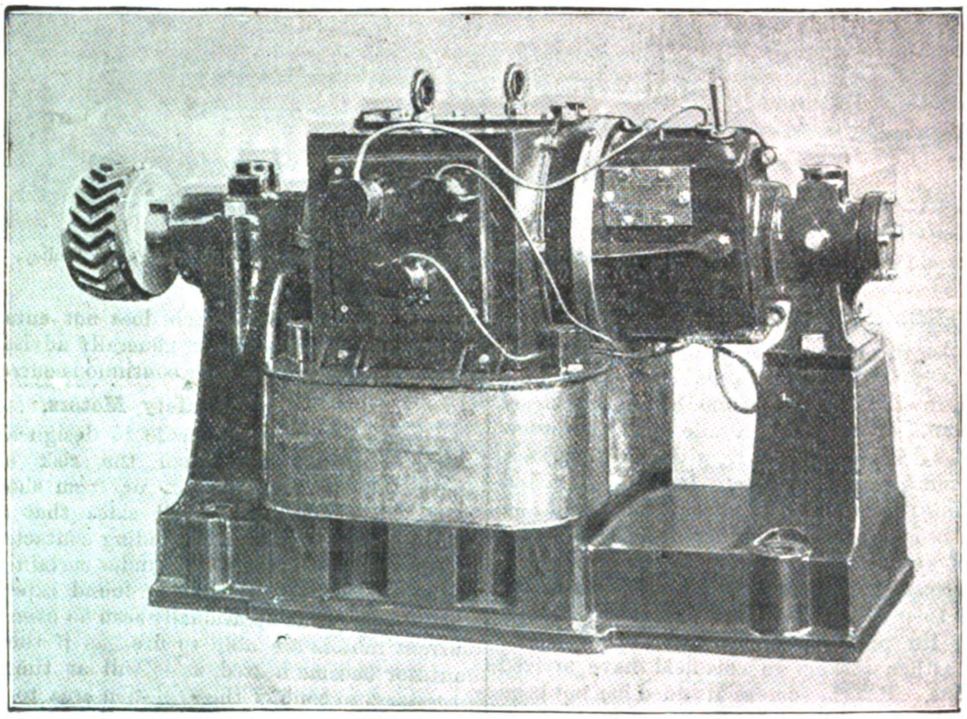

Fig. 117.—Goolden Safety Mining Motor.

Messrs. Davis and Stokes, of Derby, have invented an ingenious "safety motor," a sectional view of part of which is shown in Fig. 118. It will be seen that the commutator is inverted, and the brushes placed inside of it, instead of on the outer perimeter, as is usual. The brush arms are attached to a movable ring, sliding upon the bearing parallel to the shaft, and arranged to lock in the proper running position through a screw collar. The brushes are thus placed in a small circular space inside the commutator, the cubic contents of which in small motors is comparable with that of a safety lamp; and in even large machines can always be made sufficiently small to render an explosion within it quite harmless. It should be noticed that the brushes can only be got at by the attendant when the motor is standing, and, therefore, when there is no chance of danger. Motors of this make have been tested in an explosive mixture of air and gas by Mr. John Rhodes, at Aldwark Main Colliery, who found that, although the gas continually flashed inside the commutator, it did not communicate flame to the outside. This is, perhaps, the safest form of continuous-current motor yet invented, and been successfully used for the past four years in connection with a variety of underground work.

It is questionable, however, whether all of these designs are not chiefly important as dust protectors. (It is absolutely necessary that a motor worked on a coal face should be dust-proof.) Though the cases may fit well when new, they probably soon get loose and defective from the rough usage inseparable from the class of work, and become then useless as safety devices; indeed, they may then be a positive source of danger from the apparent security attached to them.

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The only real safeguard against explosions from sparking at brushes and commutators (sliding contacts) is to do away with them altogether, and the only way in which this is practicable at present is by the use of polyphase motors. The mechanical simplicity and excellent speed regulation of these machines have already been urged. These advantages, in combination with their safety, must gradually tell. They will necessarily oust all other types of motors for driving coal cutters, rock drills, and other machines which have to be driven in a dusty atmosphere, liable at any moment to be charged with gas.

In the author's judgment, the mining motor of the future will probably present the appearance of a circular iron box. The revolving part will have no electric connection with the supply mains, and will resemble an iron cylinder with closed

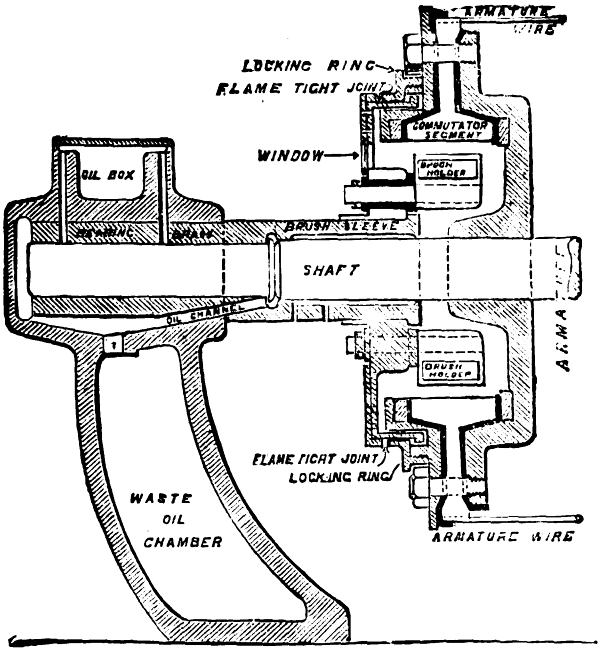

Fig. 118.—Sectional view of Davis and Stokes' Inverted Commutator as used on their Safety Mining Motor.

ends and steel shaft. A breakdown of the insulation inside the cylinder will simply affect the efficiency, *it will not cause sparking*. The windings in connection with the mains will be few in number, wound in recesses, and entirely protected from external damage by means of the outer framework. The conductors will be of the concentric type, and in permanent plants it is probable that the Pownall Safety Mining System, or some development of it, will be generally adopted. The junction boxes, switch, cut-outs, and regulating devices will be all flame-tight, and protected by oil, or air under pressure. An explosion from an inadvertent spark will be a more remote contingency than one from a safety lamp.

(*To be continued.*)

SOME ADVANTAGES OF ALTERNATE CURRENTS.*

BY PROF. SILVANUS P. THOMPSON, D.SC., F.R.S.

Amongst electrical engineers there remain a few, chiefly of the old pioneers, who have not yet grasped the advantages possessed by alternate currents over continuous currents in systems of electric supply. Superstitions still linger that alternate currents are less easy to manage, or are less economical, or are more dangerous, or are less readily measured than continuous currents. There is a special superstition that they cannot drive motors. Such superstitions once set afloat die hard. And, sad to relate, they are sedulously fostered by a few interested persons who ought to know better.

The present Paper is intended to point out a few of the more salient advantages attendant on their use, and to add a few points that have recently claimed the writer's consideration, and are not yet generally known.

It is well known that the economic transmission to a distance of electric energy depends for its success on the use of high voltages or pressure. The reason is that power depends on the product of two factors—current and pressure, and that of these two factors the former, current, involves some waste in the conductors. If large currents are transmitted at low pressures there will either be much power wasted as useless heat in the copper conductors, or else the conductors must have such large cross-section that the interest on their prime cost involves a still more serious waste. If small currents are used at high pressures—1,000 volts, 5,000 volts, 10,000 volts, as the case may be—the copper conductors may be small, and the interest on their cost a trifling quantity.

Now, this all-important fact to the electrical engineer is absolutely independent of the nature of the current as to whether it is continuous or alternating. The advantage of alternating over continuous currents comes in in the circumstance that high pressures cannot be used in houses without being transformed down to low pressures. Hence the system which admits of transformation by a stationary transformer, consisting merely of two coils wound upon a common core, is to be preferred over one that requires running machinery for transformation.

Again, it is an advantage, not only for high-voltage systems as distinguished from low, but in all systems, whether high or low, in which currents of considerable magnitude have to be collected and delivered, that there should be no necessity for employing either in the generating plant or in motors any commutators, or sliding contacts, with their adjustable brushes, and the like paraphernalia. The commutator—the indispensable adjunct of the continuous-current dynamo and motor—has long been known to be its weakest part from the engineering point of view. It is complex and costly as compared with other parts. It requires far more attention than any other part of the machine. It undergoes greater wear; and the circumstance that under conditions not far removed from normal it may give rise to serious sparking is also a disadvantage. Alternate-current generators have no commutators. Those types of alternator in which the armature revolves require indeed collecting rings (for sliding contacts) and brushes; a device to which the foregoing remarks on commutators scarcely apply, seeing they need no adjustments nor give rise to sparks. But the types of alternator now coming most in favour do not even require these (except on the exciting circuits where their disadvantages are nil), since in them the high-voltage armature parts are stationary. The only parts that need revolve are most substantial masses of iron and copper needing no special insulation in their construction, or attention in their operation. To be spared all the troubles arising from commutators and brushes is no small advantage in itself to the central station engineer.

Another advantage of an entirely different character is the greater safety of alternate currents. With them there is far less likelihood of trouble from leaks in the distributing circuit than if continuous currents were used at the same voltage. This arises from the circumstance that the electrolytic action of the alternate current is so extremely small. If there is a weak point in the insulation of a main or branch conductor, where damp can get in to form a path for leakage, the continuous current will find it out and promptly set up chemical corrosion. Corrosion, sooner or later, ends in setting up an arc, and an outbreak of fire results. The corrosions of water and gas-pipes complained of in many districts where a continuous-current supply is maintained, are unknown where alternate currents are used. The danger to life for equal voltages is, I think, now established to be greater with continuous currents than with alternating, as their destructive action on the tissues is greater.

Again, it is no light matter that while in a continuous-current supply there is but one way of moderating or regulating the strength of the current which flows to a lamp or motor from the supply mains at a given pressure, there are two modes of regulation possible if the supply be one with alternating currents. In the continuous current case we regulate by introducing resistances which regulate by wasting power. It

* Paper read before the British Association at Oxford, Section G.

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is as though, when we wanted to put a slow speed on to a power lathe, we did it, not by changing the gearing, but by putting a grindstone on the same piece of shafting, and slowed it down by grinding something that would waste the power. But in the case of alternate currents—though we may still, if we please, regulate by wasteful means—we have another and non-wasteful way available in regulation—namely, the use of so-called *choking coils* or *reactance coils*—which operate by setting up opposing electromotive forces in a purely automatic way, damming back the currents instead of wasting them. The use of choking coils is destined to find a very great increase in services of this kind.

It would be travelling too far from the range of this Paper to enter to any great length upon the work that has been done during the past five or six years with combinations of two, three, or more alternate currents in different phases. Two-phase and three-phase combinations of alternate currents, using three or four wires for their transmission, instead of the ordinary two-wire system of conductors, are now quite well known, and their advantages in special cases are fully recognised. Of course, it will be at once replied that any phase-system of currents that is a combination of two or three alternate currents, and requires three or four wires instead of two, cannot be entirely an advantageous system as compared with simple continuous currents, being more complicated. This is very obvious; and yet the fact remains that with two-phase and three-phase systems of currents one can accomplish results which the simpler systems cannot accomplish, and meet conditions which the simpler systems cannot meet. Without attempting any complete exposition of the phasal systems, let one or two points suffice for remark. It has been found essential, or at least advantageous in those districts where continuous currents are used on a large scale, to depart from the sweet simplicity of the two-wire system, and, in order to economise in the total cost of copper in the mains, to adopt a three-wire, or a four-wire, or even a five-wire distribution, so that sweet simplicity is not always on the side of continuous currents. Again, if a three-wire three-phase system of alternate currents is used, the total weight of copper needed in the conductors (at equal voltage) is less than in the ordinary two-wire system for an equal amount of power, whether that two-wire system be with continuous currents or with alternate currents. The main advantage of three-wire polyphase alternate-current systems (whether three-phase or two-phase) is, however, the greater facility that they offer in the handling of motors, since they are more readily made self-starting than is the case when merely single alternating currents are supplied on a two-wire system of distribution.

At the Electrical Congress of Chicago, in the debate on a Paper by Mr. Scott, of the Westinghouse Company, upon polyphase systems, the writer expressed the opinion that, while a polyphase system was adopted to the case of the transmission of power from a single generator to a single motor, in the generality of cases in which the power was to be not only transmitted, but distributed to a number of motors at independent points, the greater simplicity of the simple alternating current would render it preferable now that self-starting motors were in the market. Bearing, however, in mind the advantages to be derived in the possibility of using two and three phase motors, the author gave considerable thought during the winter to the problems of transformation, and particularly to the question whether it might not be possible to transform alternating currents from two-phase to three-phase, or from either of these to single phase, or *vice versâ*. No mode of doing this was known save by the combination of moto-generators as running machines. As one result of his cogitations, he found that such transformations might be readily be effected by stationary transformers, or, in the least easy case, by stationary transformers with a revolving iron core. The simplest case—that of transforming three-phase currents into two-phase, or *vice versâ*—involved no moving parts, being effected by using a ring-coil (or its magnetic equivalent) with connections made appropriately. A simple ring transformer (without revolving core) was shown by the author at his lecture on the transformations of electric currents, at the Royal Institution, on February 23, 1894. It is of some interest to note that on March 7th Mr. Scott read an elaborate Paper to the American Institution of Electrical Engineers, in which he gave an independent solution to the very same problem, using two sets of windings (instead of one), but working out in detail many possible applications.

It is no exaggeration to say that an electrical engineer, starting, let us say, with three-phase alternate currents as the method of supply, is in a position to furnish any customer who may desire either two-phase currents or single-phase currents with what he desires by merely putting in a small appropriately connected transformer.

Another advantage, about which even electrical engineers are as yet almost wholly unenlightened, arises in the application of alternate currents to electro-magnets. Great as have been the services of electro-magnets, as used with continuous currents since their invention in 1825, they are destined to fulfil wider services than ever in practical problems of an electro-mechanical nature now that their properties, when supplied with alternate currents, are becoming known. In 1887 Prof. Elihu Thomson discovered a number of singular properties of alternate-current magnets in producing repulsion of copper discs, and rotation of cylinders and balls by reason of the eddy-currents induced in them. During the past winter the author has been studying the design, construction, and properties of alternate-current magnets, and recently, in conjunction with his assistant, Mr. Miles Walker, read a Paper on the subject before the Physical Society of London. A few words on this topic will emphasise the advantages offered by alternate currents in this application. It has long been known that the magnetic forces of a magnet fall off very rapidly at small distances from their poles. For steel magnets, in those cases in which the poles can be considered as points, the force falls off inversely as the square of the distance, other things being equal. In the case of soft iron electro-magnets operated by continuous currents, the pull on their armatures falls off much more rapidly than this. The forces when in contact may be relatively enormous, and yet the magnet may have no range of attraction worthy of mention. A pull of 150lb. in contact may dwindle to a few ounces at a distance of a couple of inches.

But with alternate currents supplied at constant voltage from the mains, the author finds all this to be different. With a properly-designed and well-constructed electro-magnet, the pull on its armature can be kept fairly constant over a considerable range; nay, in some cases can be caused to be *greater at a distance than when near*. For example, the author has lately had an alternate-current magnet constructed for him by Mr. Walker, the pull of which, when excited at 50 volts, was 8oz., when the armature was closely in contact with the core; but which exercised a pull of 32oz. when the space between them was 3 inches. This obviously introduces into electric mechanism a new element hitherto undreamed of.

The secret of these things is that in the case of alternate-current electro-magnets, the self-inductive reaction of the system, and not the mere electric *resistance* of the wires, is that which governs the flow of current. Whereas Ohm's well-known law for continuous currents is

$$\text{Current} = \frac{\text{electromotive-force}}{\text{resistance}} \text{ or } C = \frac{E}{R},$$

The rule that governs the alternate current in these cases is different, being

$$\text{Current} = \frac{\text{electromotive-force}}{\text{reactance}} \text{ or } C = \frac{E}{pL},$$

where p is the *pulsation* of the alternate current (*i.e.*, the number of radians per second in the revolution of the circle of reference) and L the inductance.

As the armature of the alternate-current magnet is withdrawn from the core the reactance diminishes and more current flows, making the pull greater at a distance instead of less.

Another curious point about alternate-current magnets relates to their winding. In the case of electro-magnets supplied with continuous currents it is well known that the more turns of wire that are wound on the core, the more powerfully is it magnetised. But with alternate-current magnets this is not so. There is one particular number of

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windings for each magnet, generally a small number, for which the magnetism is a maximum, and any additional wire wound on above this number *diminishes* instead of increasing the magnetic power.

Returning from this digression respecting magnets to the general question of the supply of alternate currents, the author has finally to point out one further set of advantages hitherto both neglected and unknown in this country, though known to a few, and actually in use in the United States.

One of the difficulties which beset the distribution of electric currents on the large scale, is that of maintaining constant, at all points of the network of conductors, the voltage, or pressure, at which the current is delivered to the consumers. Between the generating station and the centre of distribution there occurs a loss of pressure (comparable to the loss of head in the case of water-power) and, beyond the centre of distribution, between it and the points of consumption, in the house lamps, there is a further drop in the voltage. The former drop in the voltage can be compensated for by due arrangements at the central station, but the further drop between the distributing centre and the consumers' houses, though it may be guessed at and partially compensated by some system of over-compensating at the distributing centre, cannot be accurately compensated. The result is that the consumers' lamps do not receive their supplies of current at an unvarying pressure. Now, in the case of continuous-current distribution, the only cause for drop in the voltage at distant points is the resistance offered by the conducting wires leading to those points. The drop due to such resistance—or ohmic drop—is proportional to the ohms of resistance and to the amperes of current. Suppose a group of lamps requiring 20 amperes at some outlying point, the wires to which have a total resistance of only $\frac{1}{10}$th of 1 ohm. The drop in voltage due to the ohmic resistance will be $20 \times \frac{1}{10} = 2$ volts. The lamps, which ought to receive their currents at a pressure of 1,000 volts only receive it at 98, and burn dimly in consequence. But in the case of alternating currents there is a second or additional cause of drop, which has hitherto been held to be a serious disadvantage in their use, namely, a drop due to the self-inductive action of the lines reacting and setting up back-electromotive force, and tending to choke the current. In general, this second or inductive drop is not serious, the mains and branches being arranged concentrically for the purpose of avoiding it as far as possible. But it may become serious when motors as well as lamps are employed upon the circuit, because of the considerable inductive reactions that are set up in the electromagnetic operations of these machines.

Alternate-current motors are of many sorts, but may be grouped under two chief classes, the synchronous and the asynchronous. Synchronous motors are those which only run at one fixed speed—determined for them irrespective of their load—a speed determined solely by the number of their own poles and the number of the alternations imposed upon the current by the generating machinery at the station. They must either run in synchronism with the pulsations of the current, or else not run at all. The other class, the asynchronous, are mostly polyphase machines requiring two-phase or three-phase currents to operate them. The phase currents, led into a suitable armature, there combine to produce a rotating magnetic field, and in this rotating field masses of iron or iron carrying closed circuits of copper are set into rotation, being magnetised inductively, and dragged round by the reaction of the eddy-currents induced in them. The rotor, or rotating part of the asynchronous motor, may be regarded as a revolving field-magnet, not magnetised by any special exciter, or initially, but magnetised only by the eddy-currents induced in it. Now, if it could spin at the same rate as the revolving magnetic field that surrounds it, there would be no relative motion, no eddy-currents, no reactions, and no driving force. It is driven by forces which depend for their existence upon the rotation not being synchronous with the pulsations of the currents in the circuits. Within certain limits it adjusts its speed so that its magnetic slip is proportional to the turning moment which it is called upon to exert.

Now, owing to these necessary reactions the asynchronous motors produce upon the mains which supply them an inductive drop, and cause the pulsations of current to lag in phase behind the impressed pulsations of voltage. Whereas the ohmic drop is not accompanied by any lag of phase in the current, the inductive drop is so accompanied. Happily, with alternate currents there exists more than one remedy. It has long been known that a condenser exercises a reaction of another kind, which, though it tends to choke the currents, does so not by retarding the phase of the pulsation, but by accelerating it. This precious property has long been known and used in submarine telegraphy to compensate, by the use of condensers, the retardations of the signals. But to apply condensers to systems of alternate current supply for the purpose of counteracting the inductive drop when motors are used would be a rather formidable task—the remedy is too heroic for the malady.

A remedy of a different kind is, however, possible, and must before long become general when its advantages are known. To explain it we must return to the subject of synchronous motors, about which little has been said. It was shown in 1868 by Wilde, and in 1879 by Hopkinson, that two alternate current machines could run together synchronously, one as generator, the other as motor, the one which served as motor adjusting itself so that its pulsations of electromotive force tended (as in all motors) to oppose those of the impressed electromotive force. In 1884 Dr. Hopkinson further predicted that an alternate current machine could run as motor, even if its mean electromotive force was higher than that of the circuit, a result verified in practice by Mr. Mordey in 1890. In 1892 Mr. Mordey gave at the Institution of Electrical Engineers some further results of alternate current working, including a very remarkable curve, showing the dependence of the armature current upon the excitation of the field magnets of the motor when loaded with a given load. To this curve and its meaning the author directed attention at the time, and he has since given much thought to it. It will be found to be most significant. The curve presents the form of a letter **V**. The lowest point corresponds to a particular state of things; namely, that the motor having its magnetism excited to a particular degree, draws a certain minimum amount of current from the mains in order to drive its mechanical load at the speed imposed upon it. But, to do the same work—drive the same load at the same speed—will take more current from the mains if the excitation of the magnets is either more or less than this particular amount. This seems very strange; but the explanation and its consequences are no less so. The particular stage of excitation which makes the armature current a minimum for the particular load in question is that stage which corresponds to there being no difference of phase between the pulsations of impressed voltage and those of the resulting current. Suppose, for example, the armature had a resistance of $\frac{1}{2}$ ohm, and that the current was supplied at 100 volts, and that a current of 10 amperes was found to be the minimum current that would drive the load, it would be found (approximately) that the excitation corresponding to this minimum current would be such as would make the motor work with a back electromotive force of 95 volts; for then, by Ohm's law, $(100 - 95) \div \frac{1}{2} = 10$ amperes. But, now, suppose the excitation is lessened, the machine acting at the same unalterable speed will generate less than 95 volts; suppose it drops to 90 volts. Then, if nothing else happened, the current would increase to $(100 - 90) \div \frac{1}{2} = 40$ amperes. But 40 amperes at 90 volts is much more power than 20 amperes at 95 volts, and is more than is wanted for the load—what must happen? The machine is synchronous, and cannot—physically cannot—run faster, so as to take up this power. It tries to do so, with the result that it shifts the phase of its reactions, the current now lagging in phase behind the impressed electromotive force—choked down, in fact, from the 40 amperes to something more than 20—choked down, in fact, to such an amount as would, if multiplied by the cosine of the angle of lag, and by the 90 volts, come up to the same product as the original volts and amperes, namely, $95 \times 10 = 950$. The synchronous motor, *if under-excited*, acts then as a choking coil, producing a reactive drop. But continue the argument the other way: Suppose the excitation is increased so that the 95 volts become 100 volts $(100 - 100) \div \frac{1}{2} = 0$; and there would

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be current at all to drive did not again an adjustment of phases come into play. Instead of the current dropping to zero, more current than before now comes into play, and that current has its pulsations in advance of those of the impressed voltage, there being now an angle of *lead* in the phase relations. In other words, the synchronous alternating motor, *if over-excited*, acts as a condenser, and, instead of producing a drop in the voltage, tends to raise it by compensating the inductive drops due to self-induction in other parts of the circuit. When the importance of this deduction from Mr. Mordey's curve dawned upon the author he began to prepare to test it upon the mains of the City of London Electric Lighting Company. But before any experiments could be even arranged, he learned that the same conclusions had been arrived at by the officials of the General Electric Company, at Lynn, Massachusetts, and that they had found it in practice to work out favourably. By the courtesy of Mr. W. F. Parshall, one of the engineers of that Company, who has been associated for long with Prof. Elihu Thomson, Mr. Steinmetz, and other engineers, the author is able to state the following particulars: They found that in a line where self-induction played the part of choking coil, it did not matter very much whether the voltage needed for driving the current through the line and machines were situated mainly in the generator or in the motor, as the mean voltage in the line was not far from a mean between that of the two. Accordingly, in a three-phase power transmission at Hartford, Connecticut, of 300 kilowatt output, the motor was arranged to be over excited. Later, after Mr. Steinmetz had submitted the question to calculation, this feature was introduced into the synchronous motors used in all their recent power transmissions, so that by proportioning the armature reaction and the over-excitation to the self-induction likely to arise, the voltages on the circuit remain quite constant regardless of load within the limits of the capacity of the machines. In thanking Mr. Parshall for this information, I may add two points of comment. The advantage so to be derived from over-excitation have indirectly another advantage—namely, that for single transmission cases the motor and the generator may be designed and constructed as identical machines, instead of the motor being made smaller than the generator. Further, the regulation of the voltages in such a network as that of the City of London Electric Lighting Company, instead of being made more difficult when motors are much used—as was feared by some engineers—will be more easy, provided the motors are of the over-excited synchronous type. For the acceleration of phase these produce in the current not only tends to compensate for the inductive drop in mains and transformers, but tends to react right back through the system to the generators in the central station, acting on them as a compound-winding would do, and assisting them not only to counteract the inductive drop, but also the ohmic drop, both between the consumers' lamps and the distributing points, and also between these points and the generating station.

So manifest is this advantage that it would seem worth while to erect at one, or possibly more, points of the network, as remote as possible from the generating station, synchronous motors over-excited, to act as condensers in compensating the inductive drop; or in the primary circuit also, to furnish the idle currents for magnetising the transformer primaries.

With such possibilities open in the future for alternate-current working, and with such advantages in respect of motive power, over continuous-current working, it can hardly be doubted that, save in a few special cases, the vast majority of central stations will henceforth be operated by alternate currents.

ON THE CONSTRUCTION OF DELICATE GALVANOMETERS.*

BY ARTHUR SCHUSTER, F.R.S.

Several attempts have recently been made to increase the sensitiveness of galvanometers; but I have not seen any calculations on the limits which it is possible to reach, or on the advantages gained by winding in the theoretically best manner.

* Paper read before the British Association at Oxford Section A

Maxwell has shown how a coil would have to be wound, so as to give the maximum magnetic field for a given current. A certain space must be left free at the centre of the coil, so as to make room for the magnetic needle, and the sensitiveness will depend on the form and dimensions of this space. We may take the case of a spherical or cylindrical cavity, as these lend themselves most easily to a numerical calculation.

Let the following notation be adopted:—

G = the magnetic force at the centre of the coil for unit current.

R = the total resistance of the galvanometer.

ρ = the specific resistance of the wire used.

a = the radius of the spherical or cylindrical cavity in which the magnet is suspended.

β = the ratio of the diameter of the wire without its insulating covering to the diameter of the wire without that covering.

Then, for a galvanometer wound in the best possible way with a spherical cavity, I find

$$\frac{G^2}{R} = \frac{2\pi^2}{3}\,\frac{\beta^2}{\rho a} = 6{\cdot}58 \times \frac{\beta^2}{\rho a};$$

for a cylindrical cavity

$$\frac{G^2}{R} = \frac{3\pi^3}{16}\,\frac{\beta^2}{\rho a} = 5{\cdot}81 \times \frac{\beta^2}{\rho a}.$$

It has been assumed in the calculation that, with the exception of the cavity, all space is filled with windings, the outer layers contributing, of course, very little to the result. In practice the most important case is the one in which the groove in which the windings are laid has a rectangular section. Weber has calculated the best dimensions for such a groove, assuming the wire to be uniform throughout, and neglecting the thickness of the covering. With Weber's dimensions I find

$$\frac{G^2}{R} = 3{\cdot}22 \times \frac{1}{\rho a}.$$

If the groove is rectangular, and the wire of the same thickness along each layer, but different in different layers so as to give the best result, I calculate

$$\frac{G^2}{R} = 3{\cdot}97\,\frac{\beta^2}{\rho a}.$$

In the last case the length of the cylinder on which the wire is wound should be nearly twice its diameter.

In some of the very delicate galvanometers which have recently been constructed attention was paid chiefly to making the moment of inertia of the suspended parts as small as possible, so as to be able to render the system more astatic without the time of vibration becoming too great.

As regards the magnets there is no doubt a great advantage gained if they are made short and light; but in one galvanometer which I have examined much of the good that was done by reducing the weight of the magnets was undone by reducing too much the size of the mirror. The angle, which can be read off by means of a mirror galvanometer, is proportional to its width. The small mirrors of only about 3mm. width, which are used, are difficult to obtain with a good surface, and it seems to me to be better to risk even a small increase in the time of vibration, if we can read the deviations of the galvanometer with greater accuracy. If the magnetic system is made up of a sufficient number of short magnets placed side by side, the magnetic moment may be increased almost in the same ratio as the moment of inertia, so that we may secure a short time of vibration, together with a mass sufficiently great to allow us to attach a mirror of one centimetre width without materially increasing the period. . . . The weight of the mirror may be reduced by diminishing the vertical dimension, which does not take away from the resolving power.

In order to give an idea of the smallest current which we may expect to detect with a galvanometer of given construction, I have put together a few examples. I take the smallest angle, which is readable with a mirror of diameter d, to be $\lambda/2d$, where λ is the wave-length.

We may, for the purpose of comparison, take the case of a galvanometer wound with copper wire, having one ohm resistance and neglect the thickness of the covering material. If

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we take a mirror of one centimetre width and let the cylindrical or spherical space left free for the suspended parts have to also a diameter of one centimetre, if, further, the earth's horizontal force is taken as 0·17, the smallest readable current in amperes is, with a non-astatic system of magnets, as follows:

Description of galvometer.	Smallest current in amperes.
A galvanometer with spherical cavity wound in the best possible way	$1·50 \times 10^{-8}$
A galvanometer with cylindrical cavity wound in the best possible way	$1·60 \times 10^{-8}$
A galvanometer with bobbin of rectangular section, and wire of uniform thickness the dimensions of the bobbin being the most favourable	$2·14 \times 10^{-8}$
A galvanometer with bobbin of rectangular section, and wire of variable thickness wound in the best possible way	$2·00 \times 10^{-8}$

The advantage gained by winding with wire of varying density is, therefore, not very marked.

If the dimensions are altered, we may say that the sensitiveness increases inversely as the square root of the cavity, directly as square root of the resistance and as the width of the reflecting mirror. It will not be convenient, however, to increase the width of the mirror beyond one centimetre, as it would be inconvenient in that case to apply sufficient magnifying power to make full use of the aperture, even if sufficiently perfect and light mirrors could be obtained.

THE EQUALITY OF THE VELOCITIES OF PROPAGATION OF VERY SHORT ELECTRIC WAVES IN FREE SPACE AND ALONG CONDUCTORS.*

BY M. DUFOUR.

The equality of the speeds of propagation of electric waves in free space and along conducting wires has been established by MM. Sarasin and de la Rive † for waves between 80cm. and 8m. Hertz had already ascertained the equality of the two velocities for wave lengths of about 30cm.‡ My research was made with a view of seeing whether this equality persisted for still shorter wave lengths.

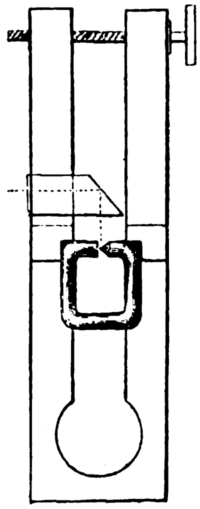
The exciter which I made use of consisted of four copper spheres 2·5cm. in diameter, the centres of which were on a straight horizontal line, and about 2·8cm § apart. They were immersed in vaseline oil. The two outside spheres were connected to the poles of a Holz machine by wires enclosed in tubes of thick india-rubber. Sparks pass between the balls, and the exciter works like that of M. Righi ;¶ it gives rise to electric waves which are propagated in free space. When one wishes to investigate the propagation of waves along conductors, two little copper plates, from which the line wires start, are placed in the vaseline opposite the two middle spheres.

The resonator was a square frame made out of a piece of thick copper wire, the spark gap being in the middle of one of the sides. One of the terminals was pointed, the other rounded (*see* figure); their distance apart was diminished by giving the frame a slight bend. To effect this the portion near the spark gap was fixed, as shown in the figure, near the centre of the arms of a sort of wooden compass, the elasticity of which tended to pull the terminals apart, and they were closed up by a screw which acted on the ends of the arms of the compass, and permitted of a very delicate adjustment. Finally, by means of a total reflection prism suitably arranged the observer was able to see the sparks without being obliged to place his head in the field. The construction and adjustment of square resonators becoming impracticable when the dimensions are very small, I had recourse in studying very short wave-lengths to circular resonators formed by a strip of copper.

In order to determine the wave-length of a resonator in free air, it was arranged vertically (with the spark gap either at top or bottom) between the exciter and the sheet of copper 35cm. by 38cm., which acted as the reflecting mirror. When this sheet was moved the secondary sparks stopped and started. The positions of the mirror at which the sparks disappeared as the node was approached first in one direction and then in the other was noted. As the adjustment was improved the distance between these non-sparking positions was reduced, and the mean was taken as the position of the node. In this way several successive nodes were determined.*

In experimenting with conducting wires I stretched these parallel to one another in an horizontal plane. The resonator was arranged between them in the same plane, so that the spark gap was equidistant from the two wires. A conducting bridge was displaced along the wires, and the position of the nodes was determined as before.

I worked with six resonators; the resonators I., II., III. were made of 0·85cm. copper wire, the sides of the squares being respectively 6·5cm., 4·4cm., and 3·2cm. Resonator IV. was of 0·5cm. wire, the sides being 2·1cm. in length. Resonator V. was circular; it was of copper strip 0·2cm. thick and 0·55cm. wide; the circle was 2cm. in diameter. Resonator VI. was also circular; its diameter was 1·2cm., the copper strip being 0·2cm. thick and 0·9cm. wide. The first column of the following table gives the number of the resonator, the second the wave-length in free space; the third, under the heading of "Distance of extinction," gives the



mean distance of the two non-sparking positions near the node; the fourth and fifth columns give the corresponding values when the waves are propagated along wires:—

Resonator.	λ (free space).	Distance of extinction.	λ (wires).	Distance of extinction.
	cm.	cm.	cm.	cm.
I.	58·0	4·0	57·0	3·0
II.	40·0	4·0	40·5	3·0
III.	21·0	3·0	20·5	3·0
IV.	16·0	2·0	16·0	2·0
V.	13·0	1·5	13·0	2·0
VI.	8·5	1·3	8·5	.. †

I repeated the measurement of the wave-lengths of several of these resonators in free space and along wires, making use of a smaller exciter composed of four spheres 1·3cm. in diameter. The effects were more feeble, and the measurement of the internode less precise; but I observed no variation whatever in the wave-length.

In conclusion I may remark that my investigations allow us to extend the assertion of MM. Sarasin and de la Rive to wave-lengths as small as 8·5cm. The velocities of propagation in free space and along conductors remain the same for small wave-lengths.‡

* *Comptes Rendus*, Vol. CXVIII., No. 19, p. 1,039. (May 7, 1894.)

† Ed. Sarasin and L. de la Rive. *Archives des Sciences, Physiques, et Naturelles*, Vol. XXIX., p. 358 and 441 (1893). *See* also *The Electrician*, Vol. XXX., January 6, 1893, p. 270.

‡ *Untersuchungen über die Ausbreitung der Elektrischen Kraft*, p. 19.

§ There is an advantage in separating the spheres as much as possible, since the intensity of the effects produced by the exciter increases with the distance separating the spheres.

¶ A. Righi. *Atti della Reale Accademia dei Lincei*, 5th Series, Vol. II., p. 505 (1893).

* The smallness of the secondary sparks rendered micrometer methods, and the measurement of the intensity of the field by the length of the sparks, inapplicable. I only made use of the method of the extinction and the rekindling of the sparks in determining the internode. I arranged the resonator parallel to the mirror, because in this position the sparks are more powerful than when it is arranged horizontally. It should not be either too far from nor too close to the exciter; in the one case the phenomena would be too feeble, in the other the direct influence of the source would predominate.

† Resonator VI., placed close to the wires, only sparked when in the immediate vicinity of the antinodes. The wave-length given in the table is the distance between the two positions of the bridge corresponding to the first and third antinodes.

‡ Investigation carried out in the Physical Laboratory of the Science Faculty of Nancy.

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IN PRAISE OF ALTERNATING CURRENTS.

Amongst electrical engineers there remain few who have not yet grasped the fact that under certain disadvantageous circumstances there is no choice but alternating currents or nothing. Herein lies the merit of this system: that it can manage to serve a straggling or poor district with more or less satisfaction to consumers, profits to shareholders, and some day, no doubt, reduction of rates to ratepayers. The Paper read before Section G by Prof. SILVANUS P. THOMPSON, and which we print elsewhere, assumes that the alternate *v.* continuous current controversy is at an end. In a sense this is true enough, but not, as he would tell us, because continuous currents have no chance. The question really is: at what point must continuous current be dropped? This admits of two answers; the one a simple question of radius, fixed by Dr. FLEMING at about one mile of feeder—that is to say, about one and a-quarter mile radius of supply; or it may be treated from the point of view of lamp density over a district, as at Bournemouth, where the successive houses are hardly within sight of each other. No careful comparison of economies, or analysis of losses was put forward by Prof. THOMPSON to aid the decision which has day by day and town by town to be made by impartial consulting engineers; but, putting aside all the real success that has been made with continuous currents, he proceeded to recite "the more salient advantages" of alternating currents, and began with a cleverly worded sentence which seems, unless carefully examined, to imply that these advantages so largely preponderate that none but a few old duffers think that any choice remains. The first paragraph ends with an amusing reference to "interested persons who ought to know better," as if the advocates of alternating currents worked for

the love of the thing, or for the public good, while the continuous current men alone were greedy enough to make a living out of the business. It is our duty to be impartial in this matter, and therefore, when a one-sided Paper makes its appearance, it is our business to criticise it. Had it glorified continuous currents our duty would have remained the same, but our task might have been more difficult.

The first topic naturally was pressure, and, as usual, low pressure was bracketted with continuous currents and high pressure with alternating, as though such a union were inevitable, and as though the laws of Nature forbade a continuous current of 5,000 or 10,000 volts. In fact, alternate currents effect a saving of copper—a fine old time-honoured delusion! Having assumed for a moment that such a thing as a dynamotor or continuous-current transformer was possible, he crushed it at once by "troubles arising from commutators and brushes," as though these were quite sufficient to settle the matter. It would be stepping perhaps beyond our impartial position if we accepted Dr. FLEMING's calculation of the one mile feeder, for we should then be compelled to admit that the City of London supply from Bankside could be better done with continuous currents. That the private lighting would have been more satisfactory than has hitherto been the case admits of little doubt; but that is another matter, for all such criticism is disarmed by the incomplete state of the plant. But, taking the lighting of the City, it is really a pity that no information whatever has been published by which a comparison of the first cost and working expenses of transformer sub-stations and dynamotor sub-stations may be made. Neither in Mr. PARKER's Paper nor in his remarks on Prof. THOMPSON's Paper was there a word about this, and if such information cannot be obtained from Oxford, where shall it be sought? From Chelsea, of course, no useful information can be expected.

It is no light matter, says Prof. THOMPSON, that while in a continuous current supply there is but one way of moderating or regulating the current, two modes are possible if the supply be with alternating currents. This is all very well in a lecture-room, but is it not a fact that in practice a long distance transmission where power is valuable, and must be carefully regulated and distributed, a continuous current is the only practicable method; but where there is plenty of power, and the surplus can run to waste, and especially where a single generator drives a single motor, polyphase or other alternators can be employed? A solitary disadvantage or two crept into the Paper by accident. It was admitted, of course, that the ohmic drop of volts in wiring is unavoidable; but the two other drops, that due to induction of the mains and that due to transformers, are felt only by users of alternate currents. The former of these may be reduced by the use of concentric mains, with their by no means simple joints, and the latter by the use of large and expensive transformers; both of which must be set off against the saving of copper, which is the main advantage of high pressures. The difficulties of synchronous motors were alluded to, and the intricate way out of these difficulties—by two-phase and three-phase currents—was pointed out. The unfortunate lag of phase due to inductive drop was admitted, and the lecture-room remedy—namely, condensers—was suggested; but not a word about how such currents or how the power is to be measured. So truly ingenious are these alternate current men, and so impressed are they of the infallibity of their system, that they seem rather to exult in these impediments, and at all events keenly delight in the invention of means to surmount them. The poor continuous current man has not had the opportunity of enjoying a single important improvement—except, perhaps, the Sayers winding—for several years, so lamentably simple, so faultily faultless is his plant, so childishly artless are his ways. A rather long account of the complicated system of adjusting the excitation of a motor was given, and the last paragraph but one actually contemplated the erection at one or possibly more points of the network, as remote as possible from the generating station, of synchronous motors over-excited to act as condensers in compensating the inductive drop; or, in the primary circuit also, to furnish the idle currents for magnetising the transformer primaries! How do alternate current men like this? The opinion has been expressed that "it goes without saying that it was an important addition to our knowledge on the subject, and it is to be hoped that the matter may be brought before the Institution of Electrical Engineers for adequate discussion;" perhaps the alternate current men are saying "save us from our friend!"

The climax of this Paper is brief and clear. "With such possibilities"—why not call them interesting complications?—"open in the future for alternate current working, and with such advantages"—such advantages!—"in respect of motive power, over continuous current working, it can hardly be doubted"—by a man who keeps his eyes shut—"that, save in a few special cases, the vast majority of central stations will henceforth be operated by alternate currents." We should be very reluctant to harshly criticise the carefully-thought expressions of a man of zeal, of conviction, and of purpose; but we have Prof. THOMPSON's own statement that this Paper was only a bit of special pleading; and, even if we had used severe language, it would fall as harmlessly as the fierce words which counsel hurl at each other in the law courts. Prof. THOMPSON is no manufacturer committed to bolster up a lot of expensive patents, he is no inventor of motors, transformers, or other apparatus, and bound to prove that they are indispensable to his system, and that his system is the only practicable one. Such individuals are often thin-skinned, and it is cruel, if not dangerous, to belittle their fads. It is difficult, when such a Paper is brought so prominently before the public, to maintain a strictly impartial position. Some eighteen months ago Dr. FLEMING proved as well as figures could prove, and as yet without refutation, that taking the all-day efficiency of a three-wire feeder one mile long, and delivering 24 kilowatts at 200 volts, and the all-day efficiency of a 24 kilowatt transformer and losses in a double 7/16 primary cable one mile long, that there was practically nothing to choose between the total annual costs. But we then observed that there was still plenty of room for alternating currents under certain circumstances, and that we thought that Dr. FLEMING had rather overdone his comparison, and we were loth to believe that the result was so greatly in favour of continuous currents as his calculations showed. Since then transformer efficiencies have improved, and since then also a five-wire system has been successfully worked. Prof. THOMPSON's Paper suggests that choking coils, condensers, over-excited motors and polyphase currents may be required, to say nothing of more or less automatic complex sub-station switching gear and station synchronising apparatus, to which he made no allusion. The continuous current system needs none of these, and will therefore hold its own, nor can it be excluded from the alternate current stations themselves, for attention must even there be paid to the greatly dreaded commutators and the mischievous brushes.

But we are thoroughly impartial, and are convinced that a majority, and perhaps a considerable majority, of *future* stations will generate alternate currents, for the simple reason that Manchester, Liverpool, Birmingham, Glasgow, and Edinburgh, and other important cities and towns, are

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committed to the continuous current system, which has proved so successful in London. In London, at the beginning of this year, there were about 373,000 lamps supplied by continuous currents, and about 320,000 by transformers. This is no test of merit, nor would the dividends, though exhibiting a striking difference in favour of the former, give a basis for comparison. The fact is that the continuous-current men seized on the cream of the districts, and the alternate current men had to put up with what other parts they could find. In the provinces there were 235,000 lamps on continuous currents and 181,000 on alternating current mains; and this, largely for the same reason, but not altogether; for the five largest cities were well advised in adopting the system which is so admirably suited for densely-populated districts.

There remain, as we said in our opening paraphrase of Prof. THOMPSON's words, certain disadvantageous circumstances under which alternate currents will prosper, and this is their glory. There is much barren soil which no continuous current man cares to till, but from which an alternating man may with care reap a golden harvest. It is greatly to be hoped that the dynamos which he will use will be constructed on sound principles of mechanical engineering, the engines connected direct, the transformers free from annoying drop of volts, the station switching gear decently simple, not spread all over the station, and not blinking the lights all over the district whenever it is handled. These engineering difficulties are not insurmountable, and the scientific difficulties for which such ingenious remedies are proposed will, we believe, disappear of their own accord. They are merely kept before us by scientific men who enjoy them. When HERTZ visited this country in 1890 he was asked some question about alternate current transformers. He had never heard of them, and had no idea of their use. Happy man!

WOODHOUSE AND RAWSON.

From June 18th until a few days ago Mr. Registrar HOOD, aided by the Official Receiver, Mr. C. J. STEWART, and a cohort of Counsel, was intermittently engaged in inquiring into the affairs of Woodhouse and Rawson United (Limited), with the result that no one seems to have been found guilty of anything. To the unsophisticated this may possibly appear to be an extremely tame ending to an extremely lame story. It must, however, be borne in mind that it is not so much formal punishment as mere inconvenience and fear of publicity that deter, and the Board of Directors which could face with equanimity the publicity, physical inconvenience, mental strain, and loss of time, money and dignity inherent to such an inquiry as that recently terminated, would probably go further and fare worse—at Old Bailey. To ordinary men—that is to say, to most directors—considerations such as those just mentioned are, by themselves, likely to prove wholesome and powerful deterrents. When inquiries under the Companies Act of 1890 have been multiplied sufficiently, promoters and directors of companies, it is permissible to anticipate, will have been educated up to their legal and moral responsibilities, and the public, it is to be hoped, will have learnt the unwisdom of confiding the management of commercial and manufacturing undertakings to inadequately salaried men without special business training, and of placing any reliance whatsoever upon auditors' certificates as they are now drawn up. In another column we reproduce an article on the promotion and management of limited liability concerns, by Mr. GEORGE WREFORD, every line of which, with unimportant exceptions, we endorse. Mr. WREFORD proposes, amongst other things, to increase the power of the Board of Trade to such an extent as to make the Certificates of Incorporation, which are at present—like so much connected with the law of joint-stock companies—completely misleading, a kind of Government guarantee of the *bona fides* of the concerns to which certificates are issued. Such a plan, it seems to us, is objectionable on two grounds. No Government department, no, not even the Board of Trade, could really make sure of the good faith of company mongers, so that the guarantee would be illusory and lead to worse than has hitherto befallen the investor. Secondly, such a guarantee would tend to make the average investor even more inclined to trust in the integrity and ability of others than he already is. Let the duties and responsibilities of promoters, directors, and auditors be accurately defined, and the punishment for derelictions of trust be made certain and speedy, and the law will have done all it can safely do to protect the unwary investor. Even this degree of protection is deemed by some excessive, and likely to prove detrimental to trade; as if the commercial reputation of the nation could by any possibility be enhanced and its investors encouraged by such a tale as that just told to Mr. Registrar HOOD.

In August, 1889, Woodhouse and Rawson United (Limited) invited the public to supply it with capital, and by May, 1893, it was being wound up, having between times successively floated a number of not over-successful companies, paid a couple of huge dividends, and declared a balance loss of £130,000. Without questioning the original solvency of the constituent items of this concern, or the correctness of the valuation of the patents and good-will at £85,500 and £97,000 respectively, we will only point out that had two small things been done, which undoubtedly ought to have been done, Woodhouse and Rawson United would, in all probability, never have secured any money from the public, and the electrical industry would have been spared association with such a disastrous venture. Had it been made indubitably clear to the public that what they were asked to subscribe to was to be largely a limited liability financing concern, it may well be doubted whether they would have risen to the bait offered. That this point was not made indubitably clear is evident from the Registrar's own researches. He found that the clause in the Memorandum of Association which was brought forward as exonerating everyone from intentionally misleading the uninitiated was common to 70 out of 93 Memoranda examined by him. Again, had the circular which was sent round to the applicants upon the retirement of the three directors who were dissatisfied with the amount of capital subscribed, contained, as promised to them, the statement that any money subscribed could be had back, the rise and fall of Woodhouse and Rawson United would not, we venture to think, have occurred. Lastly, without endeavouring to do that which has partially defied the skill even of the OFFICIAL RECEIVER, namely, to unravel the tangled skein of the affairs of Woodhouse and Rawson United, the Woodhouse and Rawson Electric Supply Company, the Woodhouse and Rawson Manufacturing Company, the Woodhouse and Rawson Contract and Maintenance Company, and C. L. Baker and Co., the main cause of the disasters that befell the concern which united these threads of varied hue into a garment of so many colours was the ambitious and unskillful attempt to combine *la haute finance* with a plain, everyday manufacturing business. Remembering 1883, one would have thought that a second object lesson in the danger attending such an enterprise would scarcely have been needed.

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REVIEWS.

Traité de Télégraphie Électrique. By H. Thomas. (Paris: Baudry et Cie.)

Division of labour is no doubt an admirable device for obtaining the best, or rather we should say the maximum, effect for a given consumption of mental or physical energy. But whilst the happiest results usually accrue from one set of men sitting down to chronicle the deeds of another set, it is difficult to realise why a nation which is admittedly at the head of the telegraphic branch of engineering should leave the writing of the two best text-books on the subject in the hands of foreigners; for in Wünschendorff's "Traité de Télégraphie Sous-Marine," reviewed in these columns some years since, and in Thomas's "Traité de Télégraphie Électrique," now under consideration, we have the best treatise hitherto published on submarine and land-line telegraphy respectively. The reason for this strange phenomenon is probably to be sought for in that highly developed critical faculty and that power of lucid expression which enable French writers, even on such subjects as practical telegraphy, first to winnow the wheat from the chaff, and then to compound the residue into an attractive whole. We probably possess a copious supply of telegraph men with practical knowledge enough, especially in so far as submarine telegraphy is concerned, to put the authors of these two treatises to immediate flight. But it is permissible to doubt whether, all official restrictions being removed, they would turn out as satisfactory a compilation as either that of M. Wünschendorff or that of M. Thomas. We probably should be unable to see the forest for the trees.

In his "Traité de Télégraphie Électrique," M. Thomas has succeeded in rendering what may be termed the philosophy of telegraphy positively palatable. No only so, but the typography and the illustrations of his volume are also excellent; readers are not treated to an irritating succession of old outside views of ancient apparatus, but the meaning of the letterpress is elucidated both by well-drawn sectional views of actual modern mechanisms and by helpful diagrammatic sketches; the mathematical digressions, which are few and far between, are neither awkwardly thrown into the middle of the descriptive matter, nor relegated to the end of the volume, but are placed in their proper place, but in small type. In addition to other favours, the author has seen to it that what he has compiled does not remain unread or unreferred to for lack of a table of contents and a good index.

One of the best and briefest chapters in the whole volume is that devoted to the question of the propagation of an electric current along a telegraph line, in which the general principles governing the adaptation of instruments to circuits having capacity and inductance are illustrated by useful curves. Relays and line dischargers are discoursed upon in Chapter XI.; the scientifically interesting device of d'Arlincourt, with its so-called *coup-de-fouet* action, having several pages devoted to it. The chapters on printing, writing, automatic, diplex, duplex, quadruplex, multiplex and harmonic telegraphs, although long, are excellent of their kind, and exhibit a sense of proportion not too often met with, but which characterises the author's work throughout.

Alternating Currents. By Frederick Bedell, Ph.D., and A. C. Crehore, Ph.D. (New York: The W. J. Johnson Company. London: Whittaker and Co.) Second edition. 1893.

In this second edition the authors have not thought it necessary to make any material changes "either in the subject-matter or in the arrangement" of their book. We cannot but regret that this is the case, and our criticisms of the first edition (*The Electrician*, Vol. XXXI., p. 124) must apply to the book as it now stands, in its latest form. There is still the same airy show of mathematics, without the necessary appeal to the evidences of actual experiment. There is still the same apparent desire on the part of the authors to wander away along the paths of abstract mathematical analysis, to investigate, for example, "the criterion of integrability" of a given set of conditions by appeal to Laplacians, where a simple mental inspection of the conditions would show just as much as the complicated mathematics can do. We confess to the uneasy suspicion, in reading this book, that wherever the authors have had a choice between a simple, obvious treatment and a complicated, round-about one, they have invariably cast in their lot with the latter. Students and engineers, to whom the work is addressed, do not, as a rule, care to thread their way through a maze of formulæ when the result to be attained can be arrived at by a more direct and simpler route.

We notice that the authors still make the curious statement that the inequality of consumption of the two carbons, in an alternating-current arc lamp, may be explained by the shape of the curve of positive current differing from that of the curve of negative current.

Mathematicians in search of a discussion on and expansion of one or two equations, which happen to be expressions for alternate-current phenomena, may find an interest in this work; but, as an engineering or technical treatise, it can have little value.

The Practical Management of Dynamos and Motors. By F. B. Crocker and S. S. Wheeler, D.Sc. (New York: D. Van Nostrand Company. London: E. and F. N. Spon.) Second edition. 1894.

The present volume consists of a revision and enlargement of the series of articles originally published in the *Electrical Engineer*, of New York, and which first appeared in book form in 1892. The arrangement of the matter in this present edition is similar to that adopted from the first, and is calculated to be of assistance to the reader who is desirous of turning up information about any particular piece of dynamo practice. An entirely new part has been added on the management of arc lighting machinery; and the section on inspection and testing of dynamos has been amplified and is placed in a separate part. If some of the faults stated to occur in dynamo machinery appear somewhat improbable, this can only be due to the evident desire of the authors to omit no possible accident from the category dealt with in their book. For every accident the authors suggest one, or sometimes more than one, remedy; and, with such a book as this within reach and a fair amount of common sense, no dynamo attendant should find himself in an inextricable difficulty. The book makes a useful *vade mecum* for dynamo attendants, and is of a convenient size and shape for the purpose.

ON MAGNETISATION PRODUCED BY HERTZIAN CURRENTS—A MAGNETIC DIELECTRIC.*

BY M. BIRKELAND.

"Two years ago† it was proved by conclusive experiments that Hertzian waves travelling along an iron wire magnetise transversely the very thin layer into which the alternating current penetrates, and whose thickness does not exceed some thousandths of a millimetre. Once proved that alternate magnetisation can be produced with such rapidity, other questions present themselves. One asks, for instance, if it is not possible to demonstrate in magnetic cylinders stationary magnetic waves analogous to the electric stationary waves along metallic wires."

The author finds that the conductivity of massive iron makes it an unsuitable substance, and uses instead a mixture of iron filings, or of chemically-obtained iron powder, with paraffin, to which he sometimes adds powdered quartz. This he moulds into cylinders, and inserts as the core of a spiral in an otherwise ordinary Hertz resonator.

The figure shows emitter and receiver drawn to scale; the magnetic cores are introduced into the spiral A, and their effect on the length of the resonator spark is observed. With this arrangement of exciter the *electric* effect of the spiral is negli-

* Abstracted from *Comptes Rendus*, June 11, 1894, and communicated by Dr. Oliver Lodge.

† Why two years ago? It was practically proved by Savart early in the century, and has been observed over and over again since. However, it is true that experiments have been more numerous and conclusive of late, and have been pushed to very high frequencies.—O. J. L.

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gible, since it is well removed from electrostatic disturbance, and subject only to magnetic. The spiral is of twelve well-insulated turns, the spark-gap is a micrometer with point and knob, and a pair of adjustable plates to vary the capacity for purposes of tuning.

He employed twelve different types of cylinder, all about 20cm. long, and 4cm. diameter.

1. A massive cyclinder of soft iron.

2. A bundle of fine iron wires embedded in paraffin.

3—9. Six cylinders of the agglomerate of chemically-reduced iron in powder and paraffin, containing respectively 5, 10, 15, 20, 25, and 50 per cent. of iron.

Then for control experiments:—

10. A cylinder of agglomerate of zinc powder in paraffin, with 40 per cent. of zinc.

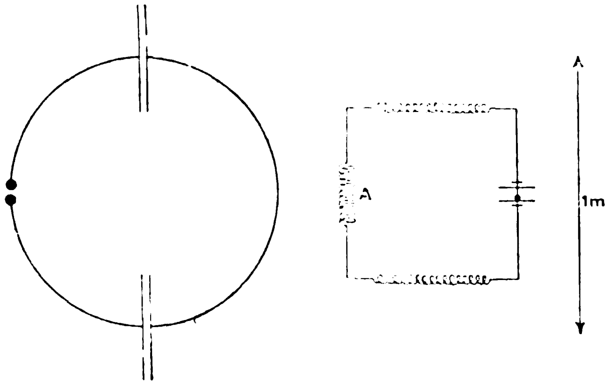
11. A cylinder of brass filings in paraffin, 20 per cent. of metal.

12. A tube of glass, 4·5cm. diameter, filled with various electrolytes.

The manner of observing was as follows (the experiments were done in the laboratory of Hertz):—

The resonator, with its spiral empty, was syntonised with the exciter, and the maximum spark measured. It was between 4 and 9mm. long in these experiments. Then one or other of the above cylinders was introduced and the spark-length measured afresh.

Cylinder 1 did not affect the maximum spark-length. Cylinders 2—4 reduced the maximum spark to $\frac{1}{10}$th of its



former value: 7 and 8 to $\frac{1}{100}$th, and No. 9 to $\frac{1}{200}$th of its former value (viz., from 9mm. to 0·05mm.). Nos. 10 and 11 had but a feeble action, they reduced the spark from 8mm. to 7mm.

Tube No. 12, filled with distilled water, scarcely affected the spark length; the period of the secondary increases a little, but the maximum spark is the same as before, once syntony is re-established. Filled, however, with dilute sulphuric acid containing 10, 20, or 30 per cent., the tube reduced the spark considerably, in each case about the same, viz., from 9 to 1·3 about. (Currents induced by Maxwellian radiation in electrolytes had been already observed by J. J. Thomson.)

While trying to re-establish syntony between primary and secondary, I found that the period of the resonator was considerably increased by the cylinders 2—4, but that the maximum spark length was much diminished. With the cylinders Nos. 5—9 in the spiral, it was no longer possible to establish syntony, "a fact which is certainly due to their considerable absorption of energy. Take, for example, cylinder 9: electromagnetic energy must converge rapidly towards it in order to be transformed, and the space finds itself empty of energy as air is exhausted of vapour in presence of an absorbing substance.

"This absorption is probably due to hysteresis in the ferruginous cylinders; the development of Joulian heat, so typically shown by cylinder 12, being undoubtedly of the same order in cylinders 3—9 as in Nos. 10, 11.

"It is probably by reason of this absorption that I have not succeeded in establishing stationary magnetic waves in a circuit of ferro-paraffin."

If one of the cylinders, 2—9, is wrapped in tinned paper before introducing it into the spiral A, its action is completely stopped. (These conducting cores *diminish* the period of the resonator; it is much as if the spiral A were partially shunted out; but the maximum spark returns as soon as syntony is re-established.) To examine this further he enclosed the cylinder in drums of cardboard having fine wires either along generating lines, or along circular parallels. The latter suspended the action of an interior ferruginous cylinder, the former did not.

To find to what depths the magnetism penetrated, Birkeland inserted hollow ferruginous drums into A, measured their effect, and then plunged solid cylinders into them to see whether the effect increased.

He thus found that the magnetisation easily traversed 7 millimetres thickness of the 10 per cent. ferro-paraffin, and 5 millimetres of the 25 per cent.

The substance is comparable to a dielectric on the theory of Poisson-Mossotti.

"The results obtained with our magnetic dielectric invite to new researches"—such as the mechanical force excited by electric waves on a delicately-suspended ferro-paraffin needle, and the rate of propagation of Maxwellian waves through such a substance.

PRELIMINARY EXPERIMENTS TO FIND IF SUBTRACTION OF WATER FROM AIR ELECTRIFIES IT.*

BY LORD KELVIN, P.R.S., MAGNUS MACLEAN, M.A., F.R.S.E., AND ALEXANDER GALT, B SC., F.R.S.E.

Experiments with this object were commenced by one of us in December, 1868, but before any decisive result had been obtained, circumstances rendered a postponement of the investigation necessary.

A glass U-tube with vertical branches, each 18in. long and about 1in. bore, with the upper 8 inches of one of the branches carefully coated outside and inside with clean shellac varnish, was held fixed by an uninsulated support attached to the upper end of this branch. The other branch was filled with little fragments of pumice soaked in strong pure sulphuric acid or in pure water; and a fine platinum wire, with one end touching the pumice, connected it to the insulated electrode of a quadrant electrometer. A metal cylinder, large enough to surround both branches of the U-tube without touching either, was placed so as to guard the tube from electric influences of surrounding bodies (of which the most disturbing is liable to be the woollen cloth sleeves of the experimenters or observers moving in the neighbourhood). This metal tube was kept in metallic connection with the outside metal case of the quadrant electrometer. The length of the exposed platinum wire between the U-tube and the electrometer was so short that it did not need a metal screen to guard it against irregular influences. An india-rubber tube (metal metallically connected with the guard cylinder would have been better) from an ordinary blowpipe bellows was connected to the uninsulated end of the U-tube. Air was blown through it steadily for nearly an hour. With the sulphuric pumice in the other branch the electrometer rose in the course of three-quarters of an hour to about nine volts positive. When the pumice was moistened with water, instead of sulphuric acid, no such effect was observed. The result of the first experiment proves decisively that the passage of the air through the U-tube gave positive electricity to the sulphuric acid, and therefore sent away the dried air with negative electricity. A corresponding experiment with fragments of chloride of calcium, instead of sulphuric pumice, gave a similar result. In repetition of the experiments, however, it has been noticed that the strong positive electrification of the U-tube seemed to commence somewhat suddenly when a gurgling sound—due to the bubbling of air through free liquid, whether sulphuric acid or chloride of calcium solution, in the bend of the U-tube—began to be heard. We intend to repeat the experiments with arrangements to prevent any bubbling of the air through liquid.

We have repeated our original experiment with pumice moistened with water in the insulated U-tube, and with an uninsulated U-tube filled with sulphuric pumice between the bellows and the insulated tube, so that the air entering it is

* Paper read before Section A of the British Association, at Oxford.

artificially dried. With this arrangement the insulated U-tube was negatively electrified by the blowing of the air through it; but this electrification may have been due to the negative electrification of the dry entering air, to be expected from the result of our first experiment. We intend to repeat the experiment with artificially dried *and dis-electrified* air blown through the U-tube containing pumice moistened with water.

PRELIMINARY EXPERIMENTS FOR COMPARING THE DISCHARGE OF A LEYDEN JAR THROUGH DIFFERENT BRANCHES OF A DIVIDED CHANNEL.*

BY LORD KELVIN, P.R.S., AND ALEX. GALT, B.SC., F.R.S.E.

In these experiments the metallic part of the discharge channel was divided between two lines of conducting metal, each consisting in part of a test-wire, the other parts of the two lines being wires of different shape, material, and neighbourhood, of which the qualities in respect to facility of discharge through them are to be compared.

The two test-wires were, as nearly as we have been hitherto able to get them, equal and similar, and similarly mounted. Each test-wire was 51cm. of platinum wire of 0·006cm. diameter and 12 ohms resistance, stretched straight between two metal terminals at the ends of a glass tube. One end of the platinum wire was soldered to a stiff solid brass mounting; the other was fixed to a fine spring carrying a light arm for multiplying the motion. The testing effect was the heat developed in the test-wire by the discharge, as shown by its elongation, the amount of which was judged from a curve traced, by the end of the multiplying arm, on sooted paper carried by a moving cylinder. Two of Lord Kelvin's vertical electrostatic voltmeters, suitable respectively for voltages of about 10,000 and 1,500, were kept constantly with their cases connected with the outer coatings of the leyden, and their insulated plates with the inside coatings of the leyden.

I. In the experiments hitherto made the two wires to be tested have generally been of the same length. When they were of the same material, but of different diameters, the testing elongation showed, as was to be expected, that the test-wire in the branch containing the thicker wire was more heated than the test-wire in the other branch. In a continuation of the experiments we hope to compare hollow and tubular wires of the same external diameter, and same length and same material.

II. With wires of different non-magnetic material—for example, copper and platinoid—of the same length, but of very different diameters, so as to have the same resistances, the testing elongations were very nearly equal.

III. In one series of experiments the tested conductors were two bare copper wires, each 0·16cm. diameter, 9 metres long, and resistance 0·085 ohm, which, it will be observed, is very small in comparison with the 12 ohms in each of the platinum test-wires. One of the copper wires, was coiled in a uniform helix of 40 turns on a glass tube of 7cm. diameter. The length of the helix was 35cm., and the distance from centre to centre of neighbouring turns therefore $\frac{7}{8}$cm. The middle of the other copper wire was hung by silk thread from the ceiling, and the two halves passed down through the air to the points of junction in the circuit. The elongation of the test-wire in this channel was more than twice as much as that of the test-wire in the channel, of which the helix was part.

IV. One hundred and seventy-one varnished pieces of straight soft iron wire were placed within the glass tube, which was as many as it could take. This made the testing elongation 10 times as great in the other channel.

V. The last comparison which we have made has been between iron wire and platinoid wire conductors. The length of each was 502·5cm. The diameter of the iron wire was 0·034cm., and its resistance 6·83 ohms. The diameter of the platinoid wire was 0·58cm., and its resistance 6·82 ohms. Each of these wires was supported by a silk thread from the ceiling, attached to its middle (as in III. and IV. for one of the tested conductors). Fourteen experiments were made, seven with the test-wires interchanged relatively to the branches in which they were placed for the first seven. The following table shows the means of the results thus obtained, with details regarding the electrostatic capacities of the leyden-jars and the voltages concerned in the results.

In each case four leyden-jars, connected to make virtually one of capacity of 0·02742 microfarad, were charged up to 9,000 volts, and discharged through divided channel. The energy, therefore, in the leyden before discharge was 11·105 $\times 10^6$ ergs. In each of the first three cases 1,450 volts were found remaining in the jars after discharge; in each of the last four 1,400.

Energy remaining in leyden after discharge.	Energy used.	Elongation of testing wires in cms.			
		In channel containing platinoid.	Means.	In channel containing iron.	Means.
$0·29 \times 10^6$ ergs	$10·82 \times 10^6$ ergs	0·01794	0·01829	0·01226	0·01239
"	"	0·01861		0·01247	
"	"	0·01832		0·01244	
$0·27 \times 10^6$ ergs	$10·84 \times 10^6$ ergs	0·01823	0·01836	0·01276	0·01261
"	"	0·01828		0·01280	
"	"	0·01828		0·01244	
"	"	0·01865		0·01244	

The mode of measuring the elongation of the test-wires was, as may be understood from the preceding description, somewhat crude; but it is reassuring to see that the mean results in the cases of 10·82 and 10·84 megalergs of energy used are so nearly equal. The ratios for the two circuits are, in the two cases, respectively 1·48 and 1·46. The conclusion that the heating effect in the test-wire in series with the platinoid wire is nearly one and a half times as great as that of the test-wire in series with the iron is certainly interesting, not only in itself, but in relation to Prof. Oliver Lodge's exceedingly interesting and instructive experiments on alternative paths for the discharge of leyden-jars, described in his book on "Lightning Conductors and Lightning Guards," which were not decisive in showing any general superiority of copper over iron of the same steady ohmic resistance, but even showed in some cases a seeming superiority of the iron for efficiency in the discharge of a leyden-jar. Our result is quite such as might have been expected from experiments made eight years ago by Lord Rayleigh and described in his Paper "On the Self-Induction and Resistance of Compound Conductors."*

* Paper read before the British Association at Oxford, Section A.

* *Phil. Mag.*, Vol. XXII. 1886, p. 469.

RESISTANCE AND TEMPERATURE COEFFICIENT OF COPPER-ZINC ALLOYS.

The specific resistances of a series of 18 wires of copper-zinc alloys form the subject of a Paper by Herr Robert Haas, in No. 8 of *Wiedemann's Annalen*. The number of alloys prepared was 28, but it was found impossible to draw them into wires when the percentage of zinc exceeded 47. The object of the investigation was the discovery of any possible "singular points" in the curves showing the relation between the composition of the alloys and their conductivities and temperature coefficients. Such a point was actually found when the percentage of zinc was 34, or that corresponding to the formula Cu_2Zn.

The greatest precautions were taken to ensure the perfect purity of the materials used. The copper was covered with powdered and dried borax during fusion in the crucible, and the zinc was added in pieces of half a gram at a time. Every such addition was attended with a slight explosion, probably a spheroidal phenomenon. The ingots were cast in the form of bars 4mm. thick, and then wire-drawn.

The electrical measurements were carried out by the metre-bridge, the standard resistance being a German-silver wire, and the specimen being heated in an oil bath. The percentages of the constituents were subsequently determined by electrolysis.

In every case the specific resistance was found to be a linear function of the temperature. The alloys resemble the pure metals in this respect, except iron. The specific resistance of pure copper was found to vary from 0·0158 to 0·0159. Matthiessen's classical value was 0·0156 for hard and 0·0154 for soft copper. The close approximation is ascribed by the author to the use of the borax and of a gas furnace. The table shows that the specific resistance of the alloy increases rapidly at first with the percentage of zinc. After about 5 per cent. it becomes slower, culminating at 34 per

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cent., at which point the resistance exceeds that of pure zinc. At 47 per cent. the specific resistance was the same as at 14 per cent. The temperature co-efficient rapidly diminishes as the percentage of zinc increases from 0 to 7. Between 17 and 30 the curve is nearly horizontal. After a minimum about 34 it increases again, and at 47 it is the same as at 2 per cent.

The following table contains some of the results of the measurements:—

Percentage of zinc.	Specific resistance in ohms.	Temperature coefficient.
0	0·01592	0·004328
1·56	0·02133	0·003185
5·51	0·03010	0·002383
18·02	0·04763	0·001691
22·71	0·05424	0·001607
34·23	0·06302	0·001579
42·55	0·05307	0·002376
46·85	0·04314	0·003105
100	0·05683	0·004029

In conclusion, the author points out that the results indicate a chemical alloy represented by Cu_2Zn. Whether the other alloy, of the formula $CuZn_2$, suspected by A. P. Laurie, also exists, could best be found by means of the induction balance, which does not necessitate the alloys being wire-drawn.

THE LIVERPOOL OVERHEAD RAILWAY.*

BY JAMES HENRY GREATHEAD AND FRANCIS FOX, MM. INST. C.E.

The need for better conveyance for passengers along the line of docks at Liverpool, a length of about 6½ miles on the eastern shore of the river Mersey, has long been felt. As far back as 1852, a proposal was made by Mr. John Grantham for a high-level railway from the Mersey Forge to the Huskisson Dock, a distance of four miles. His plan was to have six lines of way carried on columns 20ft. in height, the space below being utilised as warehouses; but whether from its magnitude or from some other cause, nothing came of the proposal.

The elevated railways over some of the streets in New York have proved of great public convenience. In 1866 a proposal was brought forward for the construction of an "overhead," or as it is now better known, an "elevated" railway in that city, and in 1872, the necessary charter having been obtained, the first elevated railway there was constructed. Although not at once successful, this railway was the forerunner of the present elaborate system of similar railways in New York. Owing to the length and narrowness of the city, no less than four such railways have been constructed, running in generally parallel lines from north to south, within a width of about one mile. The total length is about 35 miles, including about four miles of suburban railway recently completed, the capital embarked is about £10,000,000, and the number of passengers conveyed last year reached the enormous total of 221,000,000, producing a gross revenue of £2,315,000, at a cost of £1,152,000 for working. The Third Avenue line alone, about 8 miles long, carried no less than 83,500,000 passengers, or at the rate of nearly 10,500,000 per mile in the year. Though of great service to the travelling public, these railways have, on the other hand, been attended by several inconveniences; they have no parapets, and the sleepers or cross ties are placed directly on the top flanges of the girders without the intervention of a floor of any description. The result is that as the railways are worked by steam-locomotives, cinders, oil and water drop into the streets; fine shavings from the rails and tyres of the wheels fall on to foot-passengers, in some cases resulting in personal injury, and on one occasion, at least, a locomotive has fallen bodily into the street.

The authors are indebted to Mr. George Fosbery Lyster, M. Inst. C.E., Chief Engineer of the Mersey Docks and Harbour Board, for the following reference to the history of the Liverpool undertaking. About 15 years ago it became apparent that the low-level lines of railway which traversed the whole length of the dock-estate, having connections with the different goods stations along its margin, were becoming so overcrowded by the dock traffic as shortly to render it impossible, consistently with the public convenience, to allow the omnibuses which had been permitted by the Dock Board under special restrictions to continue to use those lines. For that reason, combined with the over-crowding of the adjoining streets, it was clear that some other means must be provided for the expeditious transit of the public. The surface being fully occupied, it will be readily seen that the improved facilities would have to be obtained by the construction of a new line of communication either under or above the surface. A tunnel line was considered, but was speedily abandoned as being too costly, too difficult to construct, and open to other objections in that situation. An overhead structure was therefore considered to be the only practical solution of the difficulty, and in order to obtain full and exact information as to what had hitherto been done in this direction, Mr. A. G. Lyster proceeded to New York to study the system established there, on which he subsequently presented an exhaustive report. Various plans and sketches for such a work were then prepared in Mr. Lyster's office under his instructions and direction. Mr. Alfred Holt, M.Inst.C.E., at that time a member of the Dock Board, early arrived at the conclusion that a single line of railway with passing-places at the stations would be sufficient; and upon an instruction of the Board, at his instance, a series of plans, reports, estimates and models of such structures were prepared by Mr. Lyster, who was, however, always inclined towards a double line. When matured, this scheme was submitted to Col. Yolland and other officers of the Board of Trade, who refused to approve of it on the ground that the structure should be of a character to take two lines of the standard 4ft. 8½in. gauge.

The matter then remained in abeyance for some time, pending the preparation of surveys, designs and estimates for a double line. An Act was obtained by the Dock Board in 1882 for the construction of the railway at an estimated cost of about £585,000 (subsequently reduced to £466,000 for a system fully equipped and worked by electricity). In 1885 Mr. Lyster presented a report to the Dock Board dealing minutely with the course of the proposed line and the interference it would involve with the streets and the existing dock-lines, the stations (of which there were to be 23), the equipment and the working. It was proposed that the width of the structure should be such as to admit of a double line of standard gauge with 4ft. between the lines; the carriages to be 6ft. 6in. wide, assimilated to those in use on street tramways, but longer and therefore of greater capacity. It is interesting to record that at that time electric traction had so far advanced as to be favourably considered by Mr. Lyster for propelling the trains, which were estimated to weigh when loaded 24 tons each, exclusive of motive power, and that he was in communication upon this subject with the late Sir William Siemens at the time. The structure was intended to consist of plate girders, with overhanging continuous foot-ways having parapets of iron lattice-work, with the rails laid upon greenheart planking; the whole being supported by columns of partial lattice-work placed in the normal structure, one on each side of one of the lines of dock railway.

Owing to the fact that many influential members of the Dock Board were unwilling to embark upon the railway undertaking, as being outside the scope of their functions as representatives of the dock estate, the Board in 1887 applied to Parliament for power to lease the undertaking to an independent company. As it was required that the lessees should be a statutory company the present Overhead Railway Company was incorporated by an Act in the following year, with power to undertake, by agreement with the Dock Board, the construction and maintenance of the railway. Under the chairmanship of Sir William B. Forwood, the Company raised the necessary capital and proceeded to construct the railway as it now exists. The contract for the structure was, after competition, let to Mr. J. W. Willans, to whose untiring energy and skill is due, in no small measure, the successful execution of this important work.

In the structure decided upon by the engineers the columns are placed generally vertically under the ends of the main girders, about 22ft. apart from centre to centre, giving sufficient width above for two lines of standard gauge with the usual 6ft. way between them, admitting of the use of carriages of full width (8ft. 6in.), and below for the two lines of dock railway. Local circumstances in many cases did not, however, admit of the columns being placed immediately under the main girders; and in such cases the latter are carried upon cross-girders between the columns or upon extensions of the cross-girders outside the columns. For considerable lengths also the columns had to be embedded in the boundary and warehouse walls. Owing to the presence of the dock lines below, cross-bracing of the piers in the usual way was impossible, and it was necessary to give to the columns, and to the shallow cross bracing connecting them at the top, sufficient strength and rigidity to resist the lateral stresses due to wind-pressure, and, on the curves, to the centrifugal force resulting from the motion of the trains. In designing the details of the superstructure the engineers were aided by Mr. F. Hudleston, Assoc.M.Inst.C.E., of the contractor's staff, and Mr. G. A. Hobson, M.Inst.C.E.; the latter of whom, in connection with this work, specially designed the floor which bears his name, and which is now adopted extensively elsewhere.

The length of the railway, including the short northern extension now approaching completion, but exclusive of an authorised southern extension of about 1 mile, is about 6½ miles, the portion at present

* The first of two Papers read before the Institution of Civil Engineers, February 27, 1894; the second being "The Electrical Equipment of the Liverpool Overhead Railway," by Mr. Thomas Parker.

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worked being about 5 miles. There are in all 13 stations in use, and it is intended to add four more, Fig. 1. The gradients are, generally speaking, easy; but owing to the position of the coal-line of the Lancashire and Yorkshire Railway at Wellington Dock, the overhead railway had to be carried underneath that railway, which entailed a short gradient of 1 in 40 on each side of the coal railway. The sharpest curve is of seven chains radius, and with the exception of a short length under the coal railway at the point above referred to, the railway throughout is an iron viaduct. The advantage of having a fire-proof structure in such a situation has been proved on a recent occasion, when a large fire occurred at one of the timber yards at the Canada Dock, the flames from which swept across the railway for several hours without doing serious injury except to the longitudinal sleepers, which, for a length of about 50 yards, were destroyed. Where it crosses the entrance of the Stanley Dock, a swing-bridge has been provided, both for the dock goods-lines and general traffic and for the overhead railway. At three points open bridges had to be provided to permit boilers and other high loads to pass the structure, and at these points lift or tilt-bridges have been introduced as being the simplest and most convenient type.

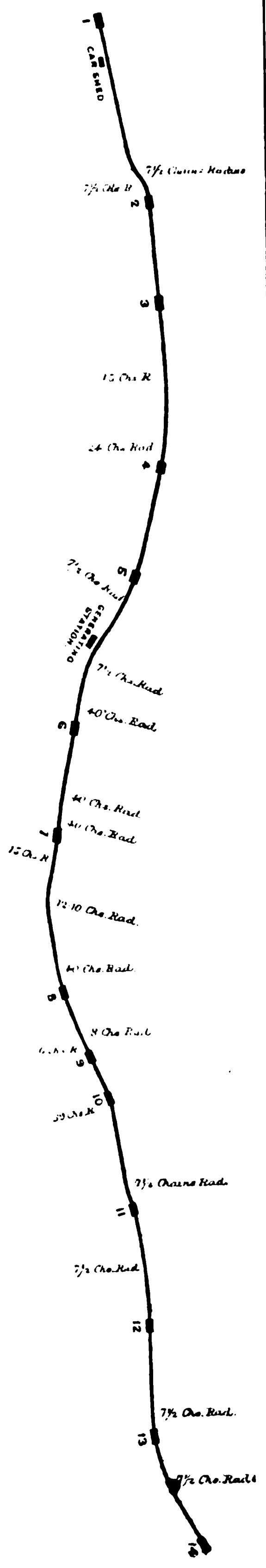

Fig. 1.—The Plan of Line.

Foundations. — No special difficulties arose in connection with the foundations of the piers. The rock is reached by them in many places, but in others, where the material excavated from the docks had been deposited and the foundations are in made ground, a block of concrete was provided to distribute the dead-weight and rolling-load in such a manner that 1 ton per square foot is the maximum load on the base. Some of these foundations were tested with pig-iron to 50 per cent. more than the greatest working-load, with satisfactory results in all cases. Along the Goreea deep sewer was encountered, running parallel with the railway and directly under one line of columns. An arch of cement concrete was built over the sewer and the columns were fixed upon that.

Alterations to the Dock Board's Goods Lines.—Owing to the railway being placed immediately over the dock-lines, the latter were in many instances diverted, straightened and improved, thus entailing considerable expense upon the Company. Police - stations, customs-depots, and other erections in the course of the line, had to be removed and re-erected elsewhere. It may be interesting to record that, in excavating for the foundations, the wall of the first dock made in Liverpool was discovered. Several lengths of the old water-pipes, consisting of trunks of trees bored out and fitted together were brought to light.

Columns.—The columns supporting the viaduct consist of two steel channel-bars riveted to two steel plates, forming a box-column with all the rivet-heads outside. These columns are grouted into cast-iron sockets, bedded in and bolted through the blocks of concrete which form the foundations. Cast-iron bumpers filled with cement concrete, protect the columns against injury from passing wagons (Fig. 2). The normal span is 50ft., but this had to be departed from in many places to avoid interference with existing lines, roads, gateways, and other structures. The longer spans are about 98ft., and the shorter about 30ft. Up to 75ft. span, the height of the girders above the rail-level does not exceed the platform-height, and plate-girders were used. Bowstring lattice-girders were used for the 98-foot spans, with a clear width of 25ft. between them. The plate-girders carry a light projecting parapet composed of gas-tubing and wrought-iron stanchions with curved foot-plates, affording a continuous foot-way on each side of the line, with wider refuges at the piers. The girders are not continuous, and provision is made by slotted holes for expansion and contraction at one end of each girder.

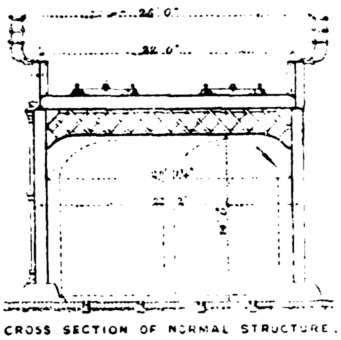

Fig. 2.

Between the girders is fixed Hobson arched-plate flooring, consisting of $\frac{5}{16}$in. plates, bent to a radius of 12in., with a flat surface 6in. wide on the top, rivetted to intervening T-irons, and made water-tight by asphalte placed in the V-channels between the arches (Fig. 3). Upon this are laid longitudinal creosoted sleepers keyed to the flooring, and no ballast is used. From each V-channel an outlet for water is provided through the web of one of the main girders, discharging into a light cast-iron gutter carried along the outside of the main girder, which conveys the water to a rectangular down-pipe fixed to the columns delivering into the drains or gutters below. This flooring combines great strength with lightness and a minimum of rivetting, while the load is more evenly distributed along the main girders than is the case where cross-girders are employed, and great lateral stiffness is secured without horizontal bracing. The flooring is practically water-tight, and after 12 months' test under traffic has not shown any defects. In order to ascertain the strength of the floor, some sections were

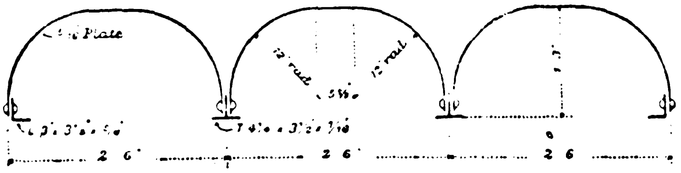

Fig. 3.

tested to destruction and the deflections at each increase of load carefully tabulated with the following results :—

Test.—Three sections of floor measuring 7ft. 6in. in width; span, 22ft., ends resting upon supports; load distributed over four points corresponding with the positions of the rails, Fig. 4.

Load. Tons.	Deflection at centre. (Inch.)	Load. Tons.	Deflection at centre. (Inch.)
30	Nil.	70	$\frac{15}{16}$
35	$\frac{1}{4}$	80	$1\frac{1}{8}$
40	$\frac{7}{16}$	90	$1\frac{1}{4}$
50	$\frac{9}{16}$	100	$1\frac{9}{16}$
60	$\frac{3}{4}$	110	2

The floor-plates ultimately collapsed by the total rupture of the T-irons at 163 tons, and with a deflection of 10in.

In the preliminary stages of manufacture of the floor considerable difficulty was experienced. The plates were heated in a furnace and were bent in a hydraulic press by dies to the required form, but it was found that in cooling the extreme ends curled upwards and spread outwards. After many trials and by giving the dies a "set" in opposite directions, and by fixing the plates in a simply-constructed frame to cool, truth and uniformity in the shape of the plates was eventually secured. The rivet-holes along both edges of the plates were then drilled simultaneously by special machi-

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nery. The system was brought to such perfection that from a single heating-oven and press, and from one drilling machine, occasionally forty to forty-five plates, or sufficient to floor the viaduct for a length of 100ft. to 112ft., were turned out daily, bent, drilled, and ready for fixing. At the final operation 344 plates were pressed in six days by one gang of men. The last day's work amounted to 64 plates. When the plates are ready bent and

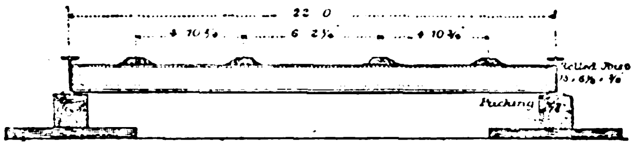


Fig. 4.

drilled, a T-iron is riveted between them at their springing. The rivets are closed up by means of machine-riveters, both heads being easily accessible from the under side. The rivets were put in by each machine at the rate of 400 per hour. The flooring was made by means of a special plant erected at the northern end of the railway for the purpose, and the girders were delivered by rail at that point.

Erection.—The structure was so designed that the spans could be put together and riveted up with floor complete at any part of the railway, and be then transported over the completed portion of the structure and placed in position. With the exception of a few ordinary and the four or five bowstring-spans and the opening bridges, the whole of the spans were erected at the north end of the railway. In this way the erection of staging, and consequent interference with the traffic in the streets and upon the dock estate, the expense of cartage, as well as the use of rivetters' fires in the midst of the dock property, were almost entirely avoided. The girders were lifted by travelling cranes on to supports above the deck of the structure at the north end, where the flooring was attached to them, thus making each span a complete bridge—a 50-foot span and its flooring weighing about 22 tons. They were then placed upon a trolley at such a level as to be higher than the main girders of the structure; the trolley travelled on the two outer rails of the permanent way, having a gauge of 16ft., and at first was hauled by horses on the roadway below, but later by a specially-designed steam-locomotive along the already completed portion of the structure.

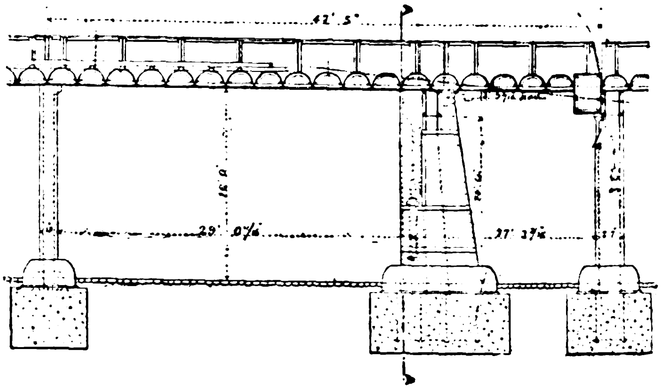
A special form of erecting-apparatus was provided, consisting of two lattice-girders standing upon legs resting on the ground at the front end, and at the hinder end supported on the girders already in position. These lattice girders were placed at such an altitude as to allow the trolley carrying the succeeding span to be rolled along underneath them. On these lattice-girders were placed two travelling cranes, so arranged as to lay hold of the spans on arrival, run them forward, and deposit them in their permanent positions upon the columns which had been erected in advance. The average time occupied in attaching the traveller to a span, running it forward and finally dropping the span on to its bearings, was one hour. The apparatus was then again run forward ready for the next span. Occasionally as many as twelve spans, of 50ft. to 70ft. each, were thus fixed in their permanent positions in five and a half working days—representing about 650ft. of finished viaduct—and from first to last this was effected without a single mishap. The total number of spans is nearly six hundred.

Swing-Bridge at Stanley Dock.—The design of the swing-bridge at Stanley Dock presented some difficulty, but was successfully accomplished by Mr. F. Hudleston. Owing to the constant traffic, both of vessels through the dock entrance and of railway and omnibus traffic passing over the old bridge, it was impossible to stop the way for more than a very short period; and the cramped nature of the available space added greatly to the difficulty of the problem.

It was decided to use a solid pivot, of cup-and-ball form, somewhat similar to that at the Hawarden Bridge,* which has fully answered its purpose. The bridge is in two halves, meeting in the middle of the dock entrance. On the level of the dock rails a double line of railway is provided for dock traffic, and on the upper level a double line of railway for the Overhead Railway, thus constituting a double-deck bridge. The lower level is arranged with bascule leaves, so that barges and small craft can pass through without the necessity of swinging the bridge and interrupting the railway. The bridge is actuated by hydraulic power obtained from the Hydraulic Power Company's mains. To enable the bridge to be completely opened, the following movements have to be made: The bridge is, in its normal position, a fixed structure resting on bearing-blocks at the tail end, and upon two legs at the front of each abutment. The first act is to lift very slightly the tail end of each half so as to allow the bearing-blocks to be withdrawn; this done, the tail end is lowered until the rollers rest on the tail-race; and in doing this the pivot of the bridge comes into contact with its cup-bearing, canting the girders upward at the nose end and lifting the legs from their supports. When this operation is completed, each half of the bridge rests on its pivot and on rollers on the tail-race, and is then ready for swinging.

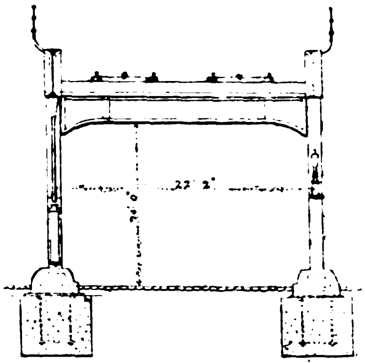
When the proper opportunity presented itself for stopping the traffic, which occurred at a holiday time, the erection of this structure was preceded by the removal of the existing bridge. The powerful floating-crane "Atlas" belonging to the Dock Board was of great assistance in this work, and enabled the old girders to be lifted bodily out and sent away without delay; some necessary alterations to the masonry had then to be made, after which the erection of the new bridge was proceeded with. The weight of the old bridge was 150 tons, whilst that of the new structure is 600 tons, and within ten days of the commencement of the work, railway traffic on the dock lines was resumed.

Lifting Bridges.—At three points on the line of railway, bascule bridges of a very simple character (Figs. 5 and 6), also designed by Mr. Hudleston, with openings of about 35ft. each, are provided to permit the passage of large boilers and other high loads. Hydraulic rams, housed in the columns and connected with the Dock Board's



LONGITUDINAL SECTION.

Fig. 5.



TRANSVERSE SECTION ON LINE A.A.

Fig. 6.

hydraulic-power mains, serve to open and close these bridges. The girders are pivoted so that as the tail end is lowered the front end rises, the difference in length and weight being balanced by kentledge placed in a balance-box attached to the tail end. The shorter arm of the girder is 14ft. 6in. in length, and the longer arm is 33ft. 9in., and when open the girders assume an almost vertical position.

Stations.—The stations are of a very simple character and design, with the exception of those at "Pier Head" and "Custom House," which are somewhat more extensive. They consist of up and down platforms (island platforms being found to be impracticable), which are 120ft. in length and 10ft. in width, each provided with a staircase, turnstiles, ticket-office, and a waiting-shed. At "Custom House" and at "Pier Head" (St. Nicholas-place), the platforms are roofed, and duplicate staircases are provided, so as to keep the arrival and departure traffic distinct. It having been found by experience that unpleasant draughtiness results from carrying the station roof over the railway, the roofing in these cases only extends a little beyond the edge of the platform, leaving the portion over the railway unroofed. A carriage shed has been erected at the north end, with five lines of way running through at the rail-level, communicating by means of a hoist with the lines and the repairing-shops at the ground level, equipped with the necessary tools driven by electric motors.

(To be continued.)

* Minutes of Proceedings Inst. C.E., Vol. CVIII., p. 304.

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LIMITED COMPANIES.*

BY GEORGE WREFORD.

Joint Stock enterprise has made rapid growth since the passing of the earlier Joint Stock Companies Acts some fifty years ago, and especially so since the principle of limited liability became firmly established by the Consolidating Statute of 1862. Undoubtedly the creation of limited companies for working large commercial and manufacturing undertakings has, upon the whole, had a very beneficial effect upon the trade and commerce of the country, and has been the means of keeping a good deal of money belonging to small capitalists employed in home industries which would otherwise have found its way into foreign channels. The principle of these co-operative undertakings has taken firm root in the country, in spite of certain abuses which have crept into the system of promoting and working them—abuses which may be roughly classified under three headings :

1. Those connected with the promotion and formation of limited companies.
2. Those arising in the administration and working of such companies.
3. Those relating to the winding-up of insolvent companies.

The Legislature has from time to time endeavoured to encourage the growth of joint-stock enterprise by affording facilities for the formation and working of limited companies, and has sought to provide remedies for some of the above-mentioned abuses.

Of late years the efforts of the legislature have, perhaps, been more particularly directed to remedying the abuses connected with the winding up of companies—as witness the Companies Act of 1890. This act, while aiming chiefly at the correction of the maladministration and delays incidental to the winding up of companies under the old systsm of procedure, bears also incidentally upon the two former classes of abuses, inasmuch as it provides for an inquiry by an independent public officer into the causes leading up to the failures of companies—causes originating either in their inception and formation or in their subsequent working. So far so good, but it seems to me that to some extent this is equivalent to locking the door after the steed is stolen. It is but scant comfort when you have been robbed to be informed by a public inquiry of the means by which the swindle has been accomplished. Far better to have prevented the robbery. In this sense the policeman may be more useful than the magistrate, even as "prevention is better than cure."

Undoubtedly the prevalent spirit of gambling is responsible for many of the abuses which exist under the first heading, and it would almost appear as though the small capitalist becomes the willing prey of the unscrupulous company promoter, although he does not forget to howl incontinently when he finds that in endeavouring to secure inordinate interest he has lost his principal. Granting, however, that, in the present complex state of society and of the ramifications of commerce, some interference by Government and Government departments is nowadays almost a necessity, I would venture to suggest that the Legislature might usefully intervene to apply some remedy for the first and second classes of abuses to which I have alluded, as well as to the third class. There seems to be an absolute necessity for the protection of small investors, who, from the causes I have mentioned, appear unable to protect themselves.

Companies frequently come to grief through going to allotment upon insufficient subscribed capital. The promoters having incurred responsibilities for the expenses incidental to the floating of a company, are naturally anxious the company should go to allotment at all hazards, so that they may recoup their outlay, and obtain their commission or profit.

Other companies are formed for the purpose of taking over bankrupt concerns, and are really frauds upon creditors rather than upon the general investor, because it often happens that no attempt is made to obtain capital from the public except by way of mortgage debentures. The issue of debentures is the sole object for the creation of these companies. Some remedy for the former branch of abuses might be found in strengthening the powers of the present Joint Stock Registry at Somerset House. I think I am correct in stating that at present the action of that department of the Board of Trade is limited to seeing that certain formalities are complied with—that the name of the proposed company does not infringe upon that of any previously registered company—that the prescribed number of persons have associated themselves together to constitute the company by signing a memorandum of association—that the objects of the company are lawful and that certain stamp duties are duly paid. These are necessary preliminaries, but they do not go far enough. Many small capitalists have, doubtless, invested their money in limited companies because they imagined that the act of their being "incorporated under the Companies Acts," and of the issue of Certificates of Incorporation, was a kind of Government guarantee of the *bonâ fides* of the concerns. Why should there not be a system of *provisional* registration embracing most of the above-mentioned preliminaries, the complete registration and issue of the certificate of incorporation being postponed until the promoters of the company can satisfy the Registrar that not less than two-thirds of the proposed capital of the company has been actually subscribed ? And further, why should not a certain percentage of such subscribed capital—say 5 per cent.—be actually deposited with the Board of Trade prior to the issue of the Registrar's certificate, and be held for a limited period, at 2½ per cent. interest, as a guarantee of good faith ? This would constitute a reserve fund for emergencies, and should not be touched until the company had paid certain prescribed dividends, except in the event of the winding-up of the company. In particular it should be exempt from the operation of any debenture issue, as also should uncalled capital be so exempt in all cases. I do not think such requirements as these would in any way limit legitimate joint-stock enterprise. On the contrary, they would tend to restore the confidence of the investing public—which has been rudely shaken of late. So much has it been shaken that many sound concerns offered for public subscription fall completely flat, especially if the promoters restrain their imagination, and promise only what they really believe can be safely assured in the way of estimated profits.

It might also have a very beneficial effect if authority could be given to the Registrar to require an independent report from experts upon the objects of the Company—the value of the property proposed to be transferred to the Company, compared with the price proposed to be paid—the profits of the middlemen—the probable chances of the success of the Company's operations, and the sufficiency or otherwise of the capital proposed to be subscribed for properly carrying out the objects of the Company. If the report on these points should be unsatisfactory the Registrar (subject to an appeal to the Court) should have power to refuse to issue his certificate.

Such an inquiry as I have indicated would certainly prevent the inception of many a bogus company, and nip in the bud many of the swindles at present foisted on the public in the form of limited companies. I am told that some such system as this obtains in Austria—perhaps even of a more inquisatorial character than the above would be.

The remedy for the second division of abuses connected with the formation of companies—those formed simply and solely for the purpose of issuing debentures—is comparatively simple. The object of the promoters in all these cases is the evasion of the Bills of Sale Acts. Every bill of sale or mortgage upon personal chattels given by an individual requires to be registered under the Bills of Sale Acts, otherwise it is void. But registration in such cases means publicity, and the creditors of a trader seeing a bill of sale registered against him promptly stop the debtor's credit, and take steps to recover their debts, so that a trader knows that the giving of a bill of sale is usually the immediate precurser of bankruptcy. A mortgage debenture, however, issued by a limited company, although it practically amounts to a bill of sale, does not require public registration. All that the Companies Act requires is that these mortgages shall be entered in a Register kept in the company's office. Hence the inducement to an insolvent trader to go through the form of registering his business as a limited "Company," and then mortgaging all the assets by means of debentures. If such debentures were brought within the provisions of the Bills of Sale Acts the inducement for registering such concerns as companies would disappear. A slight amendment of the Bills of Sale Act would be an effectual remedy.

Passing on to a consideration of the second class of abuses—those relating to the conduct and administration of the businesses of companies—it seems highly necessary to improve the tone of directorial as well as that of auditorial resposibility. I think that recent events in connection with the public examination of directors and officers of bankrupt companies, and the prosecutions of fraudulent directors must have a very beneficial effect in bringing home to the minds of directors the serious nature of the responsibilities of their position, and of the duties they owe to the shareholders whose interests it is their duty to safeguard, and impressing on them the fact that they occupy a fiduciary capacity, involving not only moral but legal responsibilities towards their *cestuique trust*—the shareholders. Logically there can be no ground for the notion that conduct, which in the case of an individual would be considered dishonest or reprehensible, ceases to be so when the misconduct is that of several individuals forming a Board of Directors acting in a corporate capacity. It would be well if Directors were imbued with the idea that equal if not greater responsibility devolves on them acting as such than would be the case if they were managing their own businesses. Notwithstanding the well-known fact that names of men of prominent social and political positions figuring at the head of a prospectus does undoubtedly influence investors in subscribing for shares in concerns so fathered, or rather, because of that fact, I would urge that gentlemen of social standing, but possessing neither business training nor commercial experience, should not allow their names

* From the *Chamber of Commerce Journal.*

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to be associated with the directorate of public companies. The company promoter—wise in his generation—knows the value of such names at the head of a prospectus, and undue importance will no doubt still continue to attach to them in the minds of investors—especially those of the smaller class—notwithstanding the disclosures which have demonstrated the unreliability in these matters of having at the head of affairs even men of good position, of honourable and upright character, but wanting in the necessary business qualifications. An efficient and practical general manager—shrewd, reliable, and straitforward—with a thorough grasp of the business under his control, and directly responsible to the shareholders, would frequently be found to be a far more satisfactory officer than any Board of Directors; but in many cases Boards have their uses, and cannot be dispensed with.

The proper check either upon a general manager or upon a Board of Directors should be the auditor. An efficient audit is a matter of prime importance. But to be efficient and reliable the auditor must be independent. How can he be independent—thoroughly independent—under the present system of appointment? He is now practically appointed by the persons whose conduct and affairs it is his duty to criticise. If the criticism be honest and thorough, how long is he likely to hold his post? Theoretically the auditor is appointed by the shareholders. He may in the first instance be nominated by the promoters or the first Board of Directors, and when the shareholders meet in annual meeting the Directors and managers generally hold the key of the situation by means of the proxies of absent shareholders. Practically, therefore, the re-election of the auditor rests with the Board. If the auditor, then, has been too inquisitive, or has been rash enough to criticise the balance-sheet in the interests of the shareholders, he will probably have to make way for a more pliable man—one who is more amenable to the appointing power. Even accountants of good standing are not free from the influences I have indicated, and in order to leave themselves a loophole of excuse, if not satisfied with the state of affairs, and in view of the possible disastrous result, they are induced to give equivocal certificates instead of the form of certificate indicated in the Companies' Act.

It is quite evident, therefore, that if audits in future are to be effective, instead of misleading, not only must competent accountants be employed, but the position of the auditor must be independent, and his powers must be considerably increased. And with these changes his responsibility would also be much enlarged. The question for solution is: How can these results be obtained? Possibly only by further legislative interference. It is, perhaps, for some reasons regrettable that such interference should be necessary, but it seems to be inevitable. There appear to be but two alternatives, either the auditors of joint-stock or limited companies must be appointed by an independent authority, such as the Board of Trade, or the auditor, when once appointed, must be a permanent officer, holding his office until he either voluntarily resigns, or is removed by an extraordinary resolution of the shareholders for sufficient cause shown.

Further legislation is being sought by professional accountants, with a view of securing a higher standard of technical acquirements, and of maintaining high professional character and standing. The enactment of a measure making provision for these objects will pave the way for securing a rota of professional auditors from which the Board of Trade or Boards of Directors could select competent men, responsible to the Board as well as to the shareholders for the due and efficient discharge of their duties.

The auditor should be empowered to call for an independent valuation of the company's assets, at the company's expense, if dissatisfied with the values appearing in the books; and his duties should not be limited to mere matters of arithmetic, vouching, and correct copying. The audit of the accounts of a limited company is on an entirely distinct footing from that of the accounts of an individual trader. In the latter case the trader wants a check upon his cashier, his book-keeper, and other employés. As a rule, he does not want a check on himself. He may deceive himself as to the value of his assets if he pleases. He fixes the value of the stock-taking of his clerks or otherwise, he goes through his book debts, and determines which are "doubtful" and which are "bad," and the auditor is not concerned as to the correctness or otherwise of the trader's estimates. But in the case of a company, a different set of interests arises. Here the auditor, as the guardian of the shareholders' interests, and as the "watch dog," to prevent their being deceived or betrayed, is, in my opinion, bound to satisfy himself, not only that the figures on the balance-sheet are correctly extracted from the books; not only that the books have been properly posted; not only that the arithmetic is correct; not only to see that the assets are in existence; but also, and above all, to see that the values placed against the assets are fair and reasonable. If, to satisfy himself on this point, it is necessary to incur expense, let the necessary expense be incurred, it will be good outlay in the long run, so will the payment of adequate remuneration for the important services which I would have the auditor render to the shareholders. At present the fee voted to the auditor is frequently ridiculously inadequate to properly pay him for what he ought to do, but which he now too often leaves undone for that reason, and this probably to the secret satisfaction of the Directors and other officials of the company.

These remarks have extended much beyond my intention in commencing them, and I do not therefore propose to dilate upon the third and last class of abuses in connection with winding-up of limited companies. Recent legislation has already grappled to a great extent with these abuses; but there has, as yet, been scarcely time to form a reliable judgment upon the general effect of that legislation. Beneficial results have unquestionably accrued therefrom, and the question of the desirability of leaving the actual administration of the estates of insolvent companies more or less in official hands, is one upon which it would be out of place for me to offer an opinion. The commercial community will doubtless determine this question for themselves, when they have had the necessary experience to guide them in regard to the respective merits of official and non-official administration. And the parties chiefly concerned—creditors and shareholders—should exercise their unbiassed judgment on the point.

The foregoing comments indicate generally the views which have suggested themselves to me during many years' observation of the matters upon which I have touched.

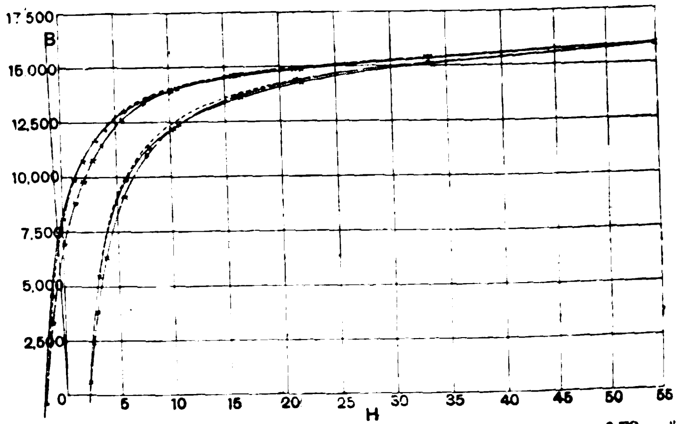
CORRESPONDENCE.

DIRECT-READING MAGNETIC APPARATUS.

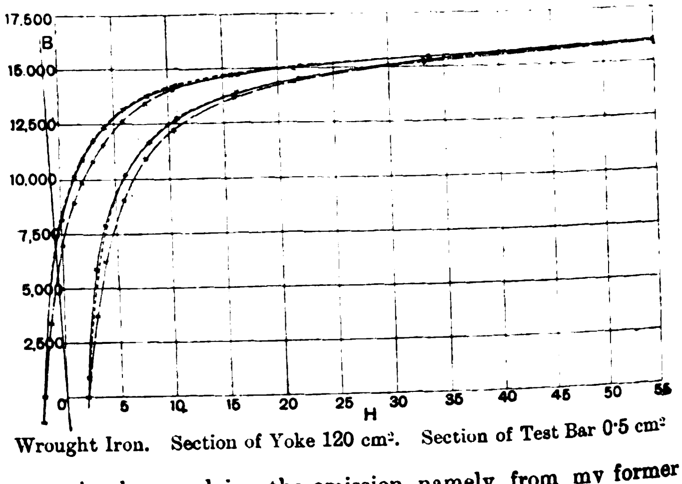
[TRANSLATION.]

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In thanking you for the publication of my letter, I take the opportunity of remedying an omission of which you



Wrought Iron. Section of Yoke 120 cm². Section of Test Bar 0·78 cm².



Wrought Iron. Section of Yoke 120 cm². Section of Test Bar 0·5 cm²

not unjustly complain; the omission, namely, from my former communication of the curves of magnetisation obtained by my apparatus, drawn to a larger scale. I hasten to repair this, and send you herewith the curves, which I hope may enable you to form an accurate idea of the capacity of my apparatus

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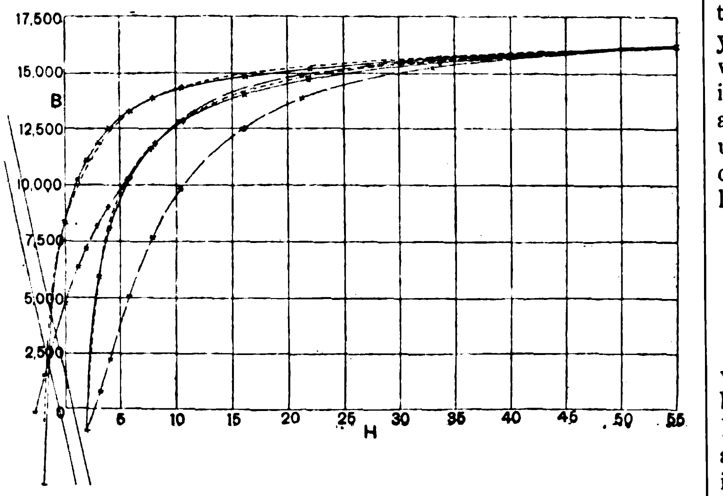
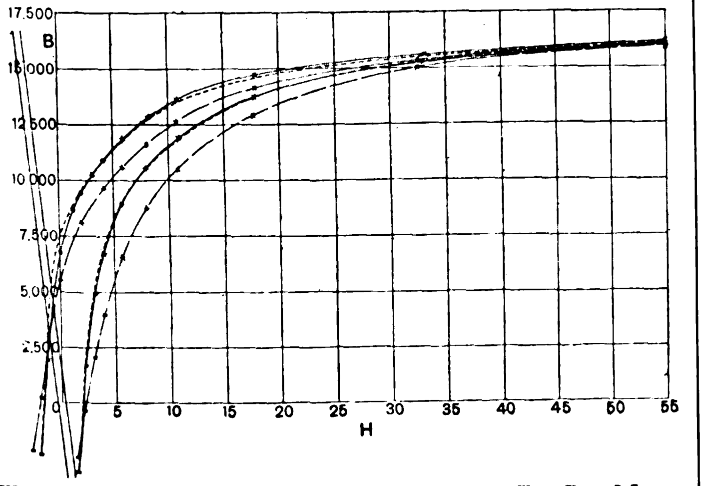
The full line curves are the magnetisation curves, determined by ballistic method, with a completely closed yoke; the long-dash curves show the direct readings of my instrument; and the short-dash curves are obtained from the latter by shearing. You will see from these curves that, with a ratio of section of



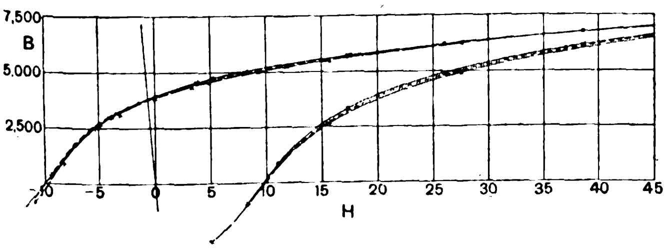
Wrought Iron. Section of Yoke, 120 cm². Section of Test Bar, 3·14 cm².

about 250 : 1 of the yoke and the test bar with wrought iron, and of 150 : 1 with cast iron, the direct readings of the instrument give values sufficiently accurate for practical purposes, without its being necessary to avail oneself of the shearing process. Further, it may be seen how the inclination of



Wrought Iron. Section of Yoke, 40 cm². Section of Test Bar, 0·5 cm².

the line of shearing alters with the ratio of the sections, and what happens at last when this ratio (with wrought iron) becomes smaller than about 100 : 1. The coercive force has then a value different from, and larger than, that obtained with a completely closed yoke; and this value rises as the section-ratio becomes



Cast Iron. Section of Yoke, 40cm² (Wrought Iron). Section of Test Bar, 0·27 cm² (Cast Iron).

smaller. The line of shearing becomes two similar parallel lines cutting the axis of abscissæ in two points each distant from the zero of ordinates by the difference of the coercive forces. A sufficient explanation of this remarkable phenomenon has not yet occurred to me; it seems contrary to theory; but I suspect that it may have to do with the coercive force of the yoke. It is therefore necessary in the construction of the apparatus to keep the ratio of the area of the yoke to that of the test bar as large as possible.

In conclusion, may I remark that if in your original Note, which has so often been mentioned, you had said "effect *on* the swinging coil," instead of "effect of the swinging coil," as you do in your repetition of the sentence, both I *and others* would not have misunderstood you. I am, therefore, far from imagining that you misunderstood the use of the compensation and its method of action, since this is made clear in the most unambiguous manner in your sentence itself. I only wished to correct the words quoted from your remarks as they might lead to misunderstanding.—Yours, &c., DR. A. KOEPSEL.

THE BURETTE-VOLTAMETER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I wish to state that the device of separating the developing and collecting parts in one and the same vessel has been already used by Maneuvrier and Chappuis (*Comptes Rendus*, 1888, CVII., p. 95), and Trouvé in his electric meter. A critical and historical Paper on the present burette-voltameter and its uses will soon be published by me, and I should be greatly obliged if any of your readers can refer me to other published descriptions of such gas-voltameters, or give indications about meters not brought to general notice, as, for example, Emmot and Ackroyd's, 1889.—Yours, &c., H. A. NABER.

London, W.C.

SINE CURVE ALTERNATORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the mathematical treatment of alternating-current phenomena the assumption is usually made that the wave is of sine shape, and this assumption frequently justified by reference to the experimental tests of some pre-historic alternator, which just happened to give very nearly a sine wave, being in this regard very different from our modern ironclad alternators, which do not give anything like a sine wave. Only very recently this theoretical objection has been overcome by defining the sine wave used in the calculation as the "equivalent sine wave"—that is, a sine wave giving the same *effective value* and the same *power* as the true wave of the alternator, and therefore replacing it in practically all cases. An enormous amount of theoretical discussion has since that time been carried on to prove the superiority of the sine wave for motor work, for the efficiency of transformers, &c., and, I am sorry to say, mostly by theoretical men, who did not have any great chance to prove or disprove their theoretical conclusions by practical experience. A number of claims of superiority made for the sine wave could, however, be easily refuted already by theoretical considerations.

Take, for instance, the case of the efficiency of transformers. The hysteretic loss per cycle in the transformer exclusively depends upon the limiting values of magnetism, and will remain the same as long as these are the same. If the wave of E.M.F. is a sine wave, the magnetism will follow a sine wave also. If the wave of E.M.F. differs from sine shape, we can consider it as a fundamental sine wave with higher harmonics superimposed thereon, and then the wave of magnetism will also be a distorted wave, consisting of a fundamental sine wave superimposed by sine waves of triple, quintuple, &c., frequency. It is obvious now that if the triple harmonic wave of magnetism is superimposed upon the fundamental wave in such a way as not to increase its maximum value, the core loss will not be increased; but the amount of energy transformed is increased by the energy of the triple harmonic, for, as known, the energy of an alternate-current wave is equal to the sum of the energies of the individual harmonics, since

$$\int_0^{2\pi}\{\Sigma n\, a_n \sin(n\phi - \delta_n)\}^2\, d\phi = \Sigma n \frac{a_n^2}{2}.$$

In this case, the wave of magnetism will be flat topped, and thus the wave of E.M.F. peaked, hence of a shape like that

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of the modern ironclad alternator. That means the sine wave of E.M.F. is not the most efficient for transformation; but the peaked form of wave, as given by the modern ironclad alternator gives in transformation a lesser core loss by from 9 to 10 per cent. Just here present I have no more recent tests at hand, and so am giving the experimental results of some tests carried out at the time when the introduction of the ironclad design of alternators was ventilated, and for this purpose careful tests made to find whether there was any difference in the action of transformers, between these machines and the old smooth core machines.

Hysteretic Loss.

Transformer.	With Sine wave (Watts).	With Ironclad wave (Watts).	Difference.
35,992	42·3	38·6	9·8 %
36,067	41·1	37·8	8·95 %
36,668	36·8	33·9	8·7 %
35,799	36·6	33·7	8·7 %

Average difference in favour of the distorted wave of the ironclad 9·03 per cent. (August, 1891.)

Coming now to the question of the influence of the wave shape upon the action of motors, I have always had some suspicion that the wave shape has been used as a scapegoat for explaining the inefficiency of a motor due to improper design. With the extensive introduction of induction motors in this country, it became necessary to see whether there was any difference in the action of a motor when operated by sine waves and by the waves of ironclad alternators. Tests, however, carried out by running one and the same three-phase induction motor—a properly designed motor, indeed—first from an alternator giving a sine wave, then from an ironclad alternator giving a sharp pointed wave, and, lastly, with a flat-topped wave given by reversing the current of the continuous current dynamo by a number of two-part commutators, showed no difference whatsoever in the action of the motor with regard to output, efficiency, starting torque, &c., except that in a few cases there seemed to be a slight advantage in efficiency in favour of the distorted wave of the ironclad alternator, probably due to the lesser hysteretic loss caused by such a wave. This difference, however, was too small to be definitely proved. Since that time induction motors and synchronous motors are built and used without further reference to the wave shape, and some thousands of kilowatts of motors in successful operation prove the correctness of this statement.

The question of resonance with higher harmonics—that is, of the dangerous rise of potential, which may occur in long distance transmission by the combined action of capacity and self-induction—can easily be disposed of by the fact that a transmission line, which is liable to give dangerous rise of voltage by resonance with the triple or quintuple harmonic, is not fit for use with the fundamental wave either.

These considerations, which, as before said, I found fully proved by practical experience, have completely convinced me that the superiority claimed for the sine wave is a mere superstition without actual foundation, and that in ordinary distribution work the sine wave is rather at a disadvantage in transformers, so that I have given up any endeavour to build an alternator with sine waves.

Thus I can only fully endorse the view taken by *The Electrician* in its criticism of sine-wave alternators, so far as the criticism is general.

To the particular machine, however, which started the discussion this criticism does not apply; but in this machine considerations entirely outside of the question of transformer efficiency or motor work have induced me to choose a design giving a practically perfect sine wave; conditions, however, entirely specific to the central station, for which this machine is intended, and therefore of no further interest for the present discussion, except in so far as they prove that even with an ironclad construction of alternator—which is indispensable in modern times—practically perfectly sine waves can be produced.—Yours, &c., CHARLES P. STEINMETZ.

August 10, 1894.

PATENT AGENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of May 11th last I referred to an editorial suggested by a misleading article in *Engineering*, and deprecated certain references to the Patent Agents Bills then before Parliament. I intimated that Mr. Warmington's Bill (promoted by the Chartered Institute) was not to be judged solely by its memorandum; and that all the honest and capable men of the profession were not in the Institute, and had no desire to be there under existing circumstances.

Both Bills were referred to a Select Committee of 11 members, who sat 16 times, and examined 15 witnesses. Evidence was given on behalf of the Board of Trade by its permanent secretary, the assistant secretary of the Railway Department, and the Comptroller-General of Patents. The Institute was represented by five witnesses, and the Society of Patent Agents by three, one of them being the writer. The evidence will shortly be issued, but I enclose a copy of the Special Report of the Committee, just published, and ask your permission to quote two paragraphs therefrom.

"The Committee do not consider that the Chartered Institute of Patent Agents, as at present constituted, sufficiently represents the general body of the practitioners at the Patent Office. Of the 245 registered patent agents only about 70 are members of the Chartered Institute, while another organised body of patent agents, the Society of Patent Agents, has 35 registered patent agents on its list of members, and many most respectable patent agents belong neither to the Chartered Institute nor to the Society.

"The governing body, having the control of the register and exercising powers of discipline, must represent not only the patent agents who are members of the Institute, but the larger number who are not members, and, accordingly, unless the Bill as amended by the Committee, or some measure on similar lines, should become law at an early date, the Committee are of opinion that the Board of Trade should remove the register and the appointment and control of the registrar and the examinations from the Chartered Institute, and make other arrangements to carry out the provisions of Section 1 of the Act of 1888. In that case the Chartered Institute should be required to pay over to Her Majesty's Treasury the balance of the fees levied under the rules of the Board of Trade, after providing for any proper expenses that have been incurred."

Your readers will see from these extracts that my statements have been confirmed by the report of the Committee; and that Mr. Alban Gibbs and others who backed our Bill were fully justified in doing so, as I claimed in my letter. Moreover, the evidence indicates that the aspersions upon "registered" agents, as compared with "chartered" agents, so freely scattered,* have no real foundation; and that the policy of the Institute has been to establish a selfish monopoly. I have already informed you that their charter is practically inoperative; and now that the Select Committee have declared that the Institute is not representative of the profession—while that is the first object for which it was formed—it remains to be seen whether the charter can be retained.

One further fact should be stated. The Committee selected Mr. Warmington's Bill for amendment, and having eliminated its objectionable features, and incorporated substantially our requirements, reported it to the House of Commons. The Institute, finding this amended Bill so little to its taste, has withdrawn it.—Yours, &c., J. SINCLAIR FAIRFAX,
Vice-President Society of Patent Agents.

433, Strand, London, W.C., August 20, 1894.

A Pocket Battery.—The Nassau Electrical Company, of New York, seem to have reached the least possible size and weight in a pocket blasting battery brought out by them. This battery is made up of chloride of silver cells, each being securely and hermetically sealed; these cells have an E.M.F. of 1·10 volts, with a maximum current of 2·00 amperes, weigh less than 1oz., are under ¾in. diameter, and less than 2¼in. long.

* *See* "The Electrician" Electrical Trades Directory.

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LEGAL INTELLIGENCE.

Re Woodhouse and Rawson United (Limited).

After the last public hearing (August 8th) of the examination in this case, Mr. Rawson put in a long statement of 129 pages, together with documents relating to various points referred to therein. Had the guarantee fund not been returned in debenture stock, Woodhouse and Rawson (Limited) would have had to be settled with by the handing over of securities or by having a charge upon the uncalled capital. In either case the debenture holders, shareholders, and creditors of Woodhouse and Rawson United would have been worse off under the special circumstances that arose. Three shareholders were chosen at the meeting in 1891 to examine the securities held by the Company, and they were perfectly satisfied. Most of the securities had a Stock Exchange quotation, and were taken at the market price, and in two cases even lower. Witness then put in a large amount of correspondence to show that the stock and plant valuations had been rigorously cut down, and that he and Sir Rawson Rawson had both gone carefully into the matter, and insisted upon reductions, notwithstanding what the managers stated with regard to the values. He then dealt with the evidence of Mr. Stutchbury, and gave 17 instances in which he alleged that the statements of that witness were incorrect. With regard to Mr. Stutchbury's analysis of trading in 1890-91, Mr. Rawson gave a large number of instances of mistakes in that analysis, and claimed that there was a profit in 1890, when he had charge of it, in every branch of the industrial business except one, which branch in the following year fulfilled the expectations he had held out. Quotations were made from various reports of meetings to show that the position with regard to industrial profits and profits made from the patent side of the business had been made clear to the shareholders. Shareholders who listened to his own statements at the meetings could not possibly have misunderstood the position. Documentary evidence was given to show that the industrial business of the Company largely increased in the first year, and had doubled by the end of the second year, notwithstanding that they were unable to manufacture the lamps. Mr. Rawson here went into the details of his interview with Mr. Pixley. He stated that Mr. Pixley was so very conservative with regard to the payment of dividend that he had even advised the non-payment in the previous year, when the guarantee fund, which had not been returned, absolutely compelled the payment of a 15 per cent. dividend, and therefore he did not attach so much importance to his advice when in the following year he advised that 5 per cent. instead of 15 per cent. should be paid. Witness drew attention to the large reserves after payment of the last dividend, the amount shown in the books being £46,996, and stated that if they had not written off various items which they were allowed by the Articles of Association not to write off, and had put in the shares at the quoted prices instead of in some instances below those prices, this amount would have been increased to £66,362. Even if the value of the shares in the Phœnix Trust and the Epstein Companies were taken at Mr. Stutchbury's estimate and the other unquoted shares at break-up prices, it would have left a balance to reserve of £17,296, or £36,662 if the amounts they could have added to the balance sheet had been added. He did not see any difference between paper profits which were not realised and profits represented by balance in hand or stock; for, if the securities were in companies intrinsically sound, as was the case in Woodhouse and Rawson United, they improved in value, whereas stock deteriorated. It would have been ridiculous not to pay a dividend simply because some of the assets were not realised in cash. This would, in his opinion, prevent most of the companies doing a financial business from paying a dividend. Coming to Mr. Edmunds's valuation of the patents, Mr. Rawson put in documents with a view to prove that that valuation was made for the Directors of the United Company. The Company dealt with their patents in a conservative way, as they only put in new patents at the cost of the patent fee and in fourteen years the total cost of their patents would have stood in their books at under £2,000, whereas in the ordinary course of business by that time they would have considerably improved in value. With regard to the suggestion that he had overestimated the profits in the first year in order to get a larger commission, he stated that in the first year they put various sums, amounting to over £5,000, to reserve, which turned out to be unnecessary, besides writing more off the patents than was necessary. All the shares that they held at the date of the balance-sheet were actually sold and paid for before the dividend was paid, and they actually had cash profits sufficient to pay the dividend. With regard to the Phœnix Trust he stated that Woodhouse and Rawson United refused to do a financial business, and that this Company was formed to underwrite various companies from the formation of which Woodhouse and Rawson made a profit which they would not otherwise have done. The industrial business was taken out of his hands after the first year, against his wish, and later, when it was put into the hands of Mr. Stutchbury, he objected to the arrangement on the ground that Mr. Stutchbury had not had sufficient experience, and he (witness) offered to pay half the cost of a competent manager. He gave other instances where he had differed from the Directors, and put in various documents to show that the goodwill of the subsidiary companies purchased was genuinely valued. Mr. Rawson went into particulars to show that the United Company did not do a financial business, there only being five pieces of business that could be called financial, and only two of these being strictly so-called. They never underwrote, never bought any shares in the market, never discounted acceptances for others or lent money, and, in fact, did not do a financial business in any way. Other electrical companies had just as much to do with the promotion of companies from which they made profits by undertaking contracts for works as Woodhouse and Rawson United who had got profits from the sale of patents to four different companies. He then dealt with the report of the Committee of Consultation, and gave twenty-two instances of statements made by them which had turned out in the examination not to be correct, and concluded by asserting that the points against the Directors which had been raised during the examination had all been fully explained and refuted.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

The 1894 Edition of "The Electrician" Electrical Trades' Directory and Handbook contains 1,000 closely-printed pages, and several new and useful features have been added. The price of the Directory and Handbook is 7s. 6d. Postage in the United Kingdom, 9d.; abroad, 1s. 4d. *The 1895 edition is in active preparation.*

"Electric Lamps and Electric Lighting," being four Lectures delivered before the Royal Institution in April-May, 1894, by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is in preparation, and will shortly be published.

"The Work of Hertz."—The lecture delivered by Dr. O. J. Lodge at the Royal Institution on June 1st is being reprinted with corrections and additions, and many illustrations, and will shortly be ready, price 2s. 6d.

"Electromagnetic Theory," by Oliver Heaviside, is now ready, price 12s. 6d. (abroad 13s.). Prospectus on application.

"The Incandescent Lamp and its Manufacture."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application to the Publisher.

"Drum Armatures and Commutators."—This book, written by Mr. F. Marten Weymouth, is also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"Electrical Engineering Formulæ," a pocket-book by W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. (abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application to the Publisher.

Tenders Invited.—The Portsmouth Town Council invite tenders for wiring and lighting by electricity the Technical School in Arundel-street, Landport. Tenders must reach the Town Clerk not later than Tuesday next.

Tenders Accepted.—The Electro-Chemical Company (Limited) have received the following tenders for engines and dynamos for the first section of the Company's plant, viz., 1,000 E.H.P., with water consumption guaranteed under a penalty of £1,000 per pound of water:—

Parsons and Co.—2 steam turbines, 15¾lb., 1,100 E.H.P. (accepted)	£4,800
Yates and Thom—horizontal engines and Holmes dynamos, 15¼lb. with extras, about	8,300
Willans and Robinson—4 engines with Holmes dynamos	9,700
Ditto—4 engines with Crompton dynamos	9,950
Ditto—4 engines with Siemens dynamos	9,980
Ditto—4 engines with Mather and Platt dynamos	10,100
Electric Construction Company (Limited)—4 Willans engines and E.C.C. dynamos, 17·384lb.	10,023
Easton, Anderson and Goolden—17¾lb., with extras	8,816
Ditto—Willans engines	£10,850 to 11,140
Musgrave and Sons—engines only, 13½lb. per I.H.P.	6,224
Crompton and Co.—4 Willans engines, 17¼lb.	£10,780 to 11,140
Johnson and Phillips—dynamos only	2,675

The water consumption is under 160lb. per square inch, and includes steam used for feed and condenser pumps. Messrs. Parsons and Co.'s tender was recommended for acceptance by the consulting electrician (Mr. J. Swinburne), and has been accepted by the Directors. Mr. T. Beeley, of Hyde, Manchester, has secured the contract for the boilers.

——— The Sunderland Corporation have accepted the tender of Messrs. Blakeborough and Sons, of Brighouse, for supplying grip boxes and connections for street lighting.

——— The Southampton Harbour Board on Tuesday, on the recommendation of the Works Committee, decided to accept the tender of Messrs. Crompton and Co. for the electric lighting of the Town Quay for the sum of £789. An amendment was moved that the tender of Messrs. Roger Dawson and Co., which amounted to £654, be accepted, but after some discussion this was rejected, and the report of the Works Committee adopted.

——— The Bootle Town Council have accepted the tender of Messrs. W. and J. Robinson and Co. for the necessary work and fittings required in connection with the lighting of the Town Hall tower clock by electricity, for the sum of £195.

——— The Electric Lighting Committee of the Hull Corporation on Monday considered the tenders received for the supply of a new engine and dynamos required for the extension of their electric lighting scheme, and decide to accept the tender of Messrs. Willans and Robinson (Limited) for the engine, and that of Messrs. J. H. Holmes and Co. for the dynamo, at £1,247 and £1,250 respectively.

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DISSOLUTION OF PARTNERSHIP.—Messrs. Donnison, Parmiter and Barber, electrical and mechanical engineers, of Manchester, London, and Southampton, have dissolved partnership. The debts of the old firm will be paid by Messrs. Parmiter and Barber.

BANKRUPTCY.—Messrs. Queen and Co., the well-known manufacturers of scientific instruments, of Philadelphia, have been compelled to make an assignment for the benefit of their creditors. The failure is attributed to the continued depression in business, and to inability to make collections. The firm was established in 1853 by J. W. Queen, who sold the business, a number of years ago, to Samuel L. Fox, who had afterwards several partners associated with him. In 1893 the Company was incorporated.

——— Under the failure of Arthur Shippey, of 13, King-street, Cheapside, London, notice is given by the Official Receiver that the first meeting of creditors will be held at Bankruptcy Buildings, Carey-street, W.C., on the 28th inst., at 2:30.

LIQUIDATIONS.—The shareholders of the Domestic Telephone Company (Limited) resolved, at meetings held on July 18th and August 9th, that the Company be voluntarily wound up, and that Mr. J. R. Gibson, 24, Fulham-road, S.W., be the liquidator.

——— It was resolved at a meeting of the International Electric Subway Company (Limited), held on August 9th, to voluntarily wind up the Company; Mr. W. C. Grimwade, 32, Walbrook, E.C., to be the liquidator.

——— In the matter of the Collier Audible Telephone Syndicate (Limited), in liquidation, the Board of Trade have appointed Mr. S. Wheeler to be the Official Receiver. The first meeting of creditors will take place at 33, Carey-street, W.C., on the 31st inst., at 11 a.m.

——— A meeting of the Trent Gas Engine Company (Limited) is to be held at King John's-chambers, Nottingham, on September 17th, at noon, to receive an account of the winding up.

APPOINTMENTS VACANT.—The Electric Lighting Committee of the Halifax Town Council require an assistant electrical engineer and a foreman to take charge of the underground mains. Applications must reach Mr. Keighley Walton, town clerk, not later than 10 a.m. on Friday next, the 31st inst. Some further particulars appear in our advertisement columns.

——— The Battersea Polytechnic Institute require an assistant lecturer in Mathematics and Physics. Applications for particulars must be made to the secretary before August 30th.

THE PROPOSED PACIFIC CABLE.—The following is from the *St. James's Gazette* of yesterday :—

"The *Ottawa Citizen* states that the Canadian Government is sending to England forms of tenders and specifications for the proposed Pacific cable, and that contractors will be invited to send in tenders by November 1st. The information offered will be obtainable at the Canadian High Commissioner's office in London, and probably also at one or two other convenient centres in Great Britain. Intending contractors will be asked to furnish estimates for the laying of the cable by one or more of the eight available routes. These are all scientifically plotted in a large chart of the Pacific and Indian oceans, showing the coasts of British Columbia, Australia, and New Zealand, with the intervening islands available for landing places. The ascertained distances between the salient points of the several routes are marked on each.

The Available Routes.

There is a tabular description of each of the proposed routes. In these Tables the distances are given in knots, or nautical miles, the nautical mile being about one-sixth longer than the statute mile. The several routes suggested are :—

1. From Vancouver, B. C., to Norfolk Island, viâ Fanning Island, Fiji, and Norfolk Island, with branches from Norfolk Island to New Zealand and Queensland in Australia ; total distance, 7,175 knots.
2. From Vancouver, viâ Necker Island, Fiji, and Norfolk, with branches to New Zealand and Australia ; total distance, 7,145 knots.
3. From Vancouver, viâ Necker Island, Gilbert Islands, Fiji, New Zealand, and the Solomon Islands to Queensland ; total distance, 8,264 knots.
4. Viâ Necker, the Gilbert and Solomon group (omitting Fiji and New Zealand) to Australia ; total distance, 6,246 knots.
5. From Vancouver, viâ Necker and Fiji, to New Zealand ; total distance 6,127 knots.
6. From Vancouver, B.C., via Honolulu (2,280 knots) and Fiji, to Norfolk Island, with branches to New Zealand and Australia ; total distance, 7,078 knots.
7. From Vancouver, B.C., to Australia, viâ Honolulu and the Gilbert and Solomon Islands ; total distance, 6,293 knots.
8. From Vancouver to New Zealand direct, viâ Fiji, with a middle section if available ; total distance, 6,030 knots.

The Requirements.

Contractors are to base their calculations upon three several propositions for the construction, maintenance, and operation of the cable.

The first requires an estimate of the cost of laying a cable to be owned and controlled by the Governments interested to be worked under Government authority, and to be kept in repair for three years by the contractor.

The second is for a cable to be owned, maintained and worked by a subsidised company, the tenders to state how much subsidy would be required and for how many years. The tenders under this form are also to be based upon maximum cable rate of 3s. per word for ordinary telegrams, 2s. for Government telegrams, and 1s. 6d. for press telegrams, to and from Great Britain and the Australasian colonies on messages between Canada and Australia.

The third form of tender is to be for a cable to be owned, maintained, and worked by a company under Government guarantees : contractors to furnish the capital, lay the cable, operate and maintain it, stating what guarantee of gross revenue would be required, the difference between gross earnings and the amount guaranteed to be made good each year to the Company by the Governments interested ; and the Company to charge the same rate as specified in the second form of tender.

Some of the Conditions.

Among other conditions it is stipulated that the cable must be able to transmit at not less than the rate of twelve words a minute. Each offer must describe the character of the cable, its approaches, and cost of buildings, with provisions for repairs. Also, in the case of tenders based on the first form, contractors are to state the number of steamships required which, together with the stores, are to remain the contractors' property for three years, when they will be taken over by the Governments at a valuation. Contractors are required to take all risks of landing places for the cable, the Governments undertaking to secure landing places at the several points mentioned."

RE WOODHOUSE AND RAWSON UNITED (LIMITED).—It is announced that the whole of the stock now at 88, Queen Victoria-street, E.C., and at Bradford, Birmingham, Glasgow, and Chiswick, consisting of electrical plant, apparatus, instruments, and accessories, is offered for sale until September 30th next. Particulars can be obtained of Mr. F. D. Leslie, Receiver and Manager, 74, Coleman-street, E.C.

TELEPHONIC STREET FIRE ALARMS.—We understand that the "call" for the fire in Silvester-street, Great Dover-street, S.E., a few days ago, involving also an order for the fire escape, was received at the headquarters of the Metropolitan Fire Brigade on the Single Wire Company's new combined telephonic fire alarm post and fire escape attendant's call, referred to in our article on Street Fire Alarms last week. The telephone was found to be even louder than when experimentally tried.

BROCKIE-PELL ARC LAMPS.—Messrs. Johnson and Phillips send us a copy of their catalogue No. 7 for August, 1894, which contains full descriptions, prices and particulars of various patterns of arc lamps, lanterns, carbons, &c., together with a long list of users.

EXPORTS OF TELEGRAPH WIRE AND APPARATUS.—During July the value of these exports reached a total of no less than £303,483, exports during the corresponding months of 1893 and 1892 being, respectively, £77,305 and £25,906. The following figures show the exports during the first seven months of this year as compared with similar periods in 1893 and 1892 :—1894, £1,187,224 ; 1893, £556,500 ; 1892, £701,741.

PROTECTION OF TRADE MARKS IN GERMANY.—The new law for the registration and protection of trade marks in Germany, which comes into force on October 1st next, in its main provisions as to what constitutes a trade mark and is registerable as such, conforms very nearly to the Trade Mark Section of the English Patent Law of 1883, and it also embodies provisions analagous to some in the Merchandise Marks Act of 1887. Foreign products which wrongfully bear the name and locality of a German firm or a registered trade mark, on entering Germany as imports or for transit, are liable to be seized by the Custom House authorities and confiscated. When an illegal mark on the goods cannot be removed the goods may be destroyed. Where German goods must bear a certain mark or signification on being imported into a foreign country to indicate that they are of German origin, or if such goods are not so favourably treated at the Custom House in respect of the trade marks as the goods of other countries, the Federal Council is empowered to subject goods imported into Germany from such foreign countries to the same restrictions, and, in case of violation thereof, to seize and confiscate the goods. All trade marks at present registered in Germany must be re-registered under the new law within the next four years—*i.e.*, before October 1, 1898.

ADVERTISEMENTS IN GOVERNMENT PUBLICATIONS.—A memorial has been presented to Lord Rosebery, on behalf of the members of the Newspaper Society, complaining of the insertion of advertisements in Government publications, thereby placing the Government Departments in direct competition with private trade enterprise. Several of the Government Departments (including the Board of Trade and Labour) now issue publications, and there can be no doubt that these journals, entering under specially favourable conditions in competition with the existing trade journals, are calculated to do serious injury to the latter from the fact that all expenses are borne by the Treasury, and canvassers and others have the advantage of the use of official stationery. It has hitherto been a universally recognised principle that periodicals issued under Government control should not accept advertisements, and this principle was, we believe, strictly adhered to prior to the publication of the *Board of Trade Journal.*

CATALOGUE.—Messrs. Peto and Radford, of Hatton Garden, E.C., have just issued a new catalogue giving prices and illustrated par-

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ticulars of electrical apparatus, including pocket and portable accumulators, portable lamps, electric jewellery, instruments, switches and switchboards, &c. The jewellery shown includes scarf pins, hair ornaments, &c. The firm have put down a number of isolated installations, and accompanying the catalogue are testimonials from those for whom the work has been done.

Exhibition.—A centennial exhibition is to be held at Baltimore, U.S.A., in 1897, and is to be second in size only to the Chicago World's Fair. Major F. Brackett has been appointed general manager.

Abergavenny.—At the last meeting of the Town Commissioners it was mentioned that the report of an expert as to the lighting of the town by electricity was in hand, and when finished would be open for the inspection of the ratepayers.

Arbroath.—The Committee of Management of the Gas Corporation have resolved to oppose a proposed application by the Northern Electric Supply Company for a Provisional Order.

Ayr.—The Lighting Sub-Committee of the Police Commissioners have reported the result of their inquiries respecting a suitable site for the electric light station, and they consider the Burgh Stores in South Harbour-street to be the most suitable, in which opinion they are supported by Mr. Hammond. The Surveyor has been requested to survey and make a plan of the ground, and a meeting of the Town Council will then be held for the purpose of settling the matter.

Bath.—The Surveying Committee of the Town Council on Monday re-affirmed their decision to resist the application of the Bath Electric Light Company for a Provisional Order.

Blackburn.—Circulars have been issued by the Town Clerk to the tradesmen in the centre of the town, stating that in the course of the next two months or so the Corporation will be able to supply the electric light to consumers in Darwen-street, Church-street, King William-street, Victoria-street, Richmond-terrace, Libray-street, Market-place, and Lord-street, and that "if the demand in these streets is sufficiently great," the Council may authorise mains to be laid in some of the neighbouring streets. The charge for the light is to be 7d. per unit, and for motive power 5d. per unit. ——Messrs. Berry and Pope inform us that they have received the contract for supplying and fixing the electric light fittings for the Art Gallery, Free Library, and Museum for the Blackburn Corporation.

Broadstairs. — The Brush Provincial Company have communicated again with the Broadstairs and St. Peter's Local Board with reference to their proposed application for a Provisional Order. In reply to a previous letter the Board said the Company's application would be opposed; but at their last meeting they decided to take a neutral position in the matter.

Bromsgrove.—A public meeting was convened at the Town Hall on Monday to consider the subject of lighting the town by electricity; but, it being considered that the time (11 a.m.) was an inconvenient one, and that a larger attendance could be obtained if the meeting were held in the evening, it was decided to adjourn until Thursday (last) evening.

Church Lighting.—The Saul-street Chapel, Preston, including the vestries, schoolrooms, &c., is to be lit by the electric light, Messrs. Bennett and Druce being the contractors.

Coventry.—The Corporate seal has been affixed to mortgages of the general district fund for raising £2,000 at 3½ per cent. for electric lighting purposes.

Cooking by Electricity.—Mr. Alderman Ellis, J.P., Chairman of the Electric Lighting Committee of the Portsmouth Corporation, gave, on Wednesday last week, a dinner to the Committee at the Portsmouth Town Hall, the food for which was cooked entirely by electricity. Mr. Pyle, of King's-road, was the caterer, and although his *chef* and staff were quite unused to electric cooking, not the slightest difficulty was encountered by them in preparing the viands. The cooking appliances were supplied by the General Electric Company (Limited).

Dewsbury.—The Local Government Board have authorised the borrowing and expenditure by the Board of Guardians of a sum not exceeding £2,150 for lighting by electricity the workhouse premises and cottage homes.

Durban.—The Town Council have decided to obtain the best advice in England on a general scheme for lighting the borough by electricity, and have instructed the Borough Engineer to at once take such steps in the matter as are necessary.

Electricity and Gas.—The Chairman of the Liverpool Gas Light Company, at the meeting on Tuesday, mentioned that an additional charge of 4d. per 1,000ft. in the previous year had only produced two-thirds of the amount which might have been expected. That had been brought about by four causes: the competition of the electric light, bad times, brighter weather, and the increase in price. It would be a matter of satisfaction, he said, to know that it was not through electric lighting competition that they had suffered most severely. They continually found, as a matter of course, that some large works in the city were resorting to the use of electricity; but they must be prepared for that. The sum, however, that had been lost from changes of that kind during the year was comparatively small, and was not of a nature to give any anxiety to the Company.

Fareham.—At a special meeting of the Fareham Local Board, held on Thursday in last week, it was resolved to sign the contract for the purchase of the electric lighting company's undertaking at a valuation, and Mr. W. H. Massey and Prof. J. A. Fleming (or, failing him, Mr. Arthur Preece) were appointed valuers.

Glasgow.—The Telephone Committee of the Glasgow Corporation have discussed the agreement between the Postmaster-General, the National Telephone Company, and the New Telephone Company, under which it was pointed out that the Postmaster-General was left absolutely free to grant a licence to the Corporation of Glasgow. It was the opinion of many of the members that the terms of the agreement were such that it would be comparatively easy for municipalities throughout the country to take over the telephone system of the districts served by them. The further consideration of the subject has been adjourned till next session, owing to the decision of the Postmaster-General to wait till then before confirming the agreement with the National Company.

Great Yarmouth.—The Town Council have resolved to charge 6d. per unit for the supply of electrical energy. Mr. A. W. Ranken has been appointed clerk of the works for the installation.

Hampshire County Council.—The Council have instructed the Public Works and Buildings Committee to obtain an estimate for the wiring of the new county buildings at Winchester for the electric light.

Hanley.—Owing, doubtless, to the success of the electric light, the gas company have again reduced the price of gas in Hanley.

Larne.—At the last meeting of the Town Commissioners a letter was read from Mr. J. D. A. Norris, the receiver and manager for Messrs. J. E. H. Gordon and Co. (Limited) stating that the agreement for the public lighting had been passed by the Court.

Margate.—Notice has been given by two companies of their intention to apply for Provisional Orders to supply electricity to the borough.

Mill Lighting.—Messrs. Berry and Pope are putting down a complete electric lighting installation for the mills of the Monton Mills Company at Sabden, Lancs., which is to be lighted throughout, including the weaving sheds, by electricity. Over 400 lights will be used. About 150 lights are being added at the Hob-lane Shed, Brierfield, for Mr. J. S. Vaners.

Monmouth.—A special meeting of the Town Council was held on Monday, when the final report of Messrs. Bramwell and Harris on the combined schemes of sewage disposal and electric lighting was adopted. The cost is estimated at about £17,600. The Mayor stated that Lord Llangattock desired to illuminate The Hendre with the electric light.

Nelson.—The Corporation Technical Schools are to be lighted by electricity, the contract having been secured by Messrs. Berry and Pope.

Portsmouth.—At the dinner given by Alderman Ellis to the Electric Lighting Committee on Wednesday last week, Mr. Ellis stated that the electric lighting had achieved a success beyond that attained in any other town in the United Kingdom. Electricians from all over the world had visited the town, and had unanimously agreed that the Portsmouth installation was far superior to anything yet accomplished. There had been such a demand for the current that unless their plant was immediately enlarged they would, within a couple of months, be unable to supply any further applicants. There were already about 4,000 incandescent and 100 arc lamps wired, and about 1,000 more lamps were being wired. Another £5,000 would enable them to supply current to about half as many more lights as they were now running, and from that outlay they hoped to reap a revenue of £4,000 a year.——At the last meeting of the Town Council the Electric Lighting Committee were authorised to extend the supply of electricity through Unicorn-road to the Connaught Drill Hall, at an estimated cost of £265. The Committee were also authorised to extend their mains through Clifton-road, and also along Clarence-parade as far as the corner of South-parade at an estimated cost of £1,000. Application is to be made to the Local Government Board for sanction to borrow the above sums.——The Town Hall Committee were authorised to advertise for tenders for purchasing the electrical plant now in the Town Hall, which is not required now the electric light station is open.

Richmond.—At the last meeting of the Town Council Mr. Heasler undertook to supply at the next meeting of the Council a statement showing the total expense of the town in connection with

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the electric light. The Council calls, and have also resolved that the fire engine house clock should be lighted by electricity.

STALYBRIDGE.—It is announced that the works of Messrs. Millburn, Sons and Co. (Limited) have been purchased by a London firm, and that they will shortly be reopened as a foundry and electrical engineering works. When in full operation 200 hands are employed.

SUNDERLAND.—The estimate of the Electric Lighting Sub-Committee for the half-year ending March 31st next, submitted to the last meeting of the Town Council, showed that £801 18s. 8d. will be required. The Highways Committee recommended that the charge for lighting be fixed at 6d. per unit, and for heating, cooking, or motive power 3½d. per unit. The estimates and recommendation as to charges were approved by the Council.

THAMES CONSERVANCY.—The new offices of the Thames Conservancy Board on the Victoria-embankment, of which formally possession was taken on Wednesday, are lighted throughout by electricity.

WAKEFIELD.—Complaints are being made that no action has been taken by the Electric Lighting Committee in the matter of lighting the town by electricity, although the report of the consulting engineer was received some time ago.

WINDSOR.—The Eton Rural Sanitary Authority have received a communication from the Board of Trade, notifying that the Windsor Corporation have applied for a revocation of the Windsor Electric Supply Order of 1890, and stating that, subject to any recommendations the Eton authority may wish to make, the Board of Trade propose to revoke the order forthwith. The Eton authorities desire to take no further action in the matter.

WOLVERHAMPTON.—The Town Council at their last meeting authorised the Lighting Committee to invite and accept tenders for the execution of the necessary work and the provision of fittings for the supply of electricity to the Town Hall, Market Hall, School of Art, Art Gallery, and Free Library, the cost not to exceed £2,000.

WORCESTER.—The Mayor has consented to perform the ceremony of opening the electric lighting works at Powick on October 11th, and the Mayoress will open the exhibition at the Public Hall in connection therewith.

BOOKS RECEIVED.

"Dictionary of Electrical Words, Terms, and Phrases." By Edwin J. Houston, Ph.D. Third Edition. (New York: The W. J. Johnston Co., Limited.) 1894.

"Turning Lathes." Edited by James Lukin. Fourth Edition. Price 3s. (The Britannia Company, Colchester.)

"A Practical Treatise on Patents, Trade Marks and Designs." By David Fulton, A.M.I.C.E. Price 15s. (London: Jordan and Sons.) 1894.

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

August 9, 1894.

15,258. H. O'REILLY. London. An improved material for the manufacture of lamp, gas, electric light shades, and other fancy articles.

15,276. M. KILIANI, W. RATHENAU, C. SUTER, and ELEKTROCHEMISCHE WERKE GESELLSCHAFT MIT BESCHRANKTER HAFTUNG. London. Improvements in or connected with diaphragms for electrolytic purposes.*

15,282. F. BRUTSCHKE and H. SCHIMPFF. London. Improvements in or connected with ploughing by electricity.

August 11. 1894.

15,321. O. SCHRIMPFF and R. RIFFELMACHER. Manchester. Improvements in and relating to flexible telephone cords.*

15,353. W. ROUTLEDGE. London. Improvements relating to electric motors.

15,356. D. T. BOSTEL. London. Improved means for opening or closing valves, taps, electric switches, and the like.

15,360. J. W. ROGERS. London. Improvements in arc lamps.

August 13, 1894.

15,376. J. WHITEHEAD. Birmingham. Improvements in holders for globes or shades of electric, gas or other lamps.

15,396. J. HOPKINSON. London. Improvements in electric tramways.

15,403. C. H. KRÜTZFELDT. London. Improvements in automatic alarm devices for use in connection with telephones and microphones.*

15,414. F. G. WARRELL. London. Improvements in telephone annunciators and call bells.*

August 14, 1894.

15,424. D. COOK. Richmond. Improvements in electro-motors.

15,429. J. LINDLEY and G. E. SUTCLIFFE. Mirfield. Improvements in conducting and economising electricity.

15,452. H. H. LAKE. London. Improvements in electric arc lamps. (R. Drysdale, United States.)*

15,455. F. F. HOWE. London. Improvements in telegraph transmitters.

August 15, 1894.

15,506. F. BROWN. Birmingham. Improvements relating to voltmeters which are applicable to ampere meters.*

August 16, 1894.

15,573. J. T. CATHCART. Newburgh. A new method of utilising running vehicles and machinery for the production and storage of electric force.

15,600. O. MARCH and A. WINTERBOTTOM. London. An improved form of electrically-heated curling-tongs.

15,617. A. MÜNCH. London. Improvements in apparatus for registering the number or duration of telephone conversations.

15,632. A. C. GIRARD and E. A. G. STREET. London. Improvements in methods of and apparatus for heating crucibles by means of electricity.

[Dates applied for under Patents, &c., Acts, 1883, Sec. 103, February 19, 1894, being date of application in France.]

August 17, 1894.

15,694. E. H. MARET. London. Improvements in or relating to electric arc lamps.

15,698. F. W. SCHINDLER. London. Improvements in electric appliances for boiling or heating liquids.

15,712. D. B. MORISON. London. Improvements in what are known as dry voltaic cells or batteries.

August 18, 1894.

15,770. J. A. KINGDON. London. Improvements in electric heating apparatus.

15,774. H. A. C. SAUNDERS. London. Improvements in electric cables. (R. Greey and W. J. Murphy.)

15,782. C. P. SHREWSBURY, F. L. MARSHALL, J. COOPER and J. L. DORELL. London. Improvements in the manufacture of carbon for electrical and other purposes.

SPECIFICATIONS PUBLISHED.

NOTE.—All Specifications can now be obtained at the uniform price of 8d. each.

1893.

15,907. KOSTER. Insulator for telegraph and telephone wires.
17,493. DION. Thermo-electric batteries.
17,981. DRACH. Magneto-electrical igniting apparatus.
18,019. TUCKER. Electrical switches.
18,530. SIEMENS BROS. AND CO. and THORNTON. Conductors for electric railways.
18,674. PHONOPORE COMPANY and SPAGNOLETTI. Electrical receiving instruments and relays.
21,629. DELANY. Telegraphy.

1894.

1,776. WALTON. Electric arc lamps.
4,005. BEHRENS. Musical instrument and dynamometer.
9,117. JENSEN (Fonda). Electromagnetic tools.
10,393. CLAREMONT. Arc lamps.
11,219. HUSSEY. Incandescent electric lamps.
12,131. FREEDLEY. Electric brake for vehicles.
12,349. THOMSON (Coffin.) Heating metals by electricity.

COMPANIES' MEETINGS AND REPORTS.

The Cuba Submarine Telegraph Company (Limited).

The forty-sixth ordinary general meeting of this Company was held on Wednesday at the offices, 58, Old Broad-street, E.C., Mr. Thomas Greenwood (Chairman) presiding.

The SECRETARY (Mr. James Scott) read the notice convening the meeting.

The CHAIRMAN said: Gentlemen, the Directors are pleased to be able to present so favourable a statement of accounts as those before you. The receipts for the half-year have been £30 more than in the corresponding period of the previous year, while the expenses which have varied a little, as they usually do, have amounted in the aggregate to £31 more than in the corresponding period of 1893. The result is that the balance of net profits is the same, within £1, as it was twelve months ago. Fortunately, we have had no repairs during the past half-year. This is the

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second half-year we have had no repairs, and therefore there appears no item in the accounts for any expenditure of that kind, whereas in the previous year there was a payment of about £1,647 for repairs. We have also added to the reserve against losses by deposits with banks only £1,000 as compared with £1,500 inthe preceding year, and as a consequence we are able to increase the amount carried to reserve fund by £2,500, and likewise to improve our balance carried forward to the next half-year. This, I am sure, must be highly satisfactory to you, and you will therefore, I hope, feel no difficulty in adopting the motion which I now move, namely,

"*That the report and accounts for the half-year ended June 30th last, now submitted, be received and adopted.*"

Mr. CHARLES W. PARISH seconded the motion, which was agreed to unanimously.

The CHAIRMAN : I have now to propose :—

"*That the following dividends for the half-year be now declared on the shares of the Company, viz., at the rate of 10 per cent. per annum, subject to income-tax, on the Preference shares, and 8 per cent. per annum, free of income-tax, on the Ordinary shares, payable on and after to-morrow.*"

Mr. ALEXANDER F. LOW seconded the resolution, and it was carried.

The CHAIRMAN : The Director who retires by rotation on this occasion is our old friend, Mr. Low. He has been a Director of the Company from the very beginning, and is the only surviving original member of the Board, and we have very much pleasure in supporting his re-election, which I beg to propose.

Mr. J. P. HOOPER seconded the proposition ,which was unanimously approved.

Mr. A. G. LOW moved :—

"*That Mr. John Gane be re-elected auditor of the Company for the current year, at a salary of 20 guineas.*"

Mr. F. DONNISON seconded the motion, and it was adopted.

The proceedings then terminated.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1894, pages 274-300, *&c., &c.*]

ARIEL ARC LAMP SYNDICATE (LIMITED).—This Company was registered on August 16th with a capital of £20,200 in £10 shares, to enter into an agreement between Samuel S. Allin and C. S. Graham Lloyd, William H. Wood and John S. Chatterton, and to carry on the business of electricians, electrical and mechanical engineers, suppliers of electricity, manufacturers of and dealers in electric and other lamps, and all kinds of electrical apparatus and appliances. The subscribers (with one share each) are: H. F. E. Capper, William G. Lloyd, Arthur Pollock, Henry E. Sanderson, Albert H. Bellingham, Aubrey F. Willoughby, and M. Gwynne-Griffith. The first Directors are Samuel S. Allin and C. S. Graham Lloyd.

BRIGHTSIDE FOUNDRY COMPANY (LIMITED).—This Company was registered on August 16th, with a capital of £25,000, in £10 shares, to carry on the business of ironfounders, engineers, makers of chilled rolls, and manufacturers of and dealers in metal goods.

MAURICE DONNE AND MORICE (LIMITED).—This Company has been registered in Edinburgh, with a capital of £10,000, in £5 shares, to take over and conduct the business of the Ayrshire Foundry Company (Limited).

SPELLER AND COMPANY (LIMITED).—This Company was registered on August 18th, with a capital of £5,000, in £5 shares, to carry on the business of manufacturers of and dealers in lamps and appliances for lighting and heating, gas and electric light fittings, &c.

SYNDICAT DE TRACTION PAR LE GAZ (LIMITED).—This Company was registered on August 17th, with a capital of £20,000, in £40 shares, to acquire certain inventions for France and the French colonies and dependencies relating in any way to the traction or propulsion of vehicles by means of gas, and to carry on the business of mechanical engineers, machinists, gas engine makers, suppliers of electricity, manufacturers of machinery and apparatus connected with the generation, storage, and distribution of gas and electricity, &c. The first Directors are Thomas H. Pearson, W. Clarkson and Henry P. Holt.

AFRICAN DIRECT TELEGRAPH COMPANY (LIMITED).—The annual return of this Company, made up to July 25th, and recently filed, shows that out of a nominal capital of £300,000, in £10 shares, 23,600 have been taken up, and the full amount called and paid.

AKESTER ELECTRO-MOTOR AND ACCUMULATOR COMPANY (LIMITED). The annual return of this Company, made up to March 25th, has been filed. The nominal capital is £5,000, in £1 shares, of which 4,348 have been taken up, and 3,500 of these have been issued as fully paid. The full amount has been called up on the remaining shares, resulting in the payment of £1,324. 12s. (which includes a sum of £475. 12s. received in respect of 652 forfeited shares), leaving £175. 8s. as yet unpaid.

BAILY AND GRUNDY, LONDON (LIMITED).—The statutory return of this Company, made up to September 5, 1893, was only recently filed. 125 shares had been taken up, out of a nominal capital of £10,000, in £10 shares. All these shares are said to have been issued as fully paid, although no agreement has been filed giving particulars of any purchase by the Company.

CUTTRISS, WALLIS AND CO. (LIMITED).—The annual return of this Company, made up to June 15th, has been filed. Out of a nominal capital of £10,000, in £5 shares, 771 have been taken up, and of these 420 were issued as fully paid. The full amount has been called on the remainder, resulting in the payment of £1,755.

EASTON, ANDERSON AND GOOLDEN (LIMITED).—The statutory return of this Company, made up to June 4, 1894, was recently filed. The nominal capital is £200,000, divided into 10,000 Ordinary and 10,000 £6 per cent. Cumulative Preference shares of £10 each. All the Ordinary and 5,486 Preference shares have been taken up, of which 9,320 Ordinary and 2,886 Preference have been issued as fully paid. The full amount has been called and paid on the remaining 2,600 Preference shares, whilst up to the present no calls have been made on 680 Ordinary shares.

ECUADOR TELEPHONE COMPANY (LIMITED).—The annual return of this Company, made up to July 19th, has been filed. Out of a nominal capital of £100,000, in £5 shares, 5,000 shares have been taken up and allotted. Upon each of these shares the full amount has been called and paid.

EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY (LIMITED).—The annual return of this Company, made up to August 9th, has been filed. The nominal capital is £1,000,000, divided into 150,000 "A" and 50,000 "B" shares of £5 each, of which 106,400 "A" and 23,564 "B" have been taken up. Of these 17,139 "A" and all the "B" were issued as fully paid, and the remaining 89,261 "A" shares were issued with £3 per share considered as paid. A call of 10s. per share has been made on these last-named shares, resulting in the payment of £44,630. 10s.

ELECTRIC AND GENERAL INVESTMENT COMPANY (LIMITED).—The annual return of this Company, made up to July 10th, has been filed. Out of a nominal capital of £200,000, divided into 39,900 Ordinary and 100 Founders' shares of £5 each, 20,000 Ordinary and all the founders' shares were taken up. The full amount has been called on the latter class, while a call of £1 per share has been made on the Ordinary, resulting in the total payment of £20,500.

MANCHESTER EDISON SWAN COMPANY (LIMITED).—The annual return of this Company, made up to July 30th, has been filed. Out of a nominal capital of £550,000, divided into 50,000 "A" shares of £9 each, and 10,000 "B" shares of £10 each ; 20,000 "A" and all the "B" shares have been taken up and allotted. Upon the former, calls amounting to £1. 5s. per share have been made, while on the latter the full amount has been called, resulting in the payment of £124,770. 5s., and leaving £229. 15s. in arrears.

SHEFFIELD ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The annual return of this Company, made up to June 27th, was recently filed. The capital is £98,000, in 14,000 shares of £7 each, of which 8,625 have been taken up. 4,000 of these were issued with £5 per share considered as paid, and a call of £1 per share has been levied on the whole, and £8,625 has been paid in respect thereof.

CITY NOTES.

BRUSH ELECTRICAL ENGINEERING COMPANY (LIMITED).—Notice is given that the transfer books of the Four and a-Half Per Cent. Debenture Stock of this Company will be closed from the 25th inst. to September 3rd inclusive.

CITY AND SOUTH LONDON RAILWAY.—The traffic returns of this Company for the week ended August 19th were £861, as against £862 in the corresponding period of 1893, being an decrease of £1. The total receipts for the half-year amount to £6,064, as against £5,928 for the corresponding period of 1893, an increase of £136.

ENGINEERING AND GENERAL CONTRACT CORPORATION (LIMITED).—At the ordinary general meeting of the shareholders of this Company, held on Wednesday at Winchester House, after some considerable discussion a Committee of investigation into the affairs of the Company was appointed.

LONDON PLATINO-BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The half-yearly coupons of the £100,000 Six per Cent. Debentures of this Company, falling due on September 1, 1894, will be paid by Messrs. Glyn, Mills, Currie and Co., 67, Lombard-street, E.C., on and after that date. Coupons must be left three clear days for examination.

THOMAS PARKER (LIMITED).—The first statutory meeting of Thomas Parker (Limited) was held on Friday, at Wolverhampton. Mr. T. C. Mander presided, and, after the usual formal business had been transacted, in response to a shareholder who inquired how matters stood with the Electric Construction Company in respect to the Eickemeyer Dynamo Winding Patents, he stated that the purchase of the patents had been completed, that the legal proceedings commenced by the Electric Construction Company remained as they were, but that the Directors were considering the question of granting a licence to the Company mentioned for the use of their patents on terms to be agreed. The Chairman announced that the erection of the works was rapidly approaching completion, and that there was every prospect of the Company at once entering upon a large and remunerative business.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended August 17th (after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited), were £2,106.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The traffic receipts for this Company for the two weeks ending August 15th were £1,631, as compared with £1,856 for the corresponding period of last year. April receipts estimated at £4,976, realised £5,019.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share	Last Dividend.	Name.	Previous Week's Price, Aug. 15.		Price Wednesday, Aug. 22.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Aug. 23.	
			TELEGRAPHS.					£ s. d.		Highest	Lowest
£1,012,880	Stock	10 0	Anglo-American	38	41	40	43	5 4 8	Jan., Apr., July, Oct.	42	41½
£2,933,560	Stock	20 0	Do. Preferred	74	76	76	78	5 15 5	" "	77½	75½
£2,933,560	Stock	5/0	Do. Deferred	6½	7	6¾	7½	..	" "	7⅜	7
£184,500	100	4%	*African Direct Teleg. 4% Deb. (Reg. & Bearer)	101	104	101	104	3 17 4	January and July	..	..
130,000	£10	3/0	Brazilian Submarine	12½	13	12½	13	5 0 0	Mar., June, Oct., Dec.	12 [illegible]	12 [illegible]
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1906)	107	111	107	111	4 10 8	June and December	..	..
10,000,000	$100	$1¼	Commercial Cable Capital Stock	139	143	139	143	4 17 11	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	12½	13½	12½	13½	5 18 6	February and August	13⅛	..
6,000	10	10%	Do. Preference 10 per Cent.	19½	20½	19½	20½	4 17 7	" "	..	..
12,931	5	1/7½	Direct Spanish (£4 paid)	4	4½	4	4½	4 8 11	April and October	4½	4½
6,000	5	10%	Do. Preference 10 per Cent.	9½	9¾	9½	9¾	5 2 7	" "	..	—
£30,000	Stock	4½%	* Do. 4½% Debentures of £50 each	103%	106%	103%	106%	..	..	..	..
60,710	20	2/0	Direct United States Cable, 1877	8	9	8½	9½	5 5 3	Jan., Apr., July, Oct.	..	..
400,000	10	5/6	Eastern	15⅝	15⅞	15⅝	15⅞	4 1 11	" "	15⅞	15⅝
70,000	10	6%	Do. 6 per Cent. Preference	16½	16¾	16½	17	3 10 7	" "	17	16¾
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	118	119	117	120	3 6 8	May and November	118½	116
£102,100	100	5%	* Do. 5 per Cent. Debentures, 1899	105	109	105	109	4 12 2	February & August	..	..
250,000	10	2/6	Eastern Extension	15⅝	15⅞	15⅝	15⅞	4 8 2	Jan., Apr., July, Oct.	15⅞	15⅝
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	114	117	115	118	3 7 10	February & August	..	..
£62,700	100	5%	* Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900	103	106	103	106	4 15 0	January and July	..	..
£95,100	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb., 1900	103	106	103	106	4 15 0	" "	104½	..
£300,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.)	103	106	103	106	3 15 8	February & August	104½	103
£200,000	£25	4%	* Do. 4% Mauritius Sub. Debs.	107%	110%	108%	111%	3 12 1	May and November	..	..
180,227	10	3 9	Globe Telegraph and Trust xd	8½	8¾	8⅜	8⅝	5 1 5	Jan., Apr., July, Oct.	8⅞	8⅝
180,042	10	6%	Do. 6 per Cent. Preference xd	15½	15¾	15½	16	3 15 0	" "	15 13/16	15 11/16
150,000	10	5 0	Great Northern	20	21	20	21	3 17 0	Jan., April, and July	..	..
£190,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	105	108	105	108	4 14 9	March & September	..	—
17,000	25	37/6	Indo-European	45	47	45	47	5 6 5	May and November	45½	..
37,548	10	5/0	London Platino-Brazilian	5	7	5	7	..	" "	..	..
£100,000	100	6%	* Do. 6 per Cent. Debentures	108	111	108	111	5 11 1	March & September	..	..
£100,000	£100	4%	*Pacific European Tel. 4% Guar. Debs. "Red" 1942	102	105	102	105	3 16 7	..	103	..
11,839	8	4/0	Reuter's	3	5	3	5	..	April and October	..	..
3,381	£100 Cert.	25/0	*Submarine Cables Trust 6 per Cent.	108	113	108	113	5 6 11	" "	..	..
15,000	10	5/0	West African Telegraph	3	5	3	5	..	January and July	..	..
£219,900	100	5%	* Do. 5 per Cent. Debentures	102	105	102	105	4 17 7	March & September	..	..
30,000	10	2/0	West Coast of America	2½	3	2½	3	..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	96	101	99	104	7 15 9	June and December	100½	..
88,321	10	9d.	West India and Panama	1	1½	1	1½	..	..	..	..
31,563	10	6%	Do. 6 per Cent. 1st Preference	10½	10¾	10½	10¾	5 11 7	May and November	10⅝	10½
4,669	10	6%	Do. 6 per Cent. 2nd Preference	9	10	9	10	6 0 0	" "	..	..
£80,000	100	5%	* Do. 5 per Cent. Debentures, 1917	107	110	107	110	4 11 6	June and December	..	..
64,242	15	7/6	Western and Brazilian	6¾	7¼	6¾	7¼	..	May and November	7 3/16	7 1/16
33,129	7½	7/6	Do. 5 per Cent. Cumulative Preferred	5¾	6¼	5¾	6¼	..	..	6⅛	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	1¾	2¼	1¾	2¼	..	..	..	..
£171,900	100	6%	* Do. 6 per Cent. Debs., Series "A" 1910	105	108	105	108	5 11 1	February & August	..	..
£214,800	100	6%	* Do. 6% Mort. Debs., Series "B" 1910	105	108	105	108	5 11 1	" "	..	..
$1,211,000	$1,000	7%	*Western Union 7% 1st Mort. (Building) Bonds	115	120	115	120	5 18 11	May and November	..	..
£166,900	£100	6%	* Do. 6 per Cent. Sterling Bonds	100	104	100	104	5 18 10	March & September	..	..
			TELEPHONES.								
44,000	5	10/0	Chili Telephone (fully paid)	1	2	1	2	..	..	..	..
224,850	10/0	2⅞d.	Consolidated Telephone Const. & Maintenance	¼	½	¼	½	..	May and November	..	..
171,504	£1	6d.	Oriental Telephone and Electric (fully paid)	¼	⅝	¼	⅝	..	Yearly	..	..
484,597	5	3/4	National	4¾	5¼	4¾	5¼	4 17 7	June and December	5⅛	4⅞
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	14	15	14	15	4 0 0	" "	..	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	13½	14½	13½	14½	4 2 9	" "	..	..
119,234	5	3/4	Do. 5% Non-Cumulative 3rd Pref.	5¼	5¾	5¼	5¾	4 6 11	..	5⅜	5⅜
1,000,000	Stock	4½%	* Do. Debenture Stock, 4½%	109	112	108	111	4 1 5	January and July	108½	..
58,000	5	1/0	United River Plate	1	2	1	2	..	" "	1½	..
£146,733	Stock	5%	Do. 5 per Cent. Debenture Stock	85	95	85	95	5 5 3	" "	..	—
			ELECTRICITY SUPPLY COMPANIES.								
40,000	£10	..	City of London Electric Lighting (fully paid)	12½	13½	12½	13½	..	..	13	..
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	14	14½	14	14½	4 2 9	..	14½	14⅜
19,900	£5	..	Electricity Supply Co. for Spain	..		..		..	..	..	..
£30,000	£5	2 0	Charing Cross and Strand Electricity Supply Corp. xd	4½	5½	4½	5½	3 12 7	—	..	..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	..		..		..	—	..	..
8,322	£5	..	House-to-House Electric	..		..		—	—	..	—
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	..		..		—	..	..	—
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..		..		—	January and July	..	—
45,000	£5	2/6	Liverpool Electric Supply (fully paid)	6½	6¾	6⅝	6⅞	—	..	..	—
111,000	5	..	London Electric Supply	¼	⅜	¼	⅜	—	..	..	..
49,900	£10	5/0	Metropolitan Electric Supply (fully paid)	8½	8¾	8½	8¾	2 17 2	..	8⅜	8⅜
£150,000	Stock	4½%	* Do. 4½% Debs. (Bonds of £10, £20, and £10)	4	6 pm	4½	5½ pm	..	June and December	..	..
6,452	£10	..	Notting Hill Electric	4½	5½	4½	5½	—	..	..	..
19,980	£5	2/0	St. James and Pall Mall	6¾	7¼	6¾	7¼	..	..	7⅛	—
20,000	£5	7%	Do. 7 per Cent. Preference	8½	8¾	8½	8¾	4 0 0	..	..	..
59,900	5	2/0	Westminster Electric Supply (fully paid)	6	6½	6	6½	3 9 3	—	6¼	6¼
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
90,000	3	1/6	Brush Electrical Engineering	2¾	3	2¾	3	6 0 0	..	2 13/16	2⅞
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	2¼	2½	2¼	2½	4 16 0	.	2 7/16	2⅜
£125,000	Stock	4½%	* Do. 4½ per Cent Debentures	110	113	110	113	4 1 3	March & September	..	..
20,000	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref. xd	2	2½	1¾	2½	—	January and July	2	..
12,130	5	..	Edison and Swan United	—		—		—	..	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	..		..		—	..	—	..
120,000	2	..	Electric Construction	¼	¾	¼	¾	..	..	—	—
12,845	2	..	Do. 7 per Cent. Cumulative Pref.	1¼	1¾	1¼	1¾	..	—	—	—
91,195	2	10/0	Elmore's Patent Copper Depositing	1	1½	1	1½	..	—	1½	1⅛
20,000	5	..	Fowler-Waring Cables (fully paid)	½	1½	½	1½	..	..	1½	..
50,000	10	10/0	India Rubber, Gutta Percha, &c., Works	23	24	23	24	5 4 2	February & August	23¾	23½
£200,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	103	105	103	105	4 7 7	March & September	—	—
15,935	£10	6/4	International Okonite Ordinary	..		..		—	.	..	..
16,000	£10	..	Do. 8 per Cent. Preference	..		..		—	December and June	—	—
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid)	—	½	—	½	—	..	—	..
78,949	5	3/6	Swan United (£3 10s. paid)	..		..		..	May and November	..	..
37,350	12	12/0	Telegraph Construction and Maintenance	40	42	40	42	5 14 3	March and July	41½	41⅜
£150,000	100	5%	Do. 5 per Cent. Bonds	102	105	102	105	4 13 6	January and July	104½	..
37,514	£5	—	Woodhouse and Rawson Ordinary (£3 15s. paid)	—		..		..	..	—	..
41,098	£5	..	Do. Preference (fully paid)	..		—		..	—	—	..
£63,?70	10	10/0	W. T. Henley's Telegraph Works Ordinary	7	8	7	8	6 5 0	..	..	..
£30,000	10	..	Do. Preference	..		..		..	..	..	..
			RAILWAYS AND TRAMWAYS.								
£630,000	Stock	1%	City and South London Railway xd	33	38	33	38	1 16 2	May and November	37	36½
7,000	10	5%	Do. 5% Perpetual Preference xd	12½	13	12½	13	3 16 11	May and November	..	..
£67,130	Stock	4%	Do. 4% Perpetual Debenture	121	123	121	123	3 5 1	..	123	122½
37,500	£10	1%	Liverpool Overhead Railway	8 1/16	8 3/16	7 13/16	7 15/16	1 4 5	..	..	..
6,295	10	5%	Do. 5% Preference	13	13½	12½	13	3 16 11	..	..	..
£125,000	Stock	4%	Do. 4% Debenture	111	113	111	113	3 10 10	January and July	..	..

* In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption.

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NOTES.

Her Majesty, by virtue of the power vested in Her by the "Weights and Measures Act, 1889," and by and with the advice of Her Privy Council, has been pleased to approve of the ohm, the ampere, and the volt. These standards, or more strictly "denominations of standards," now rank with the yard and pound, and may, we presume, be called, at all events for the present, Imperial. That this title is not officially given to them is, probably, no omission. Whether the diplomatic resources of the Foreign Office have been employed to invite other Powers to recognise and embrace these standards, we have no information, but it is well known that every care has been taken to insure their acceptance throughout the civilised world, and the necessary formalities can only be carried out with the deliberation customary in important negociations between Governments. The United States have no time for old-fashioned etiquette and conventional observances. In 1892 they adopted the *metre des archives* and the *kilogramme* of the Paris Bureau, and three months ago the House of Representatives passed a Bill legalising the ohm, volt, ampere, coulomb, farad, joule, watt, and henry, stopping short, for no obvious reason, from including Brown and Sharpe's gauge and the multiplication table. There can be but little doubt that, instead of Imperial, the ohm, the ampere, and the volt will become International standards. The specifications of the voltameter and Clark cell have been slightly modified, and we reprint them, with the Order in Council, for the last time, in another column.

The second half of Mr. Greathead's Paper on the Liverpool Overhead Railway will perhaps be of greater interest to our readers than the portion which we printed last week; but electrical engineers and electricians must not lose sight of the fact that it is only by the first-rate design and execution of the purely mechanical part of such an undertaking that success of the electrical part can be realised. In some respects this line is a simple one, for the power station is situated near the middle, and it was practicable to use a steel channel bar of 4 sq. in. in section for the conductor, without the use of feeders. The lightness of the motor cars enabled a comparatively light structure to be used, and resulted in a higher speed of the trains. With such a quick service—and the secret of success with such lines is a quick service—the time spent in emptying the carriages becomes important. The side doors greatly facilitate this, and entirely obviate the unseemly scrambling and kicking that is encouraged by end doors and platforms. The comparative tables of weights and tractive force are of considerable interest, but strict comparisons are hardly possible. Railway men contributed but little to the discussion on this Paper or the one which followed it; and as tramway men, of course, hope to benefit by the development of electric traction, nobody else but horse breeders and dealers are concerned in the matter. Though the chemico-dynamic efficiency of a warm-blooded animal is, we believe, as high as 40 per cent., horsey men have hitherto been silent on the subject. The very brief account of Mr. Timmis's electrical signals is given near the end of Mr. Greathead's Paper.

The article by Herren Rössler and Wedding, of which the first half is printed in another column, deals with the use of alternate currents for arc lighting. The subject may be divided into three parts. The first, concerning the regulation or feed of the lamps, gives a clear warning against a trouble which has annoyed several makers of arc lamps; namely, the necessity for adjusting springs, weights, and coil windings for the particular type of alternator with which the lamp is to be used. Some day we shall have names for the different kinds of curves: "hat-shape," "sugar-loaf," and others have been suggested, and "hog's back," "dromedary," and similar descriptions might be used, without having recourse to personalities—that is, to the names of well-known electricians. Meanwhile, we must refer to the three types of curve discussed in this article, by the names of the makers of the alternators, the Ganz or peaked curve, the Wechsler or slightly sheared sine curve, and the Siemens curve, which has a flat top and a final "kick." The advantages of the first of these is not very apparent. Unless Messrs. Ganz and Co. have modified it they no doubt can claim some good points for it. It seems to be for most purposes worse than a sine curve. The slight want of symmetry of the Wechsler curve need not concern us here—it is practically equivalent to a sine curve; nor need the little kick in the Siemens curve be noticed—the curve is a fair example of a flat top, the machine was a special one, and whether the shape of the curve has any connection with the peculiar work for which it was built, we have no information; the current (curve 11, Fig. 10) remains constant for more than half of the half period. This seems to be an admirable curve for many purposes. For arc lamp regulation it is vident that, with a given choking, more current passes than

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with the Ganz curve; but the photometric result is of far greater importance. The second part of this Paper, which we shall print next week, deals particularly with the photo metric measurements.

In our last week's issue we gave an account of Prof. A. Schuster's Paper "On the Construction of Delicate Galvanometers," read before the British Association, in which he gives some interesting figures as to the ultimate sensitiveness it may be possible to attain with mirror galvanometers. It appears, however, that the basis of the formulæ is "the magnetic force at the centre of the coil for unit currents," which, as Profs. Ayrton and Perry pointed out some years ago, gives erroneous results when applied to the case of a magnetic needle of sensible length in comparison with the diameter of the coil. In the cases given in the Paper, where the coils are wound so near the needle, the error due to this method of calculation would probably be large. The great mathematical convenience of considering the force on a single magnetic pole in the centre of the coil, has caused nearly all galvanometer calculations to be made on this basis, but no calculations can be considered final in which the want of uniformity of the field is neglected. The consideration of the best type of magnetic system is a problem for which it is difficult to give any general solution.

In galvanometers where measurements are made by an image on a scale, the accuracy does not greatly depend on the diameter of the mirror, and it is advantageous to use a small light magnetic system and a small mirror, thus enabling the coils to be wound nearer the magnets, and giving small inertia and damping, which is important when using the instrument as a ballistic galvanometer. On the other hand, if interference or diffraction methods of measuring the deflection are used, a greater width of mirror would be desirable, and a consequent increase of the magnetic system. It is doubtful, however, whether much increase of sensitiveness would result from the use of such methods. With the present sensitive Thomson galvanometers, when supported in the best possible way, it is difficult to read to 5′ of arc when there is any local disturbance, and although it may be possible to detect an angle of 0·00005° with a mirror 1cm. wide, it certainly would not be possible to judge whether that deflection was caused by a current, or by vibration, magnetic disturbance, eccentricity, torsion, or electrostatic effects, most of which disturbances at present escape notice. On the whole, it is safe to predict that the time is far distant when we shall approach practically the sensitiveness given in Prof. Schuster's Paper.

The endeavours of the Société d'Encouragement pour l'Industrie Nationale to promulgate a new standard screw thread and wire gauge are very praiseworthy; but we should like to know if the B. A. thread, which was designed with careful reference to the Continental watch trades, and is based on millimetres and not inches, has been brought under its notice. Excellent as is the work done by committees of the British Association, the nature of these bodies is such that as soon as the work has taken the shape of a final report, and if no request for re-appointment is made, the committee ceases to exist, and no representative remains. Such committees consist, as a rule, of one or two zealous men, who initiate and carry out the work, one generally being the secretary, two or three other men invited to join on account of their supposed interest in the matter, and two or three ornamental or influential "deadheads." The British Association screw thread has become firmly established owing to its adoption by the Post Office, and to the steps taken by the London Chamber of Commerce to bring it to the notice of manufacturers, but not until several years after the Committee had been disbanded. The diameter is in round numbers of tenths of millimetres, and the pitch in round numbers of hundredths. To express these in inches, three or four decimal places respectively are used. It seems to be nobody's business to urge that this system should be used instead of the standards suggested by M. Thury for the Société des Arts of Geneva. For large screws, over six millimetres diameter, we can hardly expect the Whitworth system to be accepted, seeing that is based on the inch; but it is the practice in many engineering establishments on the Continent to express Whitworth threads roughly in millimetres, and to actually work with English stocks and dies or with tools made from English master taps.

Some five months ago a series of very interesting articles appeared in *The Times* on Light Railways, and in commenting on these in a leading article on April 6th last we discussed the cost and working expenses of the French *chemins de fer d'intérêt local*, and observed that the conditions under which such lines must be built and worked were very favourable to the use of electric traction with motor cars. In another column some further details will be found, together with a letter to *The Times* on the State Railways of India. The Indian railways, like much other Indian engineering work, have been a heavy burden on the taxpayers, and neither the cost nor the earnings can be allocated to the districts affected. The attempt to ear-mark the *intérêt local* in France and in Belgium is not satisfactory; and while the population of the district benefits in the cost of carriage, resulting in trade which would be otherwise impossible, and in the reduced upkeep of roads, the rates and taxes which pay interest on the cost of the railway, and on the deficit in working, if any, is paid for by others who derive no advantage whatever from the undertaking. This is one of the great advantages of State Socialism.

Cable Interruptions.—No interruptions are recorded this week.

Telephonic Communication in Russia.—Telephonic communication has recently been established between Nicolaieff and Odessa.

The Australian Association for the Advancement of Science.—The annual meeting of this Association is to be held at Brisbane, commencing January 11, 1895.

The Glasgow and West of Scotland Technical College.—The new session at this college will commence on October 1st. Further particulars, and information as to the courses of instruction, &c., will be found in our advertising columns, or may be had of the College Secretary.

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Derby.—The local newspapers state that the electric light in Derby is not doing the best that the electric light can do. On Saturday night the streets appear to have had to rely upon moonlight for some time, owing to the accidental extinction of the arcs. These things ought not so to be.

Municipal Tramway Purchase.—At their first meeting after the recess, says the *City Press*, the London County Council purpose giving the necessary statutory notice of their intention to acquire the important section of the London Tramway system which runs between Kennington Park, by the Elephant and Castle, to London-bridge.

Electric Traction in Germany.—Electric traction is to be adopted on the tramway between Rheydt and Gladbach, as also on the tramways at Mulhausen. Plans have also been prepared for the construction of an electric tramway on the accumulator system between Hagen and Eckesey.

The Gohna Lake.—The Gohna lake, referred to in a recent number of *The Electrician*, reached the top of the dam on Saturday last, and is now several feet below the dam—on the other side. Thanks to the use of the specially-built telegraph line, the catastrophe was admirably "managed" by the authorities, and it may be said to have "gone off without a hitch."

Electric Traction in South Africa.—We learn by the last mail that an interdict was recently applied for in the Eastern Districts Court at Port Elizabeth, to prevent the Municipal Council giving effect to the resolution passed at a recent public meeting in the matter of the electric tramway extension. The Court, however, refused the interdict, the Council thus scoring a victory.

The Tramway Conference.—A conference of directors of tramway companies was held at the Guildhall, London, E.C., on Tuesday last, at the instance of the Tramways Institute of Great Britain and Ireland, at which Mr. W. J. Carruthers-Wain presided. It was stated that the share and debenture capital of the British tramway companies represents nearly £14,000,000 sterling, and that the decision of the House of Lords will seriously affect the capital value of this large sum. It was unanimously resolved to take immediate action to mitigate the ruinous consequences of the judgment of the House of Lords, and share and debenture holders are to be invited to sign a petition to the Board of Trade urging a fair consideration of their claims.

Electro-Chemistry in Austria.—A company has just been formed in Vienna to be known as the Consortium für Electrochemische Industrie. The Company has acquired some patents taken out by Dr. Carl Kellner, and is establishing works at Golling for the production of bleaching powder and caustic soda by the Kellner process. The works are excellently situated as regards the supply of raw material, while for motive power the water power of the Salzach is to be utilised.

Electric Lighting in France.—The municipal authorities of Aiguilte (Upper Loire) have just decided to establish an electric lighthouse on the Saint Michel rock. A central electric lighting station is to be established at Saint Rambert (Ain); water-power is to be utilised. Saint Rambert is a small town with important linen manufactories. A small central station has just been completed and put in operation at Gabian (Hérault). The plant comprises a Gramme dynamo driven by a 16-H.P. steam engine. The little town of Corbigny (Nièvre) is also to be lighted by electricity.

Chicago Exhibition.—A letter signed by 105 English exhibitors at the late Chicago Exhibition, and addressed to the Home Secretary, expresses obligations to those members of the British Royal Commission who visited Chicago, and acknowledges appreciation of the efforts of the British members of the jury. The writers place on record three points of vital importance concerning the administration of the British section. The first relates to the selection of an efficient executive officer and chief assistant, the second to the use of the headquarters of the commission as headquarters of the exhibitors, who, being denied other accommodation, were dependent on the generosity of the American authorities for a room in which to hold their meetings. The third point refers to the expenditure of £14,000 on the commissioner's offices and headquarters, which were practically of no service to exhibitors, and the expenditure of less than £3,000 on decorations of the British courts, whereby the exhibitors were placed at a great and most damaging disadvantage compared to every other nation exhibiting.

Lighthouse Communication.—The Royal Commissioners appointed to inquire into the means of communicating between lighthouses and lightships sat last Tuesday in Liverpool, and received evidence with respect to the lighthouses and lightships in and around Liverpool Bay, and as to the best means of supplying any existing deficiencies. The Earl of Mount-Edgcumbe presided, and the other Commissioners were Sir Edward Birkbeck, Admiral Sir F. Leopold M'Clintock, Admiral Sir George Nares, the Hon. H. Mulholland, M.P., Mr. R. Munro-Ferguson, M.P., Mr. J. C. Lamb, Mr. W. H. Preece, and Mr. J. A. Kempe; and Mr. Ernest Mogeridge, secretary. Mr. Harold Bateson, local hon. secretary to the Lifeboat Institution and coxswain of the New Brighton lifeboat, submitted a scheme for the improvement of the communications. The Commissioners afterwards paid a visit to Crosby Lighthouse, about six miles north of Liverpool.

Magnetic Rotary Dispersion.—Having carried on a series of experiments on the rotary dispersion of quartz in the infra-red part of the spectrum, M. G. Moreau is now investigating the magnetic rotary dispersion of carbon bisulphide for the same part of the spectrum He has also measured the refractive index of carbon bisulphide for the infra-red rays, so that he may be able to compare his experimental values for the magnetic rotary dispersion with those obtained by the formula deduced by Maxwell's electro-magnetic theory. The magnetic field used in the experiments was produced by the large coil which Verdet used in his classic researches in this subject, its intensity being measured by the rotation produced in carbon bisulphide for sodium light. In the infra-red observations a thermo pile and delicate galvanometer were employed. The author has succeeded in measuring the rotation for wave-lengths between 0·8 and 1·4 $\mu\mu$; the absorption of the CS_2 preventing any measurements being made for greater wave-lengths. The paper in which the above results are given will be found in the *Annales de Chimie et de Physique* for February.

J. and the Penny Ices.—A boy, supposes the *Engineer*, eats two ounces of ice. Let us see, says our contemporary, what is the approximate thermodynamic equivalent of the work he has made his interior do, assuming he takes five minutes to eat it. In melting the ice, taking the latent heat of fusion at 143 units, and the specific heat the same for the colouring and sweeting admixture as for the ice, he will require eighteen units to reduce the ice to water. To raise it in temperature to that of his inside, he will require seven more units, or a total of 25 British thermal units. Taking the mechanical equivalent as 777 foot-pounds, this will be equal to 19,425 foot-pounds. If the boy weighs 100lb. he will have called upon his stomach to do as much heat work as would, with a machine having unit efficiency, raise him 194ft. high, or a rate of heat extraction equal to nearly an eighth of a horse-power. Remarkable as this achievement appears to be, our contemporary will find that if the small boy is addicted to the pernicious habit of drinking a pint of ice-cold water in one minute he will, if his stomach acquires a uniform temperature in that time, expend a still greater amount of heat, for the power expended in that case will be equal to about three-quarters of a horse-power. How active a small boy can become on occasion!

The Electrolytic Purification of Sugar Juice.—In a recent number of *Sucrerie Indigène*, Dr. W. Bersch publishes some results obtained with the Schollmeyer-Behne-Dammeyer electrolytic process of purifying sugar juice. Dr. Bersch does not feel called upon to propound a theory of the process, but considers that the figures published cannot fail to give a fresh impulse to research work in this direction. The sugar juice coming from the diffusers at a temperature of 40°C. to 45°C. is heated up to about 65°C., and passed into a rectangular iron tank, divided into two equal compartments, of such a size that 330 gallons of liquid occupy a depth of about 18in. In each compartment there are seven zinc anodes of a total surface of 64½ sq. ft. The two compartments are alternately filled with juice, which is submitted for about 10min. to a current of from 50 to 60 amperes at 6 volts. A grey-green gelatinous

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substance is deposited at the cathode; this deposit can be scaled off when necessary by reversing the current for 5min. or so. At Hoym (Germany), where this process has been tried, it is found that in defecating electrolysed juice 1 per cent. of lime does the work of the 3 per cent. or 4 per cent. required in the case of non-electrolysed juice. According to Dr. Bersch, the broad result of the electrolytic treatment is that a better quality of refined juice is obtained, and that in less time and with greater facility than formerly. The first cost of the plant at Hoym was paid for in a week by the superior economy of the process.

Standard Wire Gauges and Screws.—We have frequently had occasion to refer to the useful work, in the standardisation of screws and wire gauges, which is being done by the Paris Société d'Encouragement pour l'Industrie Nationale. The latest proof of this is to be found in the publication of a circular on the "Unification des Filetages et des Jauges de Tréfilerie." The Society has had the question of a standard screw-pitch and wire-gauge in hand since the end of 1891. It was, however, only three months ago, says *Nature*, that a meeting was held for the purpose of discussing the various systems suggested, and at that meeting the scales expounded in the pamphlet before us were accepted. To secure uniformity in the manufacture of screw-threads, the Society proposes a system, to be known as the "Système Français," in which the pitch increases in steps of half a millimetre, from a screw having a diameter of six millimetres and a pitch of one millimetre (No. 0) to one having a diameter of 148 millimetres and a pitch of 10·5 millimetres (No. 19). The formula which, in this system, allows the diameter (D) corresponding to any pitch to be deduced is $D = p(p+8) - 1{\cdot}5 \div 1{\cdot}3$, where p is any pitch expressed on the adopted scale. By means of this, it is possible to extend the new system to screws of any diameter, and the number of the screw of which the diameter had been thus determined would be equal to the number of half-millimetres expressing the pitch, *minus* two. For screws less than six millimetres in diameter the standard drawn up by M. Thury for the Société des Arts of Geneva is adopted. In addition to promulgating these standards of screw construction, the Société d'Encouragement has developed a decimal system of gauging wires. In this system, the numbers of the wires express their diameters in tenths of millimetres; thus, a No. 7 wire has a diameter of 0·7mm. Such a method of designating wires is as simple as it is scientific.

Specific Inductive Capacity in Variable Electrostatic Fields.—A recent number of the Johns Hopkins University *Circular* contained a preliminary note, by E. F. Northrup, on a method of obtaining the specific inductive capacity of solids under either slowly or rapidly changing fields. It is of great importance in connection with Maxwell's electro-magnetic theory of light that, since the refractive index for most substances has only been measured for very short waves, the specific inductive capacity be measured under such circumstances that the field of force alternates with such rapidity as to produce waves comparable in length to the waves with which the refractive index is determined. The apparatus employed by the author consists of three heavy brass plates, fastened parallel to each other, and separated by about three inches. Each plate is held in position by four insulating strips of ebonite, through the ends of which pass four iron rods with a screw-thread cut upon their whole length. To the centre of each of the two outside plates, and perpendicular to the plate, is fastened a brass tube. A rod, half of which is of ebonite, moves in this tube and carries at its end a thin plane plate of glass, the surface of which is coated with metal foil. These small movable plates are as nearly as possible parallel to the large plates, and their position is given by a vernier attached to the ebonite rods. The two outside plates are connected by a metal rod which carries a metal ball. Another ball, nearly opposite the first, is fixed by a short metal pin to the middle plate, so that the distance between the balls can be adjusted. In employing the apparatus to measure specific inductive capacity with rapidly-varying fields, the following arrangement is used. The two outside plates and one terminal of a large induction coil being connected to earth, the other terminal of the coil is connected to the middle plate. When the coil works, sparks pass between the balls, and oscillations are set up. The lines of force, when air only is the dielectric, divide evenly between the plates, and in the region of the small plates the field may be considered as uniform; hence, if these plates are at equal distances from the centre plate they will always remain at the same potential. If, however, a plate of some other dielectric is placed between the centre plate and one of the movable plates, in order that the two small plates may remain at the same potential, they will have to be placed at unequal distances from the centre plate, and from their relative positions the specific inductive capacity can be deduced. In order to "weed" out the effects of the slow changes of potential due to the charge and discharge of the coil, the two small plates are connected to the primary of a small transformer, the secondary of which contains a spark-gap. In this way the effects due to the slow changes are eliminated, since the rate of variation of the induction in the transformer, due to these slow changes, is not sufficient to raise the potential in the secondary to the 300 volts or more required to break down the dielectric in the spark-gap.

Educational Endowment in America.—It may be doubted whether American universities are altogether such as we should see, or like to see, founded in this country, were the same stream of gold to flow towards educational endowment here as on the other side of the Atlantic; but until our educationalists have an opportunity of handling millions it is obviously impossible to say whether they would make better or worse similar or dissimilar use of such colossal funds as are placed at the disposal of their colleagues across the water. The way they manage these things in the United States may very well be exemplified by the case of the Chicago University. Two years ago, said *Engineering* recently, it existed only in the minds of a number of zealous Baptists; to-day it has its broad acres on the Lake Front, an imposing pile of buildings, and a student population of 1,000. Chicago, we are further informed, is no longer a place merely of surprises and wonders; it has become a city of lofty inspirations and generous impulses. The new university owes its foundation to Mr. John D. Rockefeller, who, in June, 1889, offered £120,000 for the purpose, on condition that £80,000 more would be advanced by others. The character of the response pleased Mr. Rockefeller so much that, to mark his appreciation of it, he placed a cheque for £200,000 to the credit of the contemplated institution. Example now became contagious; a sum of £140,000 found its way into the University chest from the will of Mayor William B. Ogden; S. A. Kent offered £40,000 for a chemical laboratory; G. C. Walker, £20,000 for a museum; Martin A. Ryerson, £20,000 for a physical laboratory; Major H. A. Rust, £14,000 for a dining-hall; and Marshall Field, £50,000 for a biological laboratory. Next came Mr. Yerkes, who offered £100,000 for an astronomical telescope to surpass that of Lick. The name of Mr. Armour, the packer, is not to be found on this list, he being engaged in spending a trifle of £400,000 or so on an institute of his own. The lady friends of the university scheme came forward. Mrs. Henrietta Snell gave £11,000; Mrs. Mary Beecher, £10,000; Mrs. E. J. Kelly, £10,000; and Mrs. N. S. Foster, £12,600. The executive of the university, therefore, started operations with no misgivings as to funds—a feeling quite unknown in England. The buildings were begun in November, 1891, and when the Exhibition opened in May, 1893, seven were completed, at a cost of £180,000. The university has, at present, the three faculties of arts, science, and divinity. Chicago departs from time-honoured traditions in its regulations about vacations. It must be admitted that we devote too much time to holidays. On the other hand, the Chicago legislators are in imminent danger of erring in the opposite direction. By one drastic measure they abolish all long vacations. The twelvemonth is divided by them into four quarters, the last week in each being devoted to a little mental depolarisation. The regular work of the university is carried on by a staff of more than one hundred teachers. These are of various grades, from the professor and assistants through instructors and tutors down to readers and docents. Many are graduates of Harvard, Yale, Johns Hopkins; some, too, come from Berlin and Göttingen, while others owe allegiance to Cambridge and Edinburgh. The official head of the university is Dr. Harper of Yale.

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MOTIVE POWER AND GEARING.*

BY E. TREMLETT CARTER.

(Continued from page 425.)

Feed and Steam Mains and Connections.

Feed Mains.—The life blood of a steam plant is the feed water, and, where the consequences of a failure in the supply of this vital fluid would be disastrous, precautions must be taken to ensure a steady supply of water to the boilers. Failure usually occurs from one or other of two causes: stoppage of the supply from the source, and breakdown of the

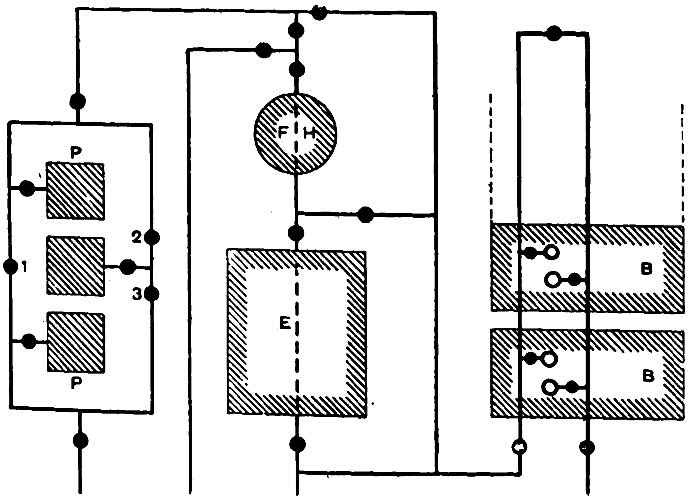


FIG. 20.——— Feed Pipes. ● Stop Valves. B, Boilers. E, Economisers. F H, Feed Heaters. P, Pumps.

main pipe or of the pumping plant. The remedy for the first is found either in a capacious cooling pond, in places where condensing plant is used, or in large tanks filled with cold water from the town mains. The remedy for the second lies in duplication or multiplication of the parts. It is insufficient for this purpose, however, to provide several pumps; it is also necessary to provide two or more distinct possible paths for the water, from the cooling pond or tanks to the battery of boilers, and, further, to provide each boiler with two injection or feed pipes. This is almost universally done now in

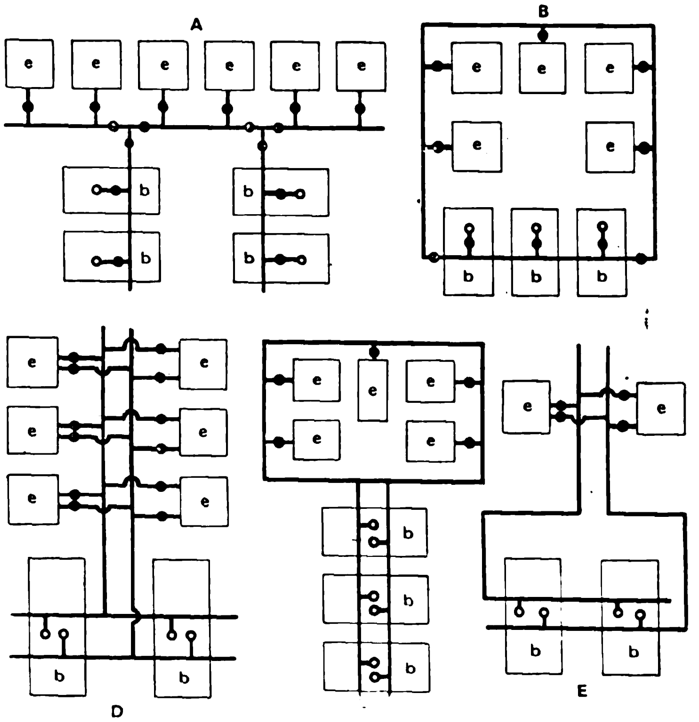
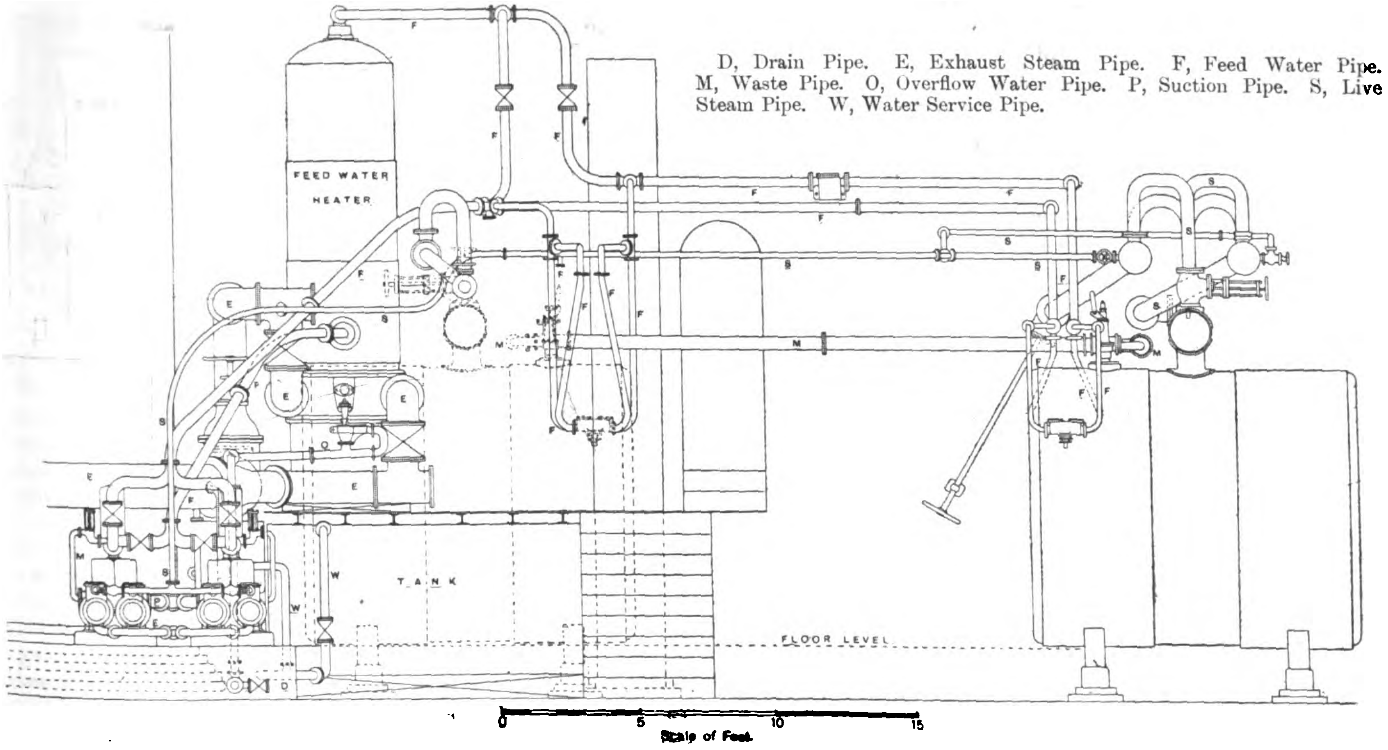


FIG. 22.—A, Ideal Single Main System. B, Single Ring Main System. C, Double Ring Main System. D, Manchester Independent Duplicate Main System. E, Portsmouth Independent Duplicate Main System. b, Boilers. e, Engines.

electric power stations. A diagrammatic representation of the feed main connections between a battery of boilers and three pumps, including an economiser and a feed-heater, is shown in Fig. 20, and may be taken as an average of usual practice. By closing the stop valves 1 and 2, two pumps will



D, Drain Pipe. E, Exhaust Steam Pipe. F, Feed Water Pipe. M, Waste Pipe. O, Overflow Water Pipe. P, Suction Pipe. S, Live Steam Pipe. W, Water Service Pipe.

FIG. 21.—Glasgow Electric Power Station. Feed System for Boilers.

supply all the boilers through one feed main; by closing the valves 1 and 3 the same result can be obtained through the other feed main; all the other valves being opened or closed as required. An elevation, to scale, of the feed connections at the Glasgow electric power station is shown in Fig. 21.

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For permission to reproduce the illustrations of the Glasgow feed and steam systems, the author is indebted to Messrs. Alley and Maclellan, by whom the work was carried out.

Steam Mains.—This idea of duplication, if logically pursued, leads to the provision of two independent paths for the steam, from the boilers to the engines; for it is evident that where only one path is provided the working of the entire plant depends on the security of that one steam main. With steam distribution, however, there is an effect to be considered which does not enter into water distribution; namely, the loss of energy by radiation from the pipes, and the consequent injury to the steam by the production of wetness. Duplication of steam mains, therefore, can only be carried out at a sacrifice of some of the efficiency of the steam plant. Many engineers of very great experience are in favour of duplicating every steam pipe and main. Others, of equal experience, consider that it is quite as safe and certainly more economical to provide only one system of pipes, but to employ an unusually high factor of safety; and to so design the parts that repairs may be carried out and extensions made without crippling more than a fraction of the plant.

Where duplicate mains are adopted, it should be arranged that, when not required to supply steam, the several sections of the mains may be cut out of circuit, thereby reducing the loss of steam by condensation. In some places this is not possible, owing to the necessity for keeping the steam joints under pressure, and an enormous rate of condensation goes on all day and night long in consequence.

Systems of Steam Mains.—Besides the simple plan of providing a single main between the boilers and the engines, there are two systems of steam mains in general use. These are: the ring main, and the independent duplicate main. Diagrams of these systems are given in Fig. 22. With the simple ring main, including all the boilers and engines in its circuit, each item of plant gives or takes steam through only one branch. This is shown at B, and is in use at, among other places, the Amberley-road station of the Metropolitan Electric Supply Company. More commonly, the ring itself is divided into two rings or loops, one for the engines and one for the boilers, as shown at C, each of the boilers supplying steam at two points to the boiler mains. This system is in use at the Glasgow electric power station, a plan of the steam

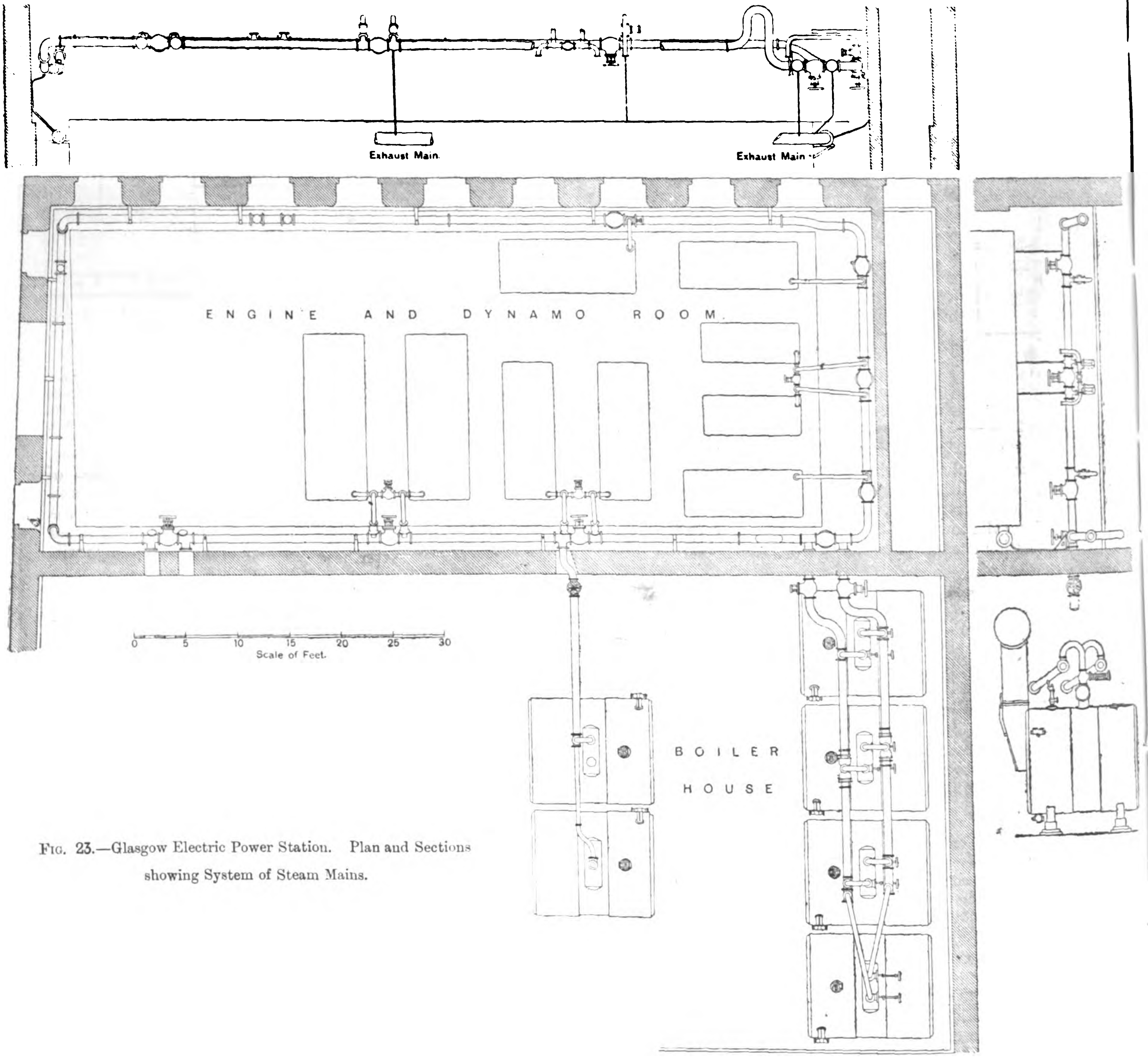

Fig. 23.—Glasgow Electric Power Station. Plan and Sections showing System of Steam Mains.

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mains at which is given in Fig. 23. At this station a great deal of trouble from condensation has been experienced. Two systems of independent duplicate mains are shown at D and E, in Fig. 22. The former of these is the one adopted at the Manchester electric power station; the latter is in use at the Portsmouth station. It will be seen that the former requires a much shorter length of main, for the same size, number and arrangement of engines and boilers.

Steam Receivers.—It has been pointed out that, owing to the irregularities in the velocity of steam through the pipes, there must be a fluctuation of pressure at the engine end, even assuming the boiler pressure to remain constant. Where several engines are taking steam from the same main, it may happen that they all take steam at the same moment, in which case the fluctuation of pressure will be very large; on the other hand, it may happen that they take steam in succession, and thus produce a fairly uniform flow in the pipe, in which case the fluctuation would be practically zero. Where the engines are driving continuous-current dynamos

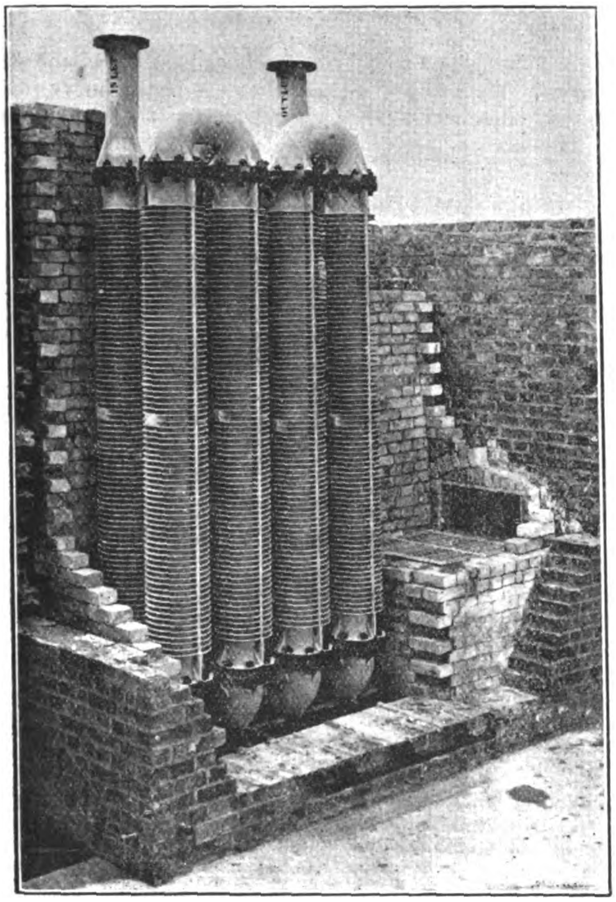

FIG. 24.—Schwoerer Superheater arranged for Independent Firing.

there is no tendency to produce any definite condition in this respect, and the engines probably come into and go out of steam-phase quite irregularly, producing complicated fluctuations of pressure in the mains. Where, however, the engines are driving paralleled alternators, the phase relation between the steam in-takes of the several engines is fixed. It is as liable, however, to be fixed badly as advantageously; for there is, at present, no attempt made to get the engines out of steam synchronism while getting the alternators into electrical synchronism. One remedy for the ills due to irregular steam-flow is to provide a small receiver or reservoir for the steam, placing it as near as possible to the engine. This will transform the irregular rate of flow into a regular rate, and will materially diminish the loss of pressure due to friction in the mains. A certain amount of condensation might be expected to take place in the receiver; but this would be less than in the receivers of compound engines, as the size might be smaller.

Superheaters.—One remedy for the evil effects of condensation in steam mains which has been proposed is to superheat the steam directly it leaves the boilers. The effect of superheating on the behaviour of the steam after it enters the engines will be considered later. Superheating, though it would without doubt reduce the condensation in steam pipes, would probably not diminish the heat losses due to radiation from the pipe surfaces; indeed, the superheated steam being hotter than the saturated, it would probably be found that these losses would be increased. A form of superheater which has been largely used in conjunction with Sulzer and similar types of engines on the Continent is shown in Fig. 24. This superheater is the invention of Mr. Schwoerer, and is manufactured in this country by Messrs. Fraser and Chalmers. From a report by Prof. Unwin on this superheater, it would appear that an economy of from 20 to 25 per cent. of coal may be obtained through its use in conjunction with the slow-speed engines just named. The superheater shown in Fig. 24 is arranged for independent firing, but superheaters are frequently set in the boiler flues so as to derive heat from the same fuel as the boiler. It is a saving in labour to adopt the latter plan, since a separate grate need not then be used. But it does not contribute to satisfactory and efficient superheating to place the heater in the colder parts of the boiler flues; and, for the best results, the gases brought to the superheater should be at least as hot as those taken to the boiler.

(To be continued.)

THE "SINE CURVE" CONTROVERSY.

In our issue of July 6th, on page 258, we observed that a considerable number of manufacturers in America are advertising the possession of a "true sine curve" as a valuable feature of their alternators. We returned to the subject a fortnight later, and on July 20th, on page 319, made some further remarks on the subject. After these were in type, we found that our views received full confirmation from some experiments which are being conducted with special reference to the efficiency of transformers, but which are not yet completed. The matter has now given rise to a considerable controversy, but is being led off the original line into cases of power transmission by special types of machines. Last week we referred to some foolish remarks in an American electrical journal published in Chicago; but the matter assumed a more important shape when, on Friday morning, we received the *Electrical World* of New York, dated August 18th, and found therein letters from Prof. Houston and Mr. Kennelly, Dr. Louis Duncan, and from Mr. F. W. Dunbar, together with an editorial comment.

Our esteemed contemporary, the *Electrical World*, takes the matter very seriously:—

"It is seldom that we find it necessary to disagree *in toto* with our esteemed London contemporary, *The Electrician*; but, notwithstanding the ability with which it has clung to its opinion as to the non-efficacy of the sine form of curves of alternating E.M.F., we have not been able to see anything but hopeless error in its views of this subject. In our issue of last week and elsewhere in the present issue several correspondents whose opinions have an authoritative value confirm the views we have expressed, and offer an accumulation of evidence, both theoretical and experimental, which should definitely settle the question. The very neat general mathematical demonstration of Mr. F. W. Dunbar complements the special deduction in Kennelly's Institute Paper on impedance, while the other letters bring to bear an accumulation of evidence that takes away every vestige of ground for the opinion which they contest. From both the theoretical and the practical standpoint it can be considered as definitely established that the sine form of curves of alternating E M.F. is the best, for the reasons that it involves less inductive drop and less iron losses in transformers, and is absolutely necessary in motor work to avoid deleterious reactions from the upper harmonics otherwise present. To these advantages may be added the further one recently referred to by us in commenting on some German experiment with alternating arcs, which is that for the practical working of such arcs the sine curve insures smoother operation of the mechanism and a minimum of noise.

Our readers may judge for themselves as to the advantages of sine curves for arc work from the German Paper, of which we print the first half in our present issue. We refer to this Paper elsewhere.

Our critics, in the majority of cases, have made two mistakes in regard to our statements as to the value of a sinusoidal electro-

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motive force. Firstly, they have understood us to say that the sine curve is the *worst* possible for such a function; whereas, all that we did say was that it is a waste of time and skill to try to get a sine curve, because the sine curve is by no means the *best* possible. Secondly, they have failed to realise that our criticisms are of a perfectly general nature, relating to the inherent qualities of the various electromotive forces, and by no means referring to the performances of any one particular machine. It is true that we pinned our remarks upon some trials of alternate-current machinery by Dr. Duncan; but we merely did so in order to say that these trials by no means warranted the general conclusion that the sine function is the best. Reference to our Note, on page 319, will show this to be the case. It is quite possible that a certain motor might have such idiosyncracies as would lead it to work better with a sine function than with an electromotive force of any other form; indeed, Dr. Duncan seems to have discovered such a motor. He says:—

"As far as the matter in question is concerned, the statement of Mr. Scott, of the Westinghouse Company, made in the discussion of the Paper referred to, is very much to the point. He instanced the case of a two-phase motor, which, when driven from a certain dynamo, heated badly and had a great deal more 'armature slip' than was expected. It was found on investigation that the curve of dynamo E.M.F. was irregular, and the third harmonic was prominent. Being supplied with a sine E.M.F., the same motor ran efficiently and satisfactorily.' Nothing can be more direct than this evidence. Mr. Scott remarked that in such a motor the third harmonic tended to turn the armature in a direction opposite to the primary wave, the result being disastrous. Mr. Steinmetz, who champions the three-phase system, pointed out that the third harmonic would tend to revolve the armature of a three-phase motor in the proper direction. While this is true, the efficiency of this component would be small."

We shall refer to the third harmonic presently. As to the evidence, it is by no means direct; it only shows that one particular *non*-sine curve was worse than the sine curve, with one particular motor.

Our esteemed friends, Messrs. Houston and Kennelly, are at variance with us when we assert that this controversy is based upon the conclusions of mathematicians rather than of practical research. We quote from their letter:—

"It is asserted that the reasons which have induced American designers to endeavour to obtain a sinusoidal E.M.F. in their alternators are mathematical rather than practical. This is by no means the characteristic of American electrical engineers, who are confessedly pre-eminently practical. In point of fact, the reasons, so far from being of a mathematical nature, are solely practical. It is known by observation that the loss of energy in the excitation of transformers is greater for non-sinusoidal than for sinusoidal E.M.F.'s, especially at high frequencies. It is true that the extra loss of energy through non-sinusoidal E.M.F. waves is usually not of sufficient importance to render a strictly sinusoidal E.M.F. of great value for merely lighting purposes. But for purposes of power transmission, deviations from the sinusoidal form of E.M.F. wave become deleterious, partly on account of the additional drop or pressure in the conductors transmitting the energy, partly owing to the additional loss of energy entailed in the transformers, but principally owing to the reactions set up in the induction motors by the virtual harmonics present in the sinusoidal form of E.M.F. whenever rotary field motors are employed."

Nevertheless, it is to the mathematics of Mr. Kennelly that Dr. Duncan and other adherents to the sine curve have referred us in support of their theories. Messrs. Houston and Kennelly make the mistake already referred to, of supposing that we are placing the sine curve at the bottom of the list.

It is vagueness itself to speak of comparisons between sinusoidal and non-sinusoidal curves, without naming exactly the components of which these latter are composed. There are non-sinusoidal curves which are vastly worse than the sine curve, and there are other non-sinusoidal curves which are decidedly better than the sine curve. Take, for example, Dr. Duncan's sine function with the third harmonic. If the harmonic is exactly in anti-phase with the fundamental, a condition of things shown in Fig. 1 will occur. The illustration shows that, with three different amplitudes, three different resultant curves are produced, every one of which has a less maximum than the primary curve. If the maxima of the two components are co-phased, however, the condition of things represented in Fig. 2 will take place. The resultant maximum will be greater than the maximum of the primary. For other phase relations between the components, intermediate results would occur. Do our critics mean to say that the losses in an alternator, transformer, or motor would necessarily be greater with the flat-topped resultant curve in Fig. 1 than with the fundamental sine curve? Do they insist that to get the best results it is necessary to avoid the flattened curve, as well as the peaky

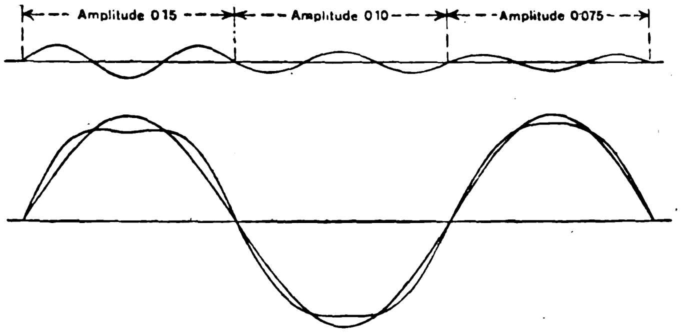

Fig. 1.—A Sine Curve compounded with its third harmonic, with maxima in anti-phase. Amplitude of harmonic, 0·15, 0·1, and 0·075. Amplitude of sine curve being unity.

curve (in Fig. 2), and to get as closely as possible to the simple sine curve? We will grant them that the peaky curve will not best satisfy their wants; but we must insist that the efficiency of the flat curve is better than either of the others. In this

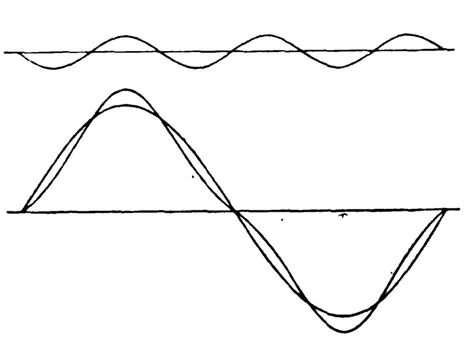

Fig. 2.—A Sine Curve compounded with its third harmonic with maxima in co-phase. Amplitude of harmonic, 0·15.

connection we would refer our critics to the letter from Mr. Steinmetz, which we published last week. Mr. Steinmetz says:—

"The hysteretic loss per cycle in the transformer exclusively depends upon the limiting values of magnetism, and will remain the same as long as these are the same. . . . If the wave of E.M.F. differs from sine shape, we can consider it as a fundamental sine wave with higher harmonics superimposed thereon, and then the wave of magnetism will also be a distorted wave, consisting of a fundamental sine wave superimposed by sine waves of triple, quintuple, &c., frequency. It is obvious now that if the triple harmonic wave of magnetism is superimposed upon the fundamental wave in such a way as not to increase its maximum value, the core loss will not be increased; but the amount of energy transformed is increased by the energy of the triple harmonic."

Finally, we would remark that since the flat-topped curve is the best for general distribution purposes, best for transformer and generator efficiency, and as good, at least, as any other for lighting purposes by glow lamps, and, if we understand Herrn Rössler and Wedding aright, better than a sine curve or a peaked curve for arc lamps, and it is therefore to the interest of makers to cultivate this type of curve. Herrn Rössler and Wedding, indeed, in the second part of their Paper, for which we cannot find space this week, say, "Apparently it would be best to build machines whose curves approach the shape of Fig. 15." This diagram, which we shall reproduce next week, is simply rectangular. That there are special cases where another type of curve is better adapted to the local conditions we are quite ready to believe; and we are also willing to recognise the existence of alternate-current plant which can only subsist on sine curves. But it remains yet to be shown that there is the smallest ground for believing the sine curve to be inherently the best and most efficient. This neither the able pen of Mr. Kennelly, nor the fallacies of Mr. F. W. Dunbar, nor the experiments of American electrical engineers, give any present indication of doing. While Dr. Louis Duncan goes to one extreme and considers the particular case of his peculiar and fastidious motor, Mr. Dunbar takes the

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other extreme, and so anxious is he to generalise, that he abandons the consideration of the presence of iron, and bases his arguments on a mechanical analogy. The discussion of the behaviour of iron-less transformers and motors may be interesting to mathematicians, and of use to some kinds of students; but the whole point of *our* case is the effect on the iron. After recapitulating our remarks, Mr. Dunbar writes :—

"These criticisms, coming from the London *Electrician* and entirely unsupported by any theoretical or practical evidence, are even more astounding when we consider the ease with which it may be shown that the most efficient rate at which electrical force may be applied to do useful work is the sine curve, and this without the necessity of discussing *individually* the 'intricate phenomena of alternating-current machinery.'"

He then indulges in some "iron-less" mathematics, and naturally arrives at the conclusion that where simple mechanical considerations of mechanics are concerned, a succession of simple sine impulses is the best. Having proved this he goes on to say :—

"The sine curve of E.M.F., then, is the curve which will impart the greatest average momentum to an electrical circuit for a given average alternating force; that is, it is the 'best' curve for an alternating E.M.F. which is to be used to do useful work, for it is evident that all losses due to eddy currents, hysteresis, &c., &c., will then also be a minimum."

This conclusion is, we maintain, quite unwarranted.

Confidently as we maintain that a sine curve is not the best, and that a flat-topped curve is better, we must point out that the difference when reduced to £ s. d. is but a trifling amount. The experiments to which we have alluded agree well with those of Mr. Steinmetz, viz., that the iron losses in generator and transformer were about 10 per cent. greater with a sine curve than with a flat-topped curve. This flat-topped curve was not, so far as we are aware, designedly of that shape, and when the "best" curve has been obtained the difference will no doubt be greater. This week Mr. Steinmetz strengthens his former statements and our position by giving an example of a motor, in which the relative economy with the non-sinusoidal wave was as high as 13 per cent. His letter will be found in our correspondence columns. We do not, therefore, urge that the saving will be a large one. The matter is not one of vital importance; it is hardly worth having a demonstration in Hyde Park about it; but our original contention, that it is folly to struggle after a sine curve for general work, remains unshaken.

LIGHT RAILWAYS.*

The Times published not long ago some articles on the subject of light railways, giving a general account of the method in which the benefits of cheap railway transport had been extended to thinly-populated agricultural districts in foreign countries without the great expense of first construction and equipment that are involved in building such railways as our Board of Trade rules require. Some particulars of a line of this character, which may be regarded as typical, and which has been at work for two years successfully, have recently been given by *Le Génie Civil*, a French engineering journal.

The line referred to is in the department of Loiret, in France. Its termini are 22 kilometres apart, but in order to serve important properties the line was made 31 kilometres in length. The termini are Pithiviers and Toury, both of which are stations on existing railways. The district is one in which the cultivation of beetroot has recently made great progress, and in which sugar factories exist. The Conseil-Général (or, as we may say, County Council) of the department decided to construct the line out of their own funds, chiefly for the development of this industry, taking into consideration, also, the fact that, by transferring to a railway the heavier cart traffic, a good deal would be saved to them in road maintenance. This is a point to which the attention of our highway boards might well be directed in connection with projected lines in England of the same character.

The French authorities have studied, with characteristic minuteness, the methods by which railway construction can be encouraged by the State without invading the proper field of private enterprise, and, at the same time, without sacrificing to contractors and company promoters the legitimate profits which the State should expect from its railway investments when they are successful. In the present case the line was built by the department, and was leased for working to a company, tenders for the purpose having been invited. The terms were ingeniously devised, and, to English railway managers, would not seem to leave much profit to the lessee. In any year when the gross receipts per kilometre fall below 1,800fr. half the difference is paid by the department to the lessee; when the receipts are over 2,300fr. the lessee pays over half the excess; when they are between 1,800fr. and 2,300fr. he keeps what he makes without subsidy or rebate. These sums represent gross earnings respectively of about £2. 4s. 6d. and £2. 17s. per mile per week, which, according to our ideas, would not be remunerative even for a very light railway. The fact, however, that a responsible and experienced firm of contractors are working the line on these terms shows that a profit is to be made with a very small volume of traffic, if the system of working is adapted to the conditions.

The following description will show how far the line departs from what English practice at present permits. It is laid at one side of the highway, and is not separated in any way from the rest of the road reserved for cart and carriage traffic. To this extent it answers to what we call a steam tramway, but on the other hand it is laid with rails of the ordinary railway pattern, on steel cross sleepers, and ballasted. At crossings check rails are, of course, provided. The gauge is only two feet. The rails are flat-footed, and weigh only 19·1lb. per yard, which is now found to be a little light for engines of 12 tons weight; 24lb. per yard, it is said by the engineer of the line, would have been better and ample. The rails, in 16ft. lengths, are riveted to light steel sleepers, and, therefore, each section can be brought whole to its place, no work being left to be done on the ground except bolting up the fish-plates.

One great advantage of this narrow gauge and portable permanent way—an advantage which our British engineers have not, perhaps, considered—is the facility with which farmers and others can lay down a temporary siding or branch which can be moved about into any field or to any warehouse or barn where there may be a few train loads to pick up. With the line we are now considering this advantage has been largely realised.

No stations were built further than an open shed with a small office to hold a weighing machine and to lock up parcels. Tickets to passengers are issued on the train by the conductor. The passenger carriages are of the tramway type, and measure 31½ft. long by 6¼ft. wide, with three compartments for different classes in each carriage. The waggons are of the American bogie type, and carry 10 tons each. This line was built for £1,225 per mile, and cost £330 per mile additional for equipment, making a total outlay of £1,555 per mile. It appears to have worked safely and usefully, and to render nearly all the services to the district which a line costing £10,000 per mile could have rendered. Last year (the only complete year it has been in operation) it carried 27,235 passengers, and during the beetroot season, lasting two months, it carried over 15,000 tons of beetroot. As the crop of beetroot was a very poor one the traffic receipts were disappointing, and only amounted to 52,145fr. This being a little under the limit named above, the department had to pay a small compensation to the lessee. The results were sufficient to show that in ordinary years the department will receive an income from the line. It is well known that with all railways a few years are necessary for the normal traffic to develop, so that the department may fairly hope in a few years to receive 4 or 5 per cent. on the modest outlay they have made on construction. Meantime, indirectly, the population all benefit by the saving in cost of carriage and in the cost of keeping up the roads to a larger extent than they lose by the increase in rates or taxes to pay interest on the capital cost of the railway.

TO THE EDITOR OF THE TIMES.

SIR: The article in your issue of the 25th inst. on light railways in France leads me to mention that one of the latest measures of Lord Lansdowne's vice-royalty was the issue of provisional standards for such railways in India, on a gauge of 2½ft. These are intended primarily to be feeders to the main lines, and to be constructed in such a way as to enable them to be laid on the sides of existing roads; the restriction as to speed—viz., 12 miles an hour—and other limitations precluding any possibility of their competing seriously, if at all, with the existing lines.

The mileage of such lines in India is at present small; but so far they have done extremely well, and further extensions are in contemplation. Built as independent lines, their cost in India has been from £1,800 to £2,000 per mile: while, laid on existing roads, they can be constructed for about half this sum. The difficulty in India, as it would be, indeed, in England, is that most of the lines would be comparatively short and isolated, and thus, in order to ensure economy in working, it would be necessary either to group a certain number in a province (or in England in a county) under one company or administration, or to enter into arrangements for each being worked by the main lines they feed.—Yours, &c.,

HORACE BELL,
late Consulting Engineer for State Railways,
Oriental Club. Government of India.

* From *The Times*.

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THE MOLECULAR THEORY OF MAGNETISM.

To a somewhat meagre and exhausted audience in Section A at Oxford, thinned collectively by the protracted sitting of the Section and individually by the want of lunch, Mr. FRANCIS G. BAILY made a communication which in scientific importance may, without undue exaggeration, be said to rank as a good second to Lord RAYLEIGH's announcement of the "new gas." The great interest of his "Note on the Hysteresis of Iron and Steel in a Rotating Magnetic Field," an abstract of which is given in another column, lies in the fact that it supplies a most remarkable confirmation of Prof. EWING's well-known theory of the molecular process in magnetic induction. Hitherto the evidence in favour of that theory has consisted in its ability to give a rational account of the host of phenomena, often complicated and obscure, which have been found by experiment to characterise the process of magnetisation. Prof. EWING has shown that his theory accounts for the division of the process into three well-marked stages, that it explains residual magnetism and hysteresis and the dissipation of energy which hysteresis involves, that it accords with what is known about magnetic saturation, that it furnishes a key to the intricate group of results which have accrued from experiments on the effects of stress and temperature on the special properties of the magnetic family of metals, and that these results can, in fact, be reproduced with astonishing completeness in a model structure built up of little permanent magnets. Moreover, it is not too much to say that in all the great collection of facts we now possess about magnetism there is not one that can be cited as antagonistic to the molecular theory. To anyone who has followed closely the experimental work of Prof. EWING himself, of Dr. HOPKINSON, and of other recent contributors to the aggregate of knowledge in this large subject,

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the cumulative evidence in favour of the theory is so strong as to carry conviction. But now an entirely new item of evidence has been supplied in the form of a verification, by experiment, of a result—otherwise improbable enough—which had been predicted as a consequence of the molecular theory.

To appreciate the point of Mr. BAILY's discovery we must hark back to the Leeds meeting of the British Association, when Prof. EWING first made his theory generally known, and exhibited his model of molecular magnets. The comment was then made, originally we believe by Mr. JAMES SWINBURNE in a descriptive article in *Industries*, that if the theory were sound it would lead to this conclusion, that a piece of iron or steel revolving like the armature of a dynamo in a very strong magnetic field should show no hysteresis, and consequently require no expenditure of work to maintain its rotation, provided, of course, that the effects of Foucault currents were eliminated. For when iron revolves in a magnetic field the hysteresis is due, according to the theory, to the breaking up of molecular engagements and to the formation of fresh ones. The molecules dissipate energy in vibrations as they fall violently into new groups. This can happen only when the field is not excessively strong, for, given a sufficiently strong field, every molecule will be held oriented in a single definite direction while the piece turns, just as the wire bobbins of a cable-winding machine remain parallel to themselves during the revolution of the frame that carries them ; and hence in the revolving iron there will, with a powerful field, be no dissipation of energy because there is no opportunity for the making and breaking of molecular ties with unstable movements of the molecules. This conclusion, so remarkable in itself and so apparently opposed to experience, was in fact adduced by Mr. SWINBURNE as an argument against the acceptance of the molecular theory. But it was clear that experience was too imperfect to be properly appealed to. According to the theory itself the work lost through hysteresis in a rotating armature should at first increase as the field is strengthened, and should not begin to diminish until a sufficiently strong value is reached to bring about a close approach to magnetic saturation. It was easy to believe that in dynamo armatures, and in other cases where hysteresis was known to play an important part, the field was insufficient to hold the molecules from swerving into dissipative courses and squandering their energy in a wild succession of temporary alliances. Experiment only could show whether a stronger directing field would preserve them from this giddy whirl of exhausting entanglements; and Prof. EWING, in his book on Magnetic Induction, published in our columns, refers to the matter as one well worthy of experimental examination from this point of view. In the discussion of Mr. BAILY's Paper he mentioned, indeed, that he was engaged for some time, along with Mr. WILBERFORCE in looking for the effect in question, but the experiments were temporarily discontinued without having been brought to a conclusive issue.

Meanwhile, Mr. BAILY has attacked the matter with complete success, and has obtained a result which is in every respect in agreement with the anticipations to which the molecular theory has led. By measuring the torque which is required to hold a small armature from revolving when the field magnet is slowly turned, he has measured the expenditure of work which would be necessary if the armature were made to turn in a fixed field. He has examined this for various strengths of the field, from weak beginnings up to values greatly exceeding those used in dynamo practice, and sufficient to bring the molecules of the armature nearly to the perfect alignment which corresponds to saturation. Starting with a weak field, he finds that the work spent in turning the iron at first increases but slowly as the field is increased, but presently a stage is reached when the expenditure grows at a vastly more rapid rate. The first stage corresponds, in the molecular theory, with that in which the molecules turn for the most part with the iron, only becoming slightly deflected to one side or the other of their normal direction in the group, in a quasi-elastic manner, in response to the varying direction of the external field. The initial molecular grouping is not seriously interfered with during the rotation of the piece. As the strength of the field augments, however, more and more of the molecules suffer deflection beyond their stable range, and a marked increase is observed in the rate at which the torque grows with increasing magnetic force. Ultimately, however, with still stronger fields, the tendency to form new groups is checked, the torque, therefore, passes a sharply defined maximum, and descends rapidly to zero, or to something closely approaching zero, as the condition of saturation is reached. Mr. BAILY finds that the same general result is exhibited by both iron and steel. In the early stages the dissipation of energy in a revolving field has the same order of magnitude as that which occurs when the field is reversed in sign without rotation ; in the later stages the effects of the two processes are widely different—the energy expended in reversal of the field goes on increasing ; but the energy expended in rotation of the field falls off, and finally approximates to zero. It is safe to say that such a result as this would never have been anticipated except in the light of the molecular theory. That it should have been found after prediction from the theory furnishes the most convincing support which the theory could possibly have received. We may adapt the language which Lord SALISBURY used in his introductory address regarding the finding of new elements after their existence had been predicted from the Periodic Law, and say that this remarkable confirmation has left Prof. EWING's molecular theory of magnetic induction in an unassailable position.

Its relation to the molecular theory gives the chief interest to Mr. BAILY's discovery ; but it may prove to be not without importance on the practical side. It is at least a matter for dynamo builders to consider whether the drawbacks incidental to a very strong armature induction are greater than the advantage which would accrue from eliminating hysteresis losses in the armature core. And other uses may in time be found for a method of treating iron which allows its magnetism to be reversed without expenditure of work. Be this as it may, there can be no question as to the immense theoretical value of Mr. BAILY's experiment. We join heartily in the chorus of congratulation which was raised by such of the attenuated and famished remnant of the Section as were able to appreciate the bearing of his result. The experiment at once takes its place with a select few which form landmarks in magnetic investigation. One may safely prophesy that it will long be cited as an event in the history of the science.

REVIEWS.

English Patent Practice. By HENRY CUNYNGHAME. (London : W. Clowes and Sons. 1894.)

Books upon Patent Law are of two kinds. The one, generally consisting of bulky volumes, is intended for lawyers, and the other for patentees, manufacturers, and others who have to do with patents. The latter class are, as a rule, of moderate size, and no clear line can be drawn between a legitimate work on the subject and a mere touting pamphlet issued by an advertising patent agent. Where no statement is made on the title page or in the preface of the aim of a book on Patent

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Law, a glance through its pages will show whether it is a mere dry law book, or whether it is written for the general public. But the volume before us, though severely compressed in arrangement and condensed in style and addressed to the legal profession, is not only of great value to lawyers, but may for the most part be read with interest and profit by those who are concerned with patents for their own inventions or otherwise. To electrical engineers particularly this book will prove attractive, for the author's intimate acquaintance with electrical science and its applications have led him to draw largely on electrical cases for examples. The Harrison, Bassano, and other telephone cases, Lane Fox *v.* Kensington Co., Edison *v.* Woodhouse, Edison *v.* Holland, the Brush compound winding cases, British Tanning Co. *v.* Groth, Goulard and Gibbs revocation, are cited, besides such older and well-known cases as The Electric Telegraph Co. *v.* Brett. One feature, which we believe to be unique, adds greatly to the lucidity of the examples, and renders the book peculiarly interesting and readable; this is the use of a large number of extremely simple sketches and diagrams. The three-wire case is, of course, easily explained with this aid, and thoroughly too, for five diagrams are given. Penn's propeller bearing is another example of the simplest possible diagram. The Plimpton skate, which is so often heard of in patent cases, and which is by no means easy to describe in words, is well explained by means of three sketches.

The most valuable feature of this work to the professional man is the arrangement of its contents. Sectional headings are used to distinguish the various rules of law, which are for the most part stated in the form of propositions. The opening chapters after a historical introduction, deal with Subject matter, Utility, Novelty, Success, Anticipation, the next five discuss the specification under the heads, Title, Provisional, Complete, Claims, and Drawings. A highly technical chapter relates to Construction. Then follow chapters on Amendment, Patentees and Procedure. Infringement is studied at considerable length, and, in a chapter on Action of Infringement, very practical information is given as to "particulars of breaches" and "particulars of objections." Besides a full table of contents and table of cases, a very complete index is given. The Statutes, Acts, rules and official forms are to be found in an appendix. The preface is not the least interesting part of the book, and it concludes with the following hint to inventors:—

"The words of Sir Hugh Platt in 1589 are as true now as they were when he wrote them: 'I have always found it in mine own experience an easier matter to devise manie and profitable inventions, than to dispose of one of them to the good of the author.'"

NOTE ON THE HYSTERESIS OF IRON AND STEEL IN A ROTATING MAGNETIC FIELD.*

BY F. G. BAILY.

It has long been known that, up to the limits of experiment, the value of hysteresis in an alternating magnetic field increases continuously. But it is a deduction from Prof. Ewing's molecular theory of magnetism that in a rotating magnetic field the hysteresis should diminish at a high induction, or at least show a reduction in the rate of increase. The following experiment substantiates this deduction in a very complete manner:—An electromagnet is rotated on bearings concentric with the bore of its own pole-pieces, which were bored out cylindrically. In the polar cavity a finely-laminated armature is suspended between centres, and held by a spiral spring attached to the axle and to a fixed support. Movement of the armature is indicated by a beam of light reflected from a mirror on it. On rotating the magnet, the armature tends to rotate with it by reason of hysteresis. The motion is checked by the spring, and the consequent deflection is proportional to the instantaneous value of the hysteresis per revolution. The curve of hysteresis and induction obtained commences like that in an alternating field, rising very slowly at first, then more rapidly, but finally reaching a maximum and bending over. The fall is very rapid so far as the experiments have been tried, shows no sign of becoming asymptotic, but runs straight towards the zero line. Soft iron and hard steel give the same results, the differences between them corresponding to their differences in the B/H curve. The three states of molecular arrangement, which are the essential point of the molecular theory, are exactly reproduced in the hysteresis curve. This first stage of quasi-elastic movement gives a very small hysteresis value. The second stage of irregular molecular groups and magnetic combinations gives a value approximately proportional to the induction at a steep inclination; this extends to the knee of the B/H curve. The third stage of approaching saturation gives a rapidly diminishing hysteresis when the molecular magnets are ranged in regular order along lines of force, and new combinations and irregular movements are prevented. Since the non-appearance of a correspondence between the B/H curve and the hysteresis curve in alternating fields has been urged as an argument against the molecular theory of magnetism, this complete accord and verification of the deduction previously made is important as giving powerful support to Prof. Ewing's theory.

* Mr. Baily intends to publish a more complete Paper on this subject, and does not wish to publish his recent communication to Section A of the British Association in full. This abstract is reprinted from *Nature.*

ALTERNATE CURRENT RESONANCE.

BY ERNEST WILSON.

The present short research constitutes an experimental verification of one or two familiar problems in the theory of alternate currents. The following is an extract from a paper by Dr. Hopkinson "On the Theory of Alternating Currents," read at the Institution of Electrical Engineers, November 13, 1884, to which reference will be made:—

"Some time ago Dr. Muirhead told me that he had observed that the effect of an alternate-current machine could be increased by connecting it to a condenser. This is not difficult to explain: It is a case of resonance analagous to those which are so familiar in the theory of sound and in many other branches of physics.

"Take the simplest case, though some others are almost as easy to treat. Imagine an alternate-current machine with its terminals connected to a condenser; it is required to find the amplitude of oscillation of potential between the two sides of the condenser. Let R γ be the resistance and self-induction of the machine, $E \sin \frac{2\pi t}{T}$ its electromotive force, C the capacity of the condenser, V the difference of potential sought, and x the current in the machine, then

$$C \dot{V} = x$$

and

$$\gamma \dot{x} + R x = E \sin \frac{2\pi t}{T} - V;$$

whence

$$\gamma \ddot{x} + R \dot{x} = \frac{2\pi}{T} E \cos \frac{2\pi t}{T} - \frac{x}{C}$$

$$x = \frac{\left\{1 - C\gamma\left(\frac{2\pi}{T}\right)^2\right\}\cos\frac{2\pi t}{T} + RC\frac{2\pi}{T}\sin\frac{2\pi t}{T}}{\left\{1 - C\gamma\left(\frac{2\pi}{T}\right)^2\right\}^2 + R^2C^2\left(\frac{2\pi}{T}\right)^2} \cdot \frac{2\pi E C}{T}$$

$$V = \frac{\left\{1 - C\gamma\left(\frac{2\pi}{T}\right)^2\right\}\sin\frac{2\pi t}{T} - RC\frac{2\pi}{T}\cos\frac{2\pi t}{T}}{\left\{1 - C\gamma\left(\frac{2\pi}{T}\right)^2\right\}^2 + R^2C^2\left(\frac{2\pi}{T}\right)^2} \cdot E \quad . \quad (1)$$

Amplitude of V is therefore

$$= \frac{1}{\sqrt{\left\{1 - C\gamma\left(\frac{2\pi}{T}\right)^2\right\}^2 + R^2C^2\left(\frac{2\pi}{T}\right)^2}} \cdot E \quad . \quad (2)$$

"Now suppose E = 100 volts, the machine would light up an incandescent lamp of about 69 volts; let $T = \frac{1}{200}$ second, C = 100 microfarads, and $\frac{2\pi\gamma}{T} = 8$ ohms, and $R = \frac{1}{10}$ ohm, all figures which could be practically realised, we have amplitude

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of $V = 80\,E$ roughly, or the apparent electromotive force would be increased eighty-fold."*

Part I.—Equation (1) in the above quotation shows that according as $C\gamma\left(\frac{2\pi}{T}\right)^2$ is greater or less than unity, so will the phase of V be retarded or accelerated. Equation (2) shows that when $C\gamma\left(\frac{2\pi}{T}\right)^2$ is unity the amplitude of V is a maximum for variation of γ.

A Siemens W 12 alternate-current machine A (Fig. 1) was connected in series with a Westinghouse transformer, B, having a closed magnetic circuit, and a condenser, C. The alternator

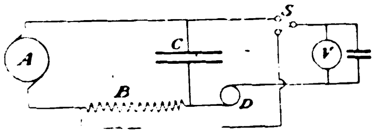
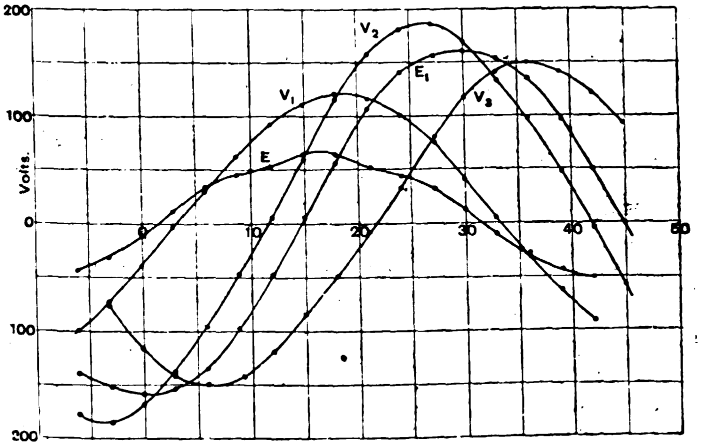


Fig. 1.

was excited with a current of 10 amperes, and gave an open circuit, at a frequency of 95·5 periods per second, a maximum electromotive force, E, of 66 volts. This is the curve E in Fig. 2.

The capacity of C was made 1 microfarad, and the frequency 88, the excitation of the alternator being kept constant at 10 amperes. V_1 (Fig. 2) is the curve of potential then taken across the terminals of the condenser by means of a revolving contact-maker, D, fixed to the shaft of the alternator, and the Kelvin multicellular voltmeter V. The frequency was increased until the amplitude of V was a maximum which occurred at 95·5. V_2 is the curve then taken across the condenser. The frequency was further increased to 118 and the curve V_3 observed.



As predicted by theory, the phase of V is retarded or accelerated with regard to its position at frequency 95·5, accompanied in either case by a diminution of amplitude.

In order to show that $C\gamma\left(\frac{2\pi}{T}\right)^2$ is approximately unity when the maximum amplitude of V is observed; the frequency being 95·5, the curve of potential across the terminals of the transformer was observed simultaneously with V_2. This was readily done by means of the two-way switch S. E_1 is the curve so obtained. In curve V_2 we see that V changes 120 volts, whilst time changes ·00117 second, therefore, the maximum current $x = \cdot 1$ ampere. We have also maximum amplitude of curve E_1 160 volts.

Then $\frac{2\pi\gamma}{T}$ = approximately 1,600 ohms;

therefore $C\gamma\left(\frac{2\pi}{T}\right)^2 = \cdot 96$ as against unity.

From curve V_2 we have also amplitude 185 volts.

$$185 = \frac{1}{RC\frac{2\pi}{T}}\,66$$

$$R = 595 \text{ ohms.}$$

* The reader is referred to Prof. J. A. Fleming's work on the Alternate Current Transformer for a full discussion of this subject.

The ohmic resistance of the circuit of the alternator and Westinghouse transformer is about 6 ohms, but there is the further dissipation of energy by magnetic hysteresis and eddy currents.

From previous experiments upon this transformer, the rate at which energy is being dissipated on open circuit for the whole core is about 80 watts, with a frequency of 98, and a maximum current of 0·3 ampere in the primary. We have already found that in the present case the maximum current $x = 0{\cdot}1$ ampere. Therefore,

$$\{\sqrt{\text{mean}^2\,x}\}^2\,R = \text{about 3 watts.}$$

Experiments have not been made to find the rate of dissipation of energy in this transformer with a maximum current of 0·1 ampere at a frequency of 95; but an examination of Prof. Ewing's experiments* on soft iron for transformer cores shows that 3 watts is not far wrong.

It should be noted that with constant excitation, E increases with a decrease of T, and γ is a variable, since it is a function of x.

Part II.—The curve E (Fig. 2) is not a simple sine curve. It is well known that if E be any function of t, periodic or not, it can be expressed in the form

$$E = A_1\cos\frac{2\pi t}{T} + B_1\sin\frac{2\pi t}{T} + A_2\cos\frac{4\pi t}{T} + B_2\sin\frac{4\pi t}{T}$$
$$+ \ . \ . \ . + A_r\cos\frac{2r\pi t}{T} + B_r\sin\frac{2r\pi t}{T} + \ . \ . \ . \ .$$

Let E be a periodic function of t which vanishes when $t = 0$, T, 2 T, . . . &c., and suppose the curve for E to be divided symmetrically by the axis of x; then E must change sign with t, and there must be no cosines.

$$\therefore\ E = B_1\sin\frac{2\pi t}{T} + B_2\sin\frac{4\pi t}{T} + \ . \ . \ . + B_r\sin\frac{2r\pi t}{T} + \ . \ . \ .$$

Next suppose, that in any half period the ascending curve is exactly similar to the descending portion, then increasing t by $\frac{T}{2}$ must merely alter the sign of E. Hence the even terms do not change sign when t is increased by $\frac{T}{2}$. Therefore, to satisfy the assumed condition, their coefficients must all vanish; that is to say $B_2 = 0$, $B_4 = 0$, &c.

$$\therefore\ E = B_1\sin\frac{2\pi t}{T} + B_3\sin\frac{6\pi t}{T} + \ . \ . \ .$$

Let

$$E = B_1\sin\frac{2\pi t}{T} + B_2\sin\frac{4\pi t}{T} + \ . \ . \ . + B_r\sin\frac{2r\pi t}{T} + \ . \ . \ .$$

Required to determine the coefficients B_1 . . . B_r . . . when E is known. Multiply each side of the equation by $\sin\frac{2r\pi t}{T}$ and integrate between the limits $t = 0$ and $t = \frac{T}{2}$; that is, over a half period.

$$\therefore \int_0^{\frac{T}{2}} E\sin\frac{2r\pi t}{T}\,dt = \int_0^{\frac{T}{2}} dt\,\sin\frac{2r\pi t}{T}\left\{B_1\sin\frac{2\pi t}{T} + \ . \ . \ . + B_s\sin\frac{2s\pi t}{T} + \ . \ . \ .\right\}$$

$$\text{Now}\int_0^{\frac{T}{2}} dt\,\sin\frac{2r\pi t}{T}\sin\frac{2s\pi t}{T} = \tfrac{1}{2}\int_0^{\frac{T}{2}}\left\{\cos\frac{2\pi(r-s)t}{T} - \cos\frac{2\pi(r+s)}{T}\right\}t\,dt$$

$$= \tfrac{1}{2}\left[\frac{T}{2\pi(r-s)}\sin\frac{2\pi(r-s)t}{T} - \frac{T}{2\pi(r+s)}\sin\frac{2\pi(r+s)t}{T}\right]_0^{\frac{T}{2}} = 0$$

This is true when r and s are different. When $r = s$

$$\int_0^{\frac{T}{2}} \sin^2\frac{2r\pi t}{T}\,dt = \tfrac{1}{2}\int_0^{\frac{T}{2}}\left\{1 - \cos\frac{4r\pi t}{T}\right\}dt$$

$$= \tfrac{1}{2}\left[t - \frac{T}{4r\pi}\sin\frac{4r\pi t}{T}\right]_0^{\frac{T}{2}} = \frac{T}{4}$$

* See *Trans. Roy. Soc.*, Vol. CLXXXIV. (1893), A, pp. 985–1,039.

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Table I.

E.	$r=1.$ $B_1=216{\cdot}1.$			$r=3.$ $B_3=0{\cdot}76.$			$r=5.$ $B_5=12{\cdot}6$			$r=7.$ $B_7=-2{\cdot}6.$			$r=9.$ $B_9=0{\cdot}52.$		
	$\alpha=\frac{2\pi}{20}.$	Sin α.	E sin α.	3α.	Sin 3α.	E sin 3α.	5α.	Sin 5α.	E sin 5α.	7α.	Sin 7α.	E sin 7α.	9α.	Sin 9α.	E sin 9α.
78	18°	0·309	+ 24·1	54°	0·809	+ 63·1	90°	1	+ 78	54°	0·809	+ 63·1	18°	0·309	+ 24·1
130	36°	0·588	+ 76·4	72°	0·951	+123·6	180°	0	0	− 72°	− 0·951	− 123·6	− 36°	− 0·588	− 76·4
162	54°	0·809	+131·1	18°	0·309	+ 50·1	− 90°	−1	−162	18°	0·309	+ 50·1	54°	0·809	+131·1
203	72°	0·951	+193·0	− 36°	− 0·588	− 119·4	0°	0	0	36°	0·588	+119·4	− 72°	0·951	− 193·0
115½	90°	1·00	+115·6	− 90°	− 1	− 115·5	90°	1	+115·5	90°	− 1	− 115·5	90°	1	+115·5
			540·1			1·9			31·5			− 6·5			1·3

Thus all terms but the rth vanish, and we have—

$$\int_0^{\frac{T}{2}} E\sin\frac{2r\pi t}{T}\,dt = B_r \times \frac{T}{4};$$

$$\therefore\quad B_r = \frac{4}{T}\int_0^{\frac{T}{2}} E\sin\frac{2r\pi t}{T}\,dt.$$

If the half period $\frac{T}{2}$ be divided into ten equal parts, and the value of E determined by observation for each of these intervals, we have:

$$\int_0^{\frac{T}{2}} E\sin\frac{2r\pi t}{T}\,dt = \frac{T}{2}\times\frac{1}{10}\Sigma E\sin\frac{2r\pi t}{T},\text{ nearly.}$$

$$\therefore\quad B_r = \frac{1}{5}\Sigma E\sin\frac{2r\pi t}{T}.$$

In $\Sigma E\sin\frac{2r\pi t}{T}$, E must be observed for values of t equal to $0, \frac{1}{10}\frac{T}{2}, \frac{2}{10}\frac{T}{2}, \frac{3}{10}\frac{T}{2}, \ldots \frac{9}{10}\frac{T}{2}$, and the results multiplied by $\sin\frac{2r\pi t}{T}$ added together.

Table I. gives the coefficients B_1, B_3, B_5, B_7, B_9 so found; and it will be observed that B_5 is important, being about 6 per cent. of B_1. If, therefore, the machine be run at constant speed, and the capacity C varied, one might expect that when C is made $\frac{1}{25}$th, this harmonic would show itself as a rise on the curve showing the relation between V and the capacity. The curve in Fig. 3 is obtained by running the alternator at a

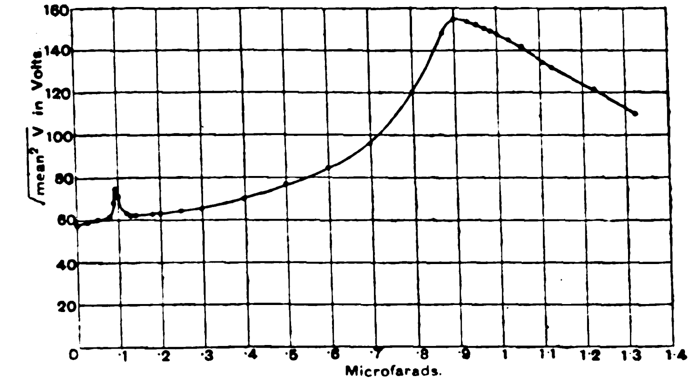

Fig. 3.

frequency of 95, gradually varying the capacity from O upwards, and observing V on the electrostatic voltmeter. We see that at 0·9 microfarad we have the maximum effect, which is what we have already observed in Fig. 2. Further, for 0·1 microfarad we have a rise on the curve. 0·1 is not a $\frac{1}{25}$th of ·9, but γ is a function of the current x which is reduced since the capacity is small, and this makes the resonance for the 5th harmonic occur at a greater value for C than $\frac{1}{25}$th—namely, $\frac{1}{9}$th. We see further from the equation that the curve in Fig. 3 would eventually reach the horizontal axis, and this would occur when $C=\infty$.

Mr. C. J. Evans, student demonstrator in the Siemens' laboratory, King's College, London, has assisted me in these experiments, and my best thanks are due to him.

THE IMPERIAL OHM, AMPERE, AND VOLT.

*At the Court at Osborne House, Isle of Wight, the 23rd day of August, 1894.

Present, the Queen's Most Excellent Majesty in Council.

Whereas by "The Weights and Measures Act, 1889," it is among other things enacted that the Board of Trade shall from time to time cause such new denominations of standards for the measurement of electricity as appear to them to be required for use in trade to be made and duly verified.

And whereas it has been made to appear to the Board of Trade that new denominations of standards are required for use in trade based upon the following units of electrical measurement, viz.:—

1. The Ohm, which has the value 10^9 in terms of the centimetre and the second of time and is represented by the resistance offered to an unvarying electric current by a column of mercury at the temperature of melting ice 14·4521 grammes in mass of a constant cross sectional area, and of a length of 106·3 centimetres.

2. The Ampere, which has the value $\frac{1}{10}$ in terms of the centimetre, the gramme and the second of time and which is represented by the unvarying electric current which when passed through a solution of nitrate of silver in water in accordance with the specification appended hereto and marked A deposits silver at the rate of 0·001118 of a gramme per second.

3. The Volt which has the value 10^8 in terms of the centimetre the gramme and the second of time, being the electrical pressure that if steadily applied to a conductor whose resistance is one ohm will produce a current of one ampere, and which is represented by 0·6974 ($\frac{1000}{1434}$) of the electrical pressure at a temperature of 15°C. between the poles of the voltaic cell, known as Clark's cell, set up in accordance with the specification appended hereto, and marked B.

And whereas they have caused the said new denominations of standards to be made and duly verified.

Now, therefore, Her Majesty, by virtue of the power vested in Her by the said Act, by and with the advice of Her Privy Council, is pleased to approve the several denominations of standards set forth in the schedule hereto as new denominations of standards for electrical measurement.

C. L. Peel.

SCHEDULE.

I.—Standard of Electrical Resistance.

A standard of electrical resistance denominated one ohm being the resistance between the copper terminals of the instrument marked "Board of Trade Ohm Standard Verified 1894" to the passage of an unvarying electrical current when the coil of insulated wire forming part of the aforesaid instrument and connected to the aforesaid terminals is in all parts at a temperature of 15·4C.

II.—Standard of Electrical Current.

A standard of electrical current denominated one ampere being the current which is passing in and through the coils of wire forming part of the instrument marked "Board of Trade Ampere Standard Verified 1894" when on reversing the current in the

* From the *London Gazette* of Friday, August 24, 1894.

fixed coils the change in the forces acting upon the suspended coil in its sighted position is exactly balanced by the force exerted by gravity in Westminster upon the iridio-platinum weight marked A and forming part of the said instrument.

III.—Standard of Electrical Pressure.

A standard of electrical pressure denominated one volt being one hundredth part of the pressure which when applied between the terminals forming part of the instrument marked "Board of Trade Volt Standard Verified 1894," causes that rotation of the suspended portion of the instrument which is exactly measured by the coincidence of the sighting wire with the image of the fiducial mark A before and after application of the pressure and with that of the fiducial mark B during the application of the pressure, these images being produced by the suspended mirror and observed by means of the eyepiece.

In the use of the above standards the limits of accuracy attainable are as follows:—

For the ohm, within one-hundredth part of 1 per cent.

For the ampere, within one-tenth part of 1 per cent.

For the volt, within one-tenth part of 1 per cent.

The coils and instruments referred to in this schedule are deposited at the Board of Trade Standardising Laboratory, 8, Richmond-terrace, Whitehall, London.

Specifications referred to in the foregoing Order in Council:—

SPECIFICATION A.

In the following specification the term silver voltameter means the arrangement of apparatus by means of which an electric current is passed through a solution of nitrate of silver in water. The silver voltameter measures the total electrical quantity which has passed during the time of the experiment, and by noting this time the time average of the current, or if the current has been kept constant, the current itself can be deduced.

In employing the silver voltameter to measure currents of about one ampere the following arrangements should be adopted. The cathode on which the silver is to be deposited should take the form of a platinum bowl not less than 10cm. in diameter, and from 4cm. to 5cm. in depth.

The anode should be a plate of pure silver some 30 sq. cm. in area and 2mm. or 3mm. in thickness.

This is supported horizontally in the liquid near the top of the solution by a platinum wire passed through holes in the plate at opposite corners. To prevent the disintegrated silver which is formed on the anode from falling on to the cathode, the anode should be wrapped round with pure filter paper, secured at the back with sealing wax.

The liquid should consist of a neutral solution of pure silver nitrate, containing about 15 parts by weight of the nitrate to 85 parts of water.

The resistance of the voltameter changes somewhat as the current passes. To prevent these changes having too great an effect on the current, some resistance besides that of the voltameter should be inserted in the circuit. The total metallic resistance of the circuit should not be less than 10 ohms.

Method of making a Measurement.

The platinum bowl is washed with nitric acid and distilled water, dried by heat and then left to cool in a desiccator. When thoroughly dry it is weighed carefully.

It is nearly filled with the solution, and connected to the rest of the circuit by being placed on a clean copper support to which a binding screw is attached. This copper support must be insulated.

The anode is then immersed in the solution so as to be well covered by it and supported in that position; the connections to the rest of the circuit are made.

Contact is made at the key, noting the time of contact. The current is allowed to pass for not less than half-an-hour, and the time at which contact is broken is observed. Care must be taken that the clock used is keeping correct time during this interval.

The solution is now removed from the bowl, and the deposit is washed with distilled water and left to soak for at least six hours. It is then rinsed successively with distilled water and absolute alcohol and dried in a hot-air bath at a temperature of about 160°C. After cooling in a desiccator it is weighed again. The gain in weight gives the silver deposited.

To find the current in amperes, this weight, expressed in grammes, must be divided by the number of seconds during which the current has been passed, and by 0·001118.

The result will be the time-average of the current, if during the interval the current has varied.

In determining by this method the constant of an instrument the current should be kept as nearly constant as possible, and the readings of the instrument observed at frequent intervals of time. These observations give a curve from which the reading corresponding to the mean current (time-average of the current), can be found. The current, as calculated by the voltameter, corresponds to this reading.

SPECIFICATION B.

On the Preparation of the Clark Cell.

Definition of the Cell.

The cell consists of zinc or an amalgam of zinc with mercury and of mercury in a neutral saturated solution of zinc sulphate and mercurous sulphate in water, prepared with mercurous sulphate in excess.

Preparation of the Materials.

1. *The Mercury.*—To secure purity it should be first treated with acid in the usual manner, and subsequently distilled in vacuo.

2. *The Zinc.*—Take a portion of a rod of pure redistilled zinc, solder to one end a piece of copper wire, clean the whole with glass paper or a steel burnisher, carefully removing any loose pieces of the zinc. Just before making up the cell dip the zinc into dilute sulphuric acid, wash with distilled water, and dry with a clean cloth or filter paper.

3. *The Mercurous Sulphate.*—Take mercurous sulphate, purchased as pure, mix with it a small quantity of pure mercury, and wash the whole thoroughly with cold distilled water by agitation in a bottle; drain off the water, and repeat the process at least twice. After the last washing, drain off as much of the water as possible.

4. *The Zinc Sulphate Solution.*—Prepare a *neutral* saturated solution of pure ("pure recrystalised") zinc sulphate by mixing in a flask distilled water with nearly twice its weight of crystals of pure zinc sulphate, and adding zinc oxide in the proportion of about 2 per cent. by weight of the zinc sulphate crystals to neutralise any free acid. The crystals should be dissolved with the aid of gentle heat, but the temperature to which the solution is raised should not exceed 30°C. Mercurous sulphate treated as described in 3 should be added in the proportion of about 12 per cent. by weight of the zinc sulphate crystals to neutralise any free zinc oxide remaining, and the solution filtered, while still warm, into a stock bottle. Crystals should form as it cools.

5. *The Mercurous Sulphate and Zinc Sulphate Paste.*—Mix the washed mercurous sulphate with the zinc sulphate solution, adding sufficient crystals of zinc sulphate from the stock bottle to insure saturation, and a small quantity of pure mercury. Shake these up well together to form a paste of the consistence of cream. Heat the paste, but not above a temperature of 30°C. Keep the paste for an hour at this temperature, agitating it from time to time, then allow it to cool; continue to shake it occasionally while it is cooling. Crystals of zinc sulphate should then be distinctly visible, and should be distributed throughout the mass; if this is not the case add more crystals from the stock bottle, and repeat the whole process.

This method insures the formation of a saturated solution of zinc and mercurous sulphates in water.

To set up the Cell.

The cell may conveniently be set up in a small test tube of about 2cm. diameter and 4cm. or 5cm. deep. Place the mercury in the bottom of this tube, filling it to a depth of say 0·5cm. Cut a cork about 0·5cm. thick to fit the tube; at one side of the cork bore a hole through which the zinc rod can pass tightly; at the other side bore another hole for the glass tube which covers the platinum wire; at the edge of the cork cut a nick through which the air can pass when the cork is pushed into the tube. Wash the cork thoroughly with warm water, and leave it to soak in water for some hours before use. Pass the zinc rod about 1cm. through the cork.

Contact is made with the mercury by means of a platinum wire about No. 22 gauge. This is protected from contact with the other materials of the cell by being sealed into a glass tube. The ends of the wire project from the ends of the tube; one end forms the terminal, the other end and a portion of the glass tube dip into the mercury.

Clean the glass tube and platinum wire carefully, then heat the exposed end of the platinum red hot, and insert it in the mercury in the test tube, taking care that the whole of the exposed platinum is covered.

Shake up the paste and introduce it without contact with the upper part of the walls of the test tube, filling the tube above the mercury to a depth of rather more than 1cm.

Then insert the cork and zinc rod, passing the glass tube through the hole prepared for it. Push the cork gently down until its lower surface is nearly in contact with the liquid. The air will thus be nearly all expelled, and the cell should be left in this condition for at least 24 hours before sealing, which should be done as follows:—

Melt some marine glue until it is fluid enough to pour by its own weight, and pour it into the test-tube above the cork, using sufficient to cover completely the zinc and soldering. The glass tube containing the platinum wire should project some way above the top of the marine glue.

The cell may be sealed in a more permanent manner by coating the marine glue, when it is set, with a solution of sodium silicate, and leaving it to harden.

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The cell thus set up may be mounted in any desirable manner. It is convenient to arrange the mounting so that the cell may be immersed in a water bath up to the level of, say, the upper surface of the cork. Its temperature can then be determined more accurately than is possible when the cell is in air.

In using the cell sudden variations of temperature should as far as possible be avoided.

The form of the vessel containing the cell may be varied. In the H form, the zinc is replaced by an amalgam of 10 parts by weight of zinc to 90 of mercury. The other materials should be prepared as already described. Contact is made with the amalgam in one leg of the cell, and with the mercury in the other, by means of platinum wires sealed through the glass.

THE LIVERPOOL OVERHEAD RAILWAY.*

BY JAMES HENRY GREATHEAD AND FRANCIS FOX, MM. INST. C.E.

(*Continued from page 494.*)

Permanent Way.—The permanent way consists of flat-bottomed steel rails, weighing 56lb. per yard, fixed on longitudinal timbers which are held down to the floor by iron lugs rivetted on to it, and oak keys. On the curves these timbers vary in thickness according to the necessary super-elevation of rail. The rails are fixed by spikes and fang-bolts, special care being taken in fixing them to avoid metallic contact with the main structure. The electrical conductor, which consists of a steel bar 4 sq. in. in section, of ⊓ form, is placed midway between the rails of each line, and is carried on porcelain insulators supported by cross timbers. The joints are provided with copper connections, and since the return current is brought back through the rails, a bent iron bond rivetted through the web of the rails is fixed at each fish-joint. Cables laid under ground from the railway to the generating station, a distance of 60 yards, connect the conductors and the rails with the dynamos.

Traction and Rolling Stock.—Running as the railway does through the entire length of the dock estate, from which steam locomotives have always been excluded, it was considered desirable that the use of such locomotives should, if possible, be avoided on the railway. Added to this consideration, the successful working of the City and South London Railway for some months pointed to the suitability of electricity as a motive power for such a service of trains as was contemplated on the Overhead Railway. Some additional reasons in favour of the adoption of electricity will be referred to hereafter. It soon became apparent that for this particular service motor cars offered advantages not to be secured by the use of separate locomotives, whether steam or electric. Where trains are heavy and long, and where the weight on the driving-wheels is not a consideration, separate locomotives may be preferable; because it is undesirable to multiply machines, and it is an advantage to have all the machinery under the eye of the driver and readily accessible—in tunnel railways also there is more space for the motors in separate locomotives. In cases, however, where it is important to limit the weight on the driving-wheels, motor-cars afford an opportunity of running trains of any length without undue weight being thrown upon the structure. For instance, on the elevated railways of New York, the structures will not admit of heavy locomotives; and though the traffic is such as to tax the carrying capacity of the trains, run at the shortest possible intervals, to its utmost limit, and beyond considerations of convenience, larger trains cannot be introduced unless the structures can be strengthened or motor-cars be adopted.

Lighter trains, resulting in better speed with a given expenditure of power, also follow from the use of motor-cars. As an illustration of this derived from actual experience, the trains of the Overhead Railway may be compared with those of the City and South London Railway. In the former case the electrical equipment for motive power adds 6 tons 7cwt. to the weight of carriages seating 114 passengers; while in the latter the corresponding weight (the locomotive) is 10 tons 7cwt., 96 passengers being carried. The avoidance of shunting at the terminal stations is another important advantage attending motor-cars. Every separate movement of even a light locomotive absorbs a comparatively large current, thus accentuating the irregularities of demand, already sufficiently variable, upon the generating engines and dynamos. Time is saved at the terminal stations, and siding accommodation is reduced in length. Wear and tear of all kinds are reduced, and the first cost of the trains is considerably less.

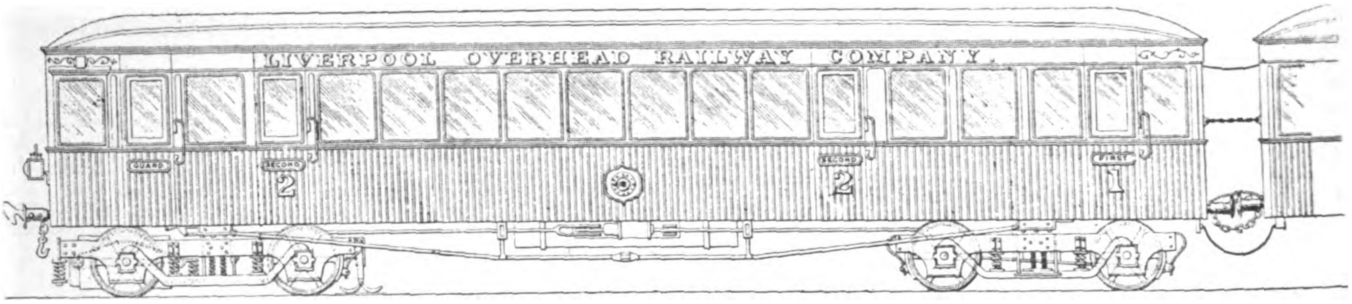

FIG. 7.

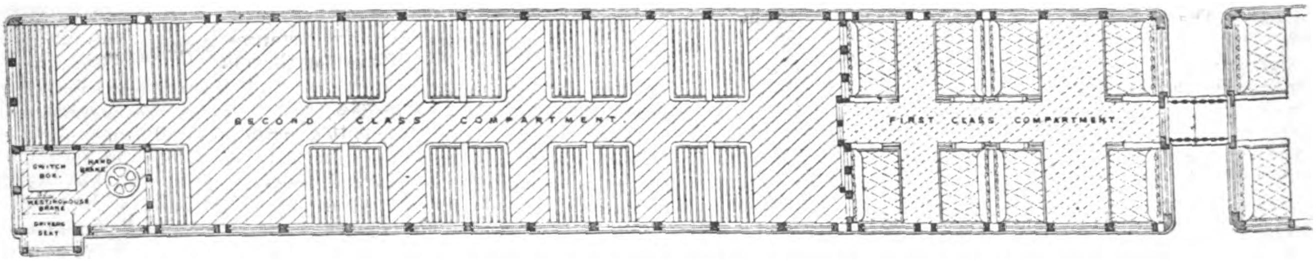

FIG. 8.

The design of the carriages (Figs. 7 and 8) received much consideration, and the result is satisfactory, both as regards weight and convenience. A train consists at present of two carriages, each 45ft. long and 8ft. 6in. wide, on two bogies, 32ft. apart from centre-pin to centre-pin, with 2ft. 9in. wheels, 7ft. wheel-base, and pressed steel frames. The carriages are all exactly alike, and contain accommodation for 16 first-class and 41 second-class passengers in each carriage, with three side doors and a passage from end to end. The first-class passengers are at one end of the carriage, and the driver's box with switches, &c., is at the other. When the two carriages are coupled together to form a train, the driver's boxes are at the extreme ends, and the two first-class compartments are consequently together in the middle of the train. A small door through the contiguous ends of the carriages enables the guard or attendant to pass from end to end of the train.

The motors, one at each end of the train, are controlled from either end; the driver, of course, always travelling at the front end of the train and changing ends upon arrival at a terminus, carrying with him a key without which the motors cannot be operated. In a train thus arranged one driver and one conductor constitute the train staff, the guard as well as the driver having it in his power to cut off the current from the motors and to apply the brakes.

The trains are fitted with the Westinghouse automatic brake, deriving its supply of compressed air from a reservoir on the train, the reservoir having a capacity sufficient for two complete journeys

* The first of two Papers read before the Institution of Civil Engineers, February 27, 1894; the second being "The Electrical Equipment of the Liverpool Overhead Railway," by Mr. Thomas Parker.

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and being recharged each journey from a receiver placed at the terminus at the north end of the line. This system of working the brakes was previously applied by Mr. Greathead and found to work well on the City and South London Railway, and has answered equally well here. The air compressors are, in this case, worked by a small electric motor, with a gas engine in reserve; and, pending the completion of the northern extension, the compressed air is conveyed a distance of about three-quarters of a mile through one of the gas-tube rails of the parapet to the present northern terminus at Alexandra Dock station. A hand-brake is also provided at each end of the train. The carriages are lighted by 32-c.p. incandescence lamps connected with the working current, and the stations are lighted by similar lamps connected with a battery of accumulators placed under one of the platforms at each station. These batteries are in duplicate, and are charged in series by the main generating dynamos. The carriages were built by Messrs. Brown, Marshall, and Co. (Limited), of Birmingham, for the Electric Construction Corporation, to whom was let, after competitive tenders had been received from leading electrical firms, the contract for the electrical equipment and rolling stock.

The site of the generating station was a question which gave rise to much discussion. It was important, with a view to economical working, that coal should be obtainable by railway direct without the expense of handling and carting; that a good supply of water should be available for condensing purposes; and that the station should be near the middle of the line. These conditions were fairly satisfied in the site eventually selected under the arches of the coal-railway of the Lancashire and Yorkshire Railway Company at Wellington Dock. The coal is here tipped direct from the railway trucks into large hoppers placed over the boilers, and is distributed by a conveyor to the shoots of the Vicars mechanical stokers with which the furnaces are fitted. There is thus no handling of the coal. Water from the adjacent dock is used for condensing, and the town water for the boilers. Mr. Thomas Parker, to whose skill is due the excellent design and construction of the electrical plant, supplements this Paper with an account thereof, and it is therefore unnecessary to describe here the details of that work.

The boilers are of the double-flue Lancashire type with cross tubes; they are of steel, six in number, each 8ft. in diameter by 30ft. long, with a working pressure of 120lb. per square inch, and Green economisers in duplicate are fixed in the main flues. The steam-and feed-pipe ranges are also in duplicate. The engines are four in number, each consisting of a pair of horizontal compound condensing engines, built by Messrs. Musgrave and Co., of Bolton, who contracted with the Electric Construction Corporation to supply the engines and boilers complete, and with the Company to erect the chimney shaft (165ft. high), foundations of boilers, engines, &c. The high-pressure cylinders are 15½in., and the low-pressure 31in. in diameter, with a stroke of 36in., fitted with Corliss valves driven by Trip gear, acted on directly by the governor. Each engine will develop 400 I.H.P. at 100 revolutions per minute with 120lb. boiler pressure. All the engines exhaust to one condenser of the tubular service type. The centrifugal circulating pump and air pumps are driven by a Musgrave "No-dead-centre" vertical compound engine, and the condensing plant is in duplicate.

Each engine drives an Elwell-Parker dynamo, from which the current is conveyed north and south along each line of the railway by the steel conductor already described. Hinged collectors of cast-iron, sliding upon this conductor, the top surface of which is about ¾in. higher than rail level, allow the current, when required, to pass through the motors and to return by the wheels and the rails to the dynamos. At the crossings the conductor is bent to form wings parallel to the rail to be crossed, in the same way as is usually done at rail crossings.

The question of the relative economy of the working of steam and electric locomotives is of great interest at the present time. The nearest approach to the Electric Overhead Railway at Liverpool seems to be the Elevated Railways in New York, worked by steam locomotives. In each case the trains are comparatively light, though the New York trains are heavier than those at present running on the Liverpool line, and in each case the stations are on an average about one-third of a mile apart. In 1889 an experiment was made upon one of the New York lines to determine the possibility and cost of working by electricity. The results of this experiment, with a continuous-current system of electric traction, were used with considerable effect in the Parliamentary Committee Rooms on behalf of the Metropolitan Railway Company against the proposed Central London Railway in 1890; and a description of the experiments and the results and conclusions derived from them, with details of the cost of working the steam locomotives on the Manhattan Railway, was published in a Paper by Mr. Lincoln Moss in October, 1890.* The main conclusion arrived at was that "the cost of direct electric propulsion would be four times that of steam locomotion" on the Ninth Avenue Railway.

It is not necessary now to describe in detail the arrangements and results of those experiments, but it may be interesting to mention that the New York experiments were made with a train of 53½ tons drawn by an electric locomotive of 9 tons or more (the exact weight is not given) over a length of 1¾ miles of line, with four intermediate and two terminal stations, and having gradients of $\frac{1}{100}$, $\frac{1}{70}$, and $\frac{1}{54}$ against, and $\frac{1}{100}$ with the load. The average speed attained was 9·4 miles per hour, stopping at the four intermediate stations; the average power of the generating engine was 176·8 I.H.P., and the average power applied on the railway was only 26·7 effective horse-power, giving thus an efficiency of 15 per cent. as regards the indicated and effective power. Estimates were made in detail of the cost of installing and working an electrical equipment capable of dealing with the traffic on the Ninth Avenue Railway, which is about 5 miles along. The total arrived at was £771,000, including 17 generating engines each of 600 H.P., dynamos aggregating 11,000 H.P., and electric locomotives alone costing £126,000. The estimated working expenses for motive power, excluding interest on the first cost, came to £135,000 per annum, or to over 3s. per train mile.

The actual cost of the whole electrical equipment of the Liverpool Overhead Railway, for six miles of line, has been little more that 5 per cent. of the above estimate for the Ninth Avenue line of five miles, and the working expenses for motive-power are about 4d. per train mile, the mileage being much below the capacity of the generating plant. With a train-mileage equal to that of the Ninth Avenue line the cost would not exceed 3d. per train-mile. The actual average consumption of coal on the Liverpool Overhead Railway is about 16lb. per train-mile for trains of about 38 tons weight with seating capacity for 114 passengers, running at an average speed, including stops at stations, of about 12 miles per hour; whereas the averages on the New York Elevated Railways are, as far as can be ascertained, 54lb. of coal per train-mile for trains of about 92 tons weight (including locomotives weighing 23 tons) running at an average speed, according to the official time-tables, of about 12 miles per hour, including stops at stations. On the Liverpool Railway, during the last half-year, over 95 per cent. of the trains were punctual to time. No returns are available as to the punctuality of the New York trains. The coal used at Liverpool is bituminous small coal (slack), whilst in New York it is anthracite of good quality. The New York fuel consumption includes the heating of the trains in cold weather; but, on the other hand, that of the Liverpool line includes the lighting of trains and stations and the working of the automatic signals. The working of the brakes is included in both cases.

It will thus be seen that, far from electric traction costing four times as much as steam-locomotive traction, it is actually less expensive after full allowance is made for the difference in the weights of trains and other circumstances, in the two cases considered; and when the mileage of the electric line increases the difference will be still more marked in its favour.

The Liverpool empty train weighs 31 tons 2½cwt., of which the electrical equipment for locomotion weighs 6 tons 6cwt. With all seats occupied by passengers the total weight is about 38 tons 6cwt.; but, on occasions, the standing room in the train is also fully occupied, bringing the weight to perhaps 50 tons. The weight of locomotive equipment is thus about 125lb. per passenger, and about 20 per cent. of the total weight of the train with all seats occupied, each passenger being taken at 140lb. weight. A comparison of these figures with those of trains on other railways using electric and steam locomotives is given in Table A :—

TABLE A.

—	Electric Motors.	Electric Locomotives	Steam Locomotives.	
	Liverpool Overhead Railway.	City and South London Railway.	M'nhattan Railway, New York.	Gt. Northern R'lway Suburban Train.
	T. C. Q.	T. C. Q.	T. C. Q.	T. C. Q.
Weight of motors or locomotive ...	6 7 0	10 7 0	23 4 0	53 10 0
Number of passenger seats in train	114	96	240	414
Weight of motors or locomotive per passenger, in pounds	125	241	217	290
Weight of full train (all seats occupied)........................	T. C. Q. 38 5 2	T. C. Q. 37 7 0	T. C. Q. 104 1 0	T. C. Q. 188 11 0
Weight of motors or locomotive relatively to weight of full train, *ex* motors or locomotives, per cent.	20	38	29	40
Average weight of empty carriages (ex-motors) per passenger seat, in pounds	487	490	615	590
Weight of full train per passenger, in pounds	752	671	972	1,020

It need only be observed in reference to the above Table that the comparison is very favourable, so far as weights are concerned, to

* *Transactions* of the American Society of Civil Engineers, Vol. XXIII., p. 193.

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the adoption of electric motor-carriages where practicable and otherwise suitable.

In other respects, also, not indicated in the above Table, the advantages of the Liverpool arrangement are considerable. The weight on the driving wheels of a full train is 13 tons 15cwt., or about 36 per cent. of the whole weight of the train. Taking the minimum available adhesion at one-seventh of the weight on the driving wheels, this gives about 115lb. per ton of train, and the motors give an equal tractive force with a current of 133 amperes. The electric locomotives of the City and South London Railway, weighing 10 tons 7cwt. each, give on the driving wheels 28 per cent. of the whole weight of the train similarly loaded, and an adhesion (at one-seventh of the weight) of 90lb. per ton; while the motors give a tractive force of 100lb. per ton with a current of 150 amperes. For comparison with steam locomotives, the District Railway trains may be taken. A train of nine carriages, weighing (empty) 87 tons, and seating 400 passengers, is drawn by a locomotive of 46½ tons weight (of which 35 tons 13cwt. is upon the driving wheels), having cylinders of 17in. diameter and 24in. stroke, and driving wheels, when new, of 5ft. 9½in. diameter. The weight on the driving wheels is therefore 19 per cent. of the full weight of the train, and taking again one-seventh of this, the available adhesion is 61lb. per ton of train. With 120lb. mean effective pressure in the cylinders, the tractive force, allowing for the friction of the engine, would be about 70lb. per ton of train. It should be observed that the tractive force given above for the electric motors is available only so long as the stated currents pass through the motors, and that, as the speed increases, the current and, to a corresponding extent, the tractive force, are reduced,

These comparative figures are shown in the following Table :—

Table B.

——	Liverpool Overhead Railway.	City and S. London Railway.	District Railway.
	T. C. Q.	T. C. Q.	T. C. Q.
Weight of train (all seats occupied) ...	38 5 2	37 7 0	157 10 0
Weight on driving-wheels	13 15 0	10 7 0	35 13 0
Weight on driving-wheels per cent. of train-weight	36	28	19
Adhesion of one-seventh of weight on driving-wheels, lbs. per ton of train.	115	90	61
Tractive force, lbs. per ton of train			
*Motors with 133 amperes	115	...	...
*Motors with 150 amperes	120	50	...
Locomotive with 120lb. mean effective pressure in cylinders	...	...	71
Maximum tractive force per ton of motors or locomotive, lbs.	750	184	234

* The tractive force is arrived at, in the case of the Liverpool motors, from Mr. T. Parker's statement, Minutes of Proceedings Inst. C.E., Vol. CXII., p. 238; and in the case of the City and South London motors, from Dr. Edward Hopkinson's statement, Minutes of Proceedings Inst. C.E., Vol. CXII., p. 221.

The last line of Table B brings out a strong feature of the electric motor or locomotive, viz., that weight for weight, it is much more powerful than the ordinary steam locomotive. The latter has not only to apply, but it has also to carry the materials for and to generate the motive power. In a separate electric locomotive this advantage cannot be utilised to the same extent as is the case in the motor cars, but it is still considerable; because, in the one case, the whole of the weight of the locomotive is available for adhesion, and the motors can always be relied upon to exert a tractive effort exceeding the adhesion due to their own weight and that of the frame and wheels carrying them; while, on the other hand, even in the case of tank-engines, only about two-thirds of their weight is usually available for adhesion. Having regard to the large tractive force available, relatively to the weight of the train, on the Overhead Railway, as shown in the Table, it is not surprising that the promptness with which the trains get up speed is frequently remarked upon by passengers.

Signals.—A line such as the Overhead Railway, worked by electricity, seemed to afford a favourable opportunity for the introduction of electric automatic block signalling; and, in inviting tenders for the electrical equipment, manufacturers were asked to include a suitable arrangement of automatic signals. The Board of Trade was subsequently approached with a view to obtaining the necessary sanction to so novel a departure in connection with the working of an important passenger line. The system proposed was that patented by Mr. I. A. Timmis, M.Inst.C.E., and, after careful investigation, the inspecting officers of the Board of Trade (Railway Department) recommended that provisional sanction should be given; and in December, 1891, subject to certain conditions recommended by the inspecting officers, sanction was received, and the system is now in use on the railway.

The signals are of the ordinary semaphore and lamp type, but they are operated entirely by electricity, applied by the motion of the trains without the intervention of signalmen. At each station, and for each line, are a "home" and a "starting" signal, no "distant" signal being necessary—or rather the starting signal being the "distant" for the station or "home" in advance. As a train passes each signal it sets it to danger, by operating a lever which breaks an electric current passing through a contact box placed at the side of the line.

A train having arrived at a station has behind it two signals both at danger, forming a block-section; viz., the starting signal at the last station and the home signal of the station at which the train is standing. Upon the train leaving the station, its starting signal or "starter" being at "line clear" is by the train put to "danger." In its further progress, at a point in this case two train-lengths beyond the signal, the train, by operating a lever of a contact box, closes a circuit. A break in this circuit at the "starter" has already been closed by that signal going to "danger," and the circuit being complete to the two signals in the rear block-section just mentioned, a current passes through it and causes an electro-magnet on each signal-post to lower the signal to "line clear," and to hold it in that position. It is obvious that should the circuit be broken at any point, the signal or signals in that circuit would go automatically to danger.

In order to reduce to a minimum the current required for this work, advantage is taken of the fact that a comparatively small current will suffice to hold an armature after it has been brought into contact with a magnet, by automatically switching in a resistance about the moment that contact occurs; the effect is to reduce the current from that necessary to give the pull to that requisite to hold the signal in the "line clear" position. The lowering current is supplied by the through circuit as described, but the holding current is supplied through a short local circuit, thus freeing the making contacts in advance for another operation. It is also obvious that each train has always at least one signal at danger behind it. The levers which effect the making and the breaking of the contacts in the boxes are actuated by a long bar attached to the rear bogie of each train on the near side. All the making and breaking contacts are in duplicate, and all the signal lamps have two incandescent lamps in each in parallel, so that if any one fails the other still gives light. The electric lamps are lit and the electro-magnets are operated by a current of 50 volts from a battery of accumulators placed at each station under one of the platforms. The batteries are in duplicate, and while one is discharging the other can be charged. They are charged in series from the main circuit of 500 volts, and also serve for the station lighting.

Besides a considerable saving in the first cost, as compared with ordinary signals, the automatic signals will lead to important economy in working; and for the purpose of establishing shorter blocks in order to deal with increasing traffic, even where ordinary signals are used at the stations, the system will, it is thought, be specially useful.

In addition to the automatic signals, electric bells are at present used between station and station. These are worked by the porter on each platform, and telephones are in use at all the stations, and are connected with the general manager's office.

The fares are uniform for any distance. On passing through a turnstile on to the platform a passenger pays either 2d. or 3d.; if the latter sum, he receives a ticket entitling him to travel in a first-class compartment, which ticket is collected on his leaving the train. The portion of the railway at present worked begins and ends upon the dock estate, but the short extension at the northern end now approaching completion, and the authorised southern extension will take the railway into or near residential districts, and will render it less dependent upon the dock traffic, which, though very considerable, practically ceases at six or seven o'clock in the evening. By extending the hours of working to accommodate this new traffic the expenses will not be materially increased, because it is at present necessary to employ two shifts of men.

The railway was inspected on behalf of the Board of Trade by Major-Gen. Hutchinson, R.E., C.B., Major Cardew, R.E., and Major York, R.E., and, having been duly passed, was fromally opened by the Marquis of Salisbury on February 4th, and opened for traffic on March 6, 1893. A ten-minutes' service of trains was worked for about two months, and since then a five-minutes' service has been maintained with perfect regularity and without mishap of any kind. On the last August Bank Holiday about 40,000 persons were carried in the space of eight hours.

The total quantity of iron and steel in the structure is about 22,000 tons. The total capital cost, including equipment and all other charges, has been about £550,000, or about £90,000 per mile of railway. The engineers are Sir Douglas Fox, Member of Council Inst.C.E., and Mr. J. H. Greathead, M.Inst.C.E., who were represented on the spot during the construction of the line by Mr. Francis Fox, M.Inst.C.E., and Mr. S. B. Cottrell, Assoc. M.Inst.C.E. To the last-mentioned gentleman great credit is due

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for the able manner in which the arrangements for working the traffic have been made. In carrying out the construction of the railway many questions had to be determined by the officers of the Liverpool Corporation and of the Dock Board; and for the courtesy and assistance rendered, especially by Mr. H. P. Boulnois, Mr. George Fosbery Lyster, and Mr. A. G. Lyster, MM.Inst.C.E., in the settlement of these questions, the Authors desire to express acknowledgment.

The Paper is illustrated by a series of drawings and tracings, a selection of which has been made for the Proceedings.

The second Paper (Mr. T. Parker's) will appear in our next issue.

(To be continued.)

THE POTENTIAL AND CURRENT CURVES OF DIFFERENT TYPES OF ALTERNATORS, AND THEIR INFLUENCE ON THE CANDLE-POWER OF ALTERNATE-CURRENT ARCS.*

BY G. RÖSSLER AND W. WEDDING.

In working alternate-current stations it has repeatedly been observed in recent times that arc lamps which have been adjusted with every care in the factory had to be readjusted when in working, in order that they might burn quietly at the same pressure and current. The cause of this phenomenon, as was soon recognised, lies in the differences of the periodic potential-waves of the machines with which they were tested from those with which they were run. Should these curves appreciably differ, as may easily be the case if dynamos and lamps are not supplied by the same firm, it may even happen that a well-regulated lamp, when tested, cannot be made to burn quietly when run on a different machine. This fact renders it necessary in building alternators for arc lamp supply to attempt always to produce a definite particular form of E.M.F. wave.

In choosing this form of wave two conditions must be considered. Firstly, how does the lamp burn? and secondly, what illuminating power does it possess when run with different character of potential and current waves? An answer to these questions can only be obtained experimentally by simultaneous electrical and photometric observations on machines and lamps at present in use. The authors have made together such researches in the Electrotechnical Laboratory of the Technical High School in Berlin at Easter, 1894. The electrical portion is the work of G. Rössler and the photometric of W. Wedding.

PART I.—ELECTRICAL.

Three machines were available for the following experiments; a 5½ kilowatt machine, by Ganz and Co., four polar, with a rotating cross-formed armature (Fig. 1); an older small 480-watt machine, by Wechsler and Co., with four magnet poles on each side of the rotating armature (Fig. 2), both machines the property of the Electrotechnical Laboratory; and, besides these, a machine by Siemens and Halske, with 12 poles, specially built for their own use for the preparation of ozone (Fig. 3), and which was very kindly placed at the authors' disposal by the firm. The arc lamp used was an excellent one, coming from the works of Messrs. Körting and Mathiesen, of Leipzig.

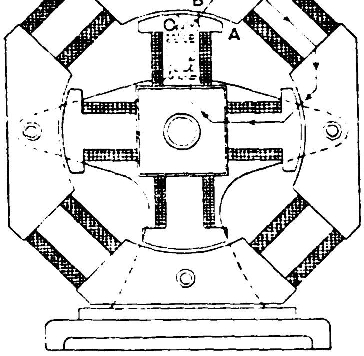

FIG. 1.

The determination of the curves of potential and current given by the machine was effected by the method described in principle by Joubert in his researches on a Siemens machine in 1881; one terminal of a voltmeter is joined to a terminal of an arc lamp, while the other terminals of voltmeter and arc lamp once in every revolution are connected together at a definite moment in the period. After suitable calibration of the voltmeter, one can measure the potential difference for every position of the armature, and the current is measured by the fall of potential across a suitable known inductionless resistance. In our case this momentary contact was produced as follows (Fig. 4): A contact block, A, imbedded in the surface of an insulating ring which rotates with the shaft, was permanently connected with the flat brass ring C, and the brush D, and touched once in every revolution the brush B, which, carried on an insulating brush-holder, E, could be moved over the

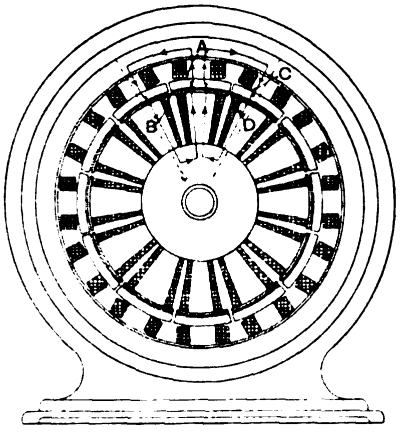

FIG. 2.

periphery of the divided arc F. B is permanently connected to one terminal of the voltmeter D to a terminal of the lamp or resistance; B could be connected with D at any particular point in the period by moving the sliding brush-holder E over the arc. For the practical work of observation the mechanical construction of the contact A B is of the greatest importance, and may easily become a source of many errors and much waste of time. The material known as stabilit, recently introduced by the Allgemeine Elektricitäts Gesellschaft, was used for the insulating ring, because

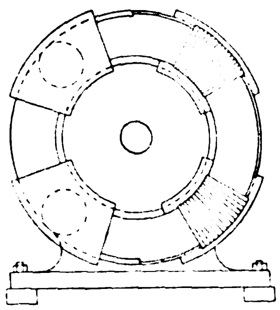

FIG. 2A.

of its excellent insulating properties, and its surface took quickly a beautiful polish under the action of the brush B. The measurements were made with an electrometer by Carpentier, which was very dead beat owing to its needle being suspended as a copper ring in a very strong magnetic field. In order to avoid variations in the reading of the electrometer, a Siemens mica condenser of one microfarad capacity was put in parallel with the electrometer. The discharges which take place owing to imperfect insulation when

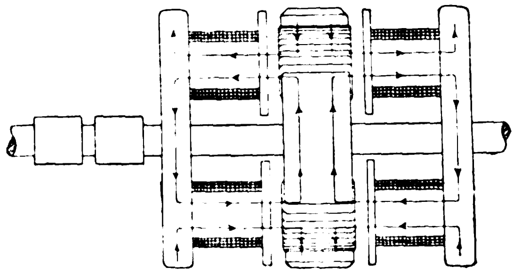

FIG. 2B.

the contact A B is broken do not affect the potential difference of a condenser of this capacity to an appreciative extent; and, similarly, the condenser obliterates all irregularities in the driving of the machinery. The system of coupling the electrometer was as in Fig. 5. One pair of quadrants is connected to the needle and one terminal of the volts, the other pair being connected to the other terminal. The turning moment is then proportional to the square of the potential difference. And since in the Carpentier

* Paper read before the Verband der Elektrotechniker Deutschlands, 1894. Slightly condensed.

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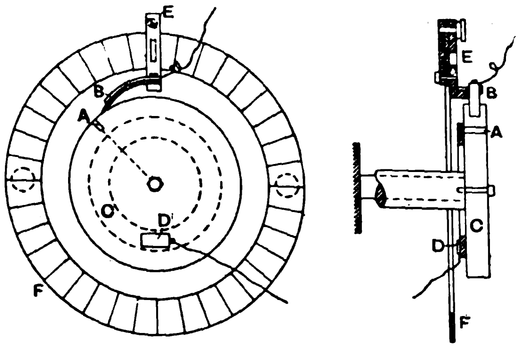
instrument the control is obtained by twisting the suspension, and this force is proportional to the angle of twist, it follows that the angle of deflection is proportional to the square of the potential difference.



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The lower readings are, therefore, less sensitive than the upper, and the lower limit of this instrument was about 20 volts. For the determination of smaller potential differences, the needle was separately charged, as shown in Fig. 6, to about 100 volts. The deflection is then proportional to the potential difference between the quadrant pairs: 1 volt gave 20mm. deflection. Special switching arrangements enabled the coupling to be altered at any moment, and the electrometer and condenser to be discharged.

In calibrating the electrometer several important points must be noticed. The torsional rigidity of the suspension depends on the temperature, and, therefore, also the constant of the instrument. As the axis of rotation of the needle is unalterable by the construction of the instrument, a completely symmetrical position of the

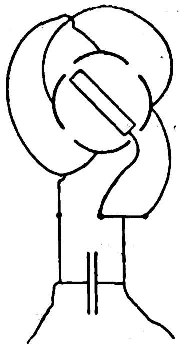

Fig. 5.

needle with respect to the quadrant is seldom attained. This has the disadvantage that the position of the needle alters when charged as in Fig. 6. To avoid the difficulties introduced by trying to treat the Carpentier instrument theoretically, the instrument was empirically calibrated over all its range, and this calibration

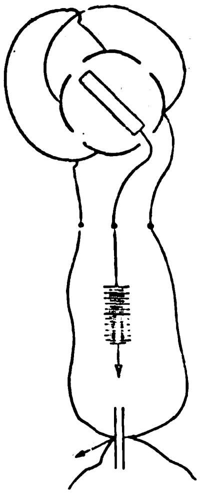

Fig. 6.

was repeated before each set of readings. An easy and convenient means of doing this was at hand in the form of a Feussner compensator with Clark standard cell, and a second small Pollak accumulator battery of 100 volts. As is well-known, one can easily produce in the main circuit of this compensator, by the aid of the Clark cell, small currents, as ·01 ampere, with the greatest accuracy. By an arrangement for switching known resistances into the circuit any voltage can be quickly produced.*

Since the charge only occupies a very small proportion of the whole time, it is necessary to calibrate by means of known voltage applied to the same rotating contact, so as to accurately reproduce the conditions. Much has been written by Hopkinson and others on the subject of the suitability of certain instruments for such measurements, but an empirical calibration of this sort immediately renders us independent of the peculiarities of the instruments used.

Besides the electrometer the following instruments were in circuit (Fig. 7):—

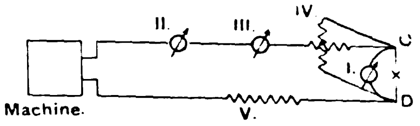

Fig. 7.

1. A Cardew voltmeter in parallel with the lamp C D.
2. A Thomson balance reading 0·1 – 10 amps.
3. A Schuckert alternate-current ammeter.
4. A Ganz wattmeter.

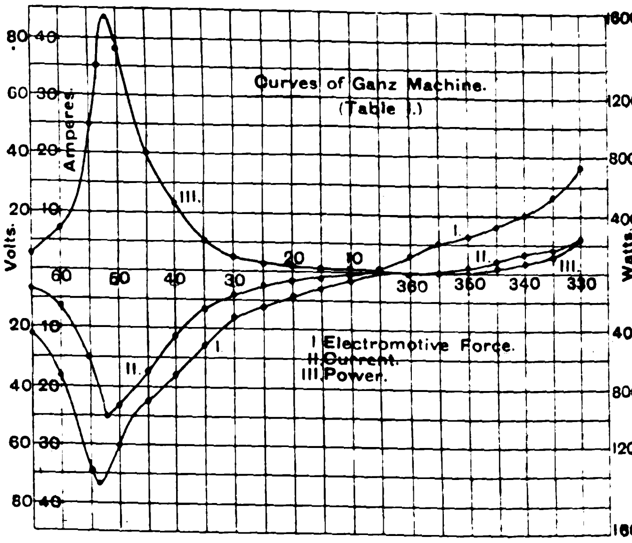

Fig. 8.

The inductionless resistance (5) was used in conjuction with the electrometer for the determination of the current curve. The instruments 1 and 3 measured the square root of the mean square of current and volts; the wattmeter (4) gave the power. The Thomson balance was only used in regulating the lamp, the Schuckert ammeter being used for keeping the current constant.

Measurements on the electrometer were only made when the signal was given that the lamp was burning normally. As the feed

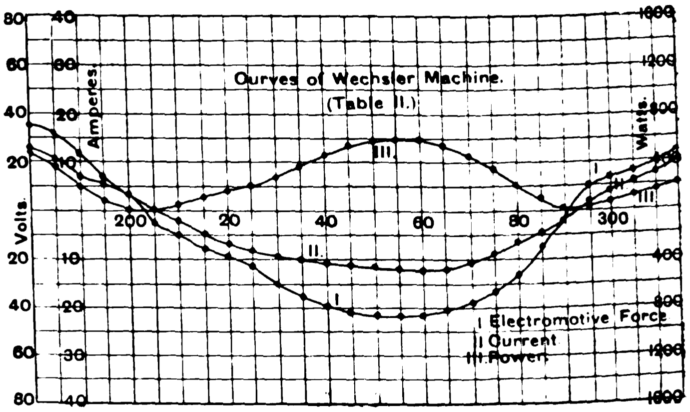

Fig. 9.

takes place in jerks, the electrometer reading is not steady, and therefore ten observations of current and volts were made for every position in the period. Altogether during the photometric measure-

* This apparatus was described in the *Zeitschrift für Instrumentenkunde*, April, 1890.

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ments four pairs of curves were taken on the Ganz machine and two pairs on each of the others ; but, as these are all in perfect accordance, only one set need be given for each machine. In the following Tables the results of the last set of observations on each machine are given. The values therein given, and graphically represented in Figs. 8, 9, and 10 are obtained from the electrometer readings by subtraction of the total current and total power taken by the Cardew voltmeter and the wattmeter shunt.

Discussion of the Results.—The periodic variation of the electrical magnitudes is very considerably different in the three machines used. The Ganz machine has a quickly rising and quickly falling wave, the ordinates rising rapidly to an extraordinarily high point, falling rapidly, and remaining for the greater portion of the period at a very low value. So that the value of the energy supplied to the lamp (Curve III.) is very small from 35°—335°, and nearly the whole supply takes place over the range 35°—65°. The lamp, therefore, receives its energy in the form of an impulse lasting only about a third of the whole time. The reverse of this is the case of the Siemens machine (Fig. 3). Here the energy rises very slowly to a maximum value, on which it waits for some time, then declines slightly, rises again more sharply to a still higher value, and then falls quickly to zero. The current curve is even more regular, remaining constant in value for more than half the half period.

The Wechsler machine takes an intermediate position ; there is no very rapid alteration of the ordinate, and, on the other hand, no sustained maximum. This machine comes very near to having a sine wave.

The general character of these curves is easily explained on the theory of electro-magnetic induction from the magnetic design of the alternators. It is more difficult to follow in detail the reaction of the armature on the magnetic field and thence on the volt and current curves. As the types of alternator here used are of special interest as extreme types of what may occur in practice as regards electrical properties, some account must be given of the cause of these properties.

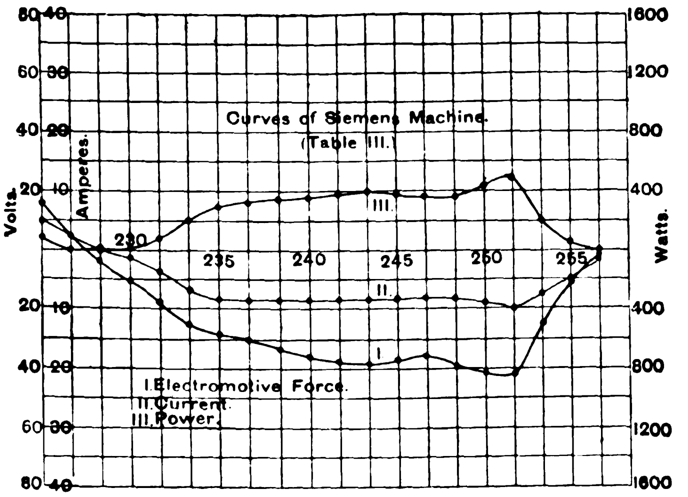

Fig. 10.

The investigation of the induction processes is best conducted on Faraday's lines of force theory (1) according to the known fundamental laws. If a closed conducting circuit be moved in a magnetic field an E.M.F. is produced, whose value in absolute units is the rate of change of the number of lines cutting the plane of the circuit ; (2) using the law of the magnetic circuit of these lines, according to which a certain magnetising force, determined by the ampere turns, always produces in a magnetic circuit a certain definite number of lines of force, inversely proportional to the magnetic resistance as calculated by certain definite rules. With these laws as starting point, the phenomena of the induction in these machines may be explained as follows :—

1. The Ganz machine (Fig. 1), armature and magnets made of charcoal iron, with armature and magnet poles of solid metal. Four magnetic circuits, taking the course shown for that position of the field magnets, the lines of force coming out of the right hand side of each limb, and passing in again on the left hand side of the next limb. A rotation of one-eighth of a revolution to the right may be divided into three parts. First, from the position drawn until the position is reached where the area taken up by the induction coming out is halved (when the point B is opposite A). The path of that going in becomes wider. The magnetic resistance of the circuit, and therefore the number of lines of force, is but little altered, and thus the induced E.M.F. is small. Second part : From this last point to that at which the left edge of the magnet pole is separated from the right edge of the armature projection by half the width of the pole face (point C, opposite A). On this part of the curve the lines of force coming out of the magnet into its pole-piece bend over into its left half, and the right half gets out of range. At the end the total area for the lines coming out and going in is equal to the area of the magnet limb. The magnetic resistance becomes somewhat greater, the number of lines of force diminishes slowly, the E.M.F. goes slowly up. Third part : From the end of the second part until the middle of the magnet pole is opposite the middle of the armature coil. In this short stretch the area of the induction path becomes rapidly smaller, the magnetic resistance rises, the number of lines of force diminishes, and the E.M.F. increases rapidly. During the second eighth of a revolution of the magnet the E.M.F. diminishes again in a symmetrical manner.

2. The Wechsler machine (Fig. 2a). Eight magnetic circuits, four on each side of the armature. Path of the magnetic lines as in Fig. 2b, as similar poles are opposite to one another. Smallest alteration of the number of lines is obviously when the armature coils are in the middle between two poles, and therefore zero of E.M.F. in this position. Greatest alteration when in the position shown in Fig. 2a, and therefore maximum E.M.F. here. In moving from one of these positions to the other there are no sharply marked divisions of the movement. The crossing of the induction from the magnets into the armature will always take place with great smoothness when the polar surfaces are divided from the armature iron by a large air gap, and this occurs in the Wechsler machine. The principle of large air gap is a useful one where sine curves of E.M.F. are to be aimed at ; the only important objection is the lowering of the electrical efficiency, but in America good dynamos are built with air space up to 15mm.

The Siemens machine (Fig. 3) gives a view of the magnetic circuits of the machine supplied by Siemens and Halske, as far as could be determined in the laboratory without taking the machine to pieces. The twelve magnet limbs, arranged as a star, come opposite as many armature coils wound on iron. Two of the magnetic circuits are indicated in Fig. 3. The pole-pieces of armature and magnet are so wide, that the edges of neighbouring pole-pieces are very close together, and herein lies the cause of its different pressure curve. If we again assume that in Fig. 3 the magnetic lines are coming out of the right hand side of the magnet limb and passing into the left hand side of the next, there exists when the armature is turned round no position where the number of lines of force suddenly alters. The rotation by a quarter period may be divided into two portions :—

First part : The magnet turns to the right between the pole-pieces of the armature, until B comes in front of A, and then D is also near C. During this part of the revolution the magnetic resistance increases, the lines from each magnet limb pass into two armature coils, and in the armature one portion of the induction is opposed to the other ; the result being during this portion of the revolution an increasing diminution of the lines of force—that is, a rising E.M.F.

Second Part : When B turns further out past A, D passes out over C, the path of the induction coming out of the limb B into the armature coil A becomes steadily narrower, and the lines coming from B pass half into A and half into C, when the induction cutting the armature coils is O. During this second half of the revolution the induction alters more rapidly than in the first part, resulting in a slowly rising E.M.F., which sinks again symmetrically as the rotation is continued.

The above considerations show afresh how extremely important the shaping of the pole-pieces for a given type of machine is in determining the character of the periodic curves of the electrical quantities. We have considered only the influence of the magnet fields, and the curves would be symmetrical were no other influence active. The deviations from symmetry are due to armature reactions weakening the field when approaching, and strengthening it when receding. To enter in detail into this effect is beyond the scope of the present Paper.

The accuracy of the above curves may be tested by comparing the average values obtained from them with the readings of the voltmeter, ammeter, and wattmeter. A wattmeter reads the average value of the watts, while the voltmeter and ammeter read the square root of the mean square, and this must be taken into account in measuring the curves by planimeter.

The comparison comes out as follows :—

Machine.	Volts.		Amperes.		Watts.	
	Measured.	Calculated.	Measured.	Calculated.	Measured.	Calculated.
Ganz	29·9	29·6	9·49	9·06	267	264
Wechsler	31·1	31·8	9·50	9·25	298	293
Siemens.........	30·4	30·8	8·87	8·81	—	—

In the first two cases the photometric and electric measurements were simultaneous ; in the last the electrical measurement directly

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preceded the photometrical, and the wattmeter was not read. The result is a closer agreement with the observed values.

A closer agreement could not be expected when driving so unsteady a load as an arc lamp. It must be noted that the phase displacement is very small, only about 1/18th of a half period. For the recognition of the nature of the arc, the determination of the cause of this small displacement is of great importance; for to prove that it took place at the arc itself would be to prove an E.M.F. in the arc. The question whether this back E.M.F. were due to self-induction or to an electromotive force in the arc itself would still remain unanswered. The experiments do not throw much light on the subject, as the back E.M.F. of the coils of the lamp cannot be accurately calculated. The only thing they prove is that no great phase difference exists in an arc lamp.

Influence of the Character of the Waves on the Regulation of the Arc Lamp.—The discussion of this question is best preceded by a short description of the arrangement of the lamp. It is a differential lamp, and its construction is indicated in Fig. 11. The two coils are over one another, the current coil A above, the pressure coil B below. The two carbons of equal thickness hang on the ends of a chain, passing over the chain wheel D. As the carbons burn away the rotation of D brings them together, and as they burn equally they are raised and lowered by equal amounts, thus remaining about in the same position as regards the reflector *e*. To regulate the lamp the coils each work on a split iron tube, *a* and *b*, which are both fastened to a brass rod, *c*, hung on the end of a three-armed lever, E. These tubes are symmetrically placed

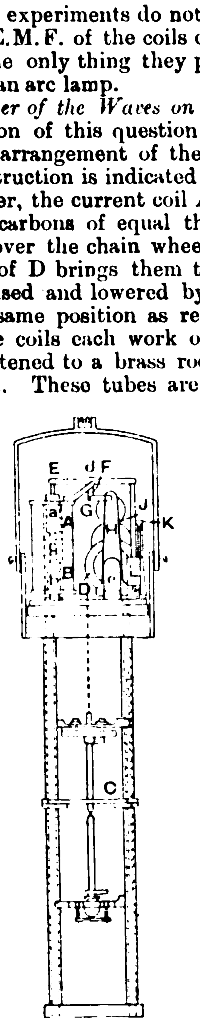

FIG. 11.

when E is horizontal, and their working is independent of any difference of phase in the currents which attract them. The working is as follows: When current passes through the lamp, the carbons being together, the current coil working alone pulls E down. The vertical arm F of the lever moves to the right, and by means of the connecting rod G moves H and D round the axle *e*, and draws the carbons apart. But H and D are only coupled together when arm J is pushed against K by the movement of H sideways. When the required pressure is attained the pressure coil lifts its core and feeds the carbons; the movements are made steady by a dash-pot L, whose piston can be weighted to control the regulation of the lamp.

These weights had to be altered considerably for the different machines, being heavier for the Ganz, and lighter for the Siemens machine; while with direct current the weight could not be sufficiently reduced to start the arc properly. This latter phenomenon is obviously due to the self-induction of the pressure coil, and resistance should be put in its circuit when used on direct currents. This also accounts for the differences between the machines, owing to the variations in shape of the E.M.F. curve. The author also gives reasons for working at a low-induction density in the iron cores if the lamp is to work on as many different kinds of machines as possible.

(To be concluded.)

Telephonic Communication in New Zealand.—It is proposed to establish a trunk line between Whananaki and Hikurangi, New Zealand. The inhabitants of Whananaki consider the telephone "a necessary adjunct to progress."

THE HUNTING OF GOVERNED ENGINES.*

BY JAMES SWINBURNE, M.INST.C.E.

Lord Rayleigh pointed out some years ago† that the ordinary explanation of the action of the electromagnet is an electrically-driven tuning-fork is incorrect, and that such a mechanism works in virtue of the self-induction of the electromagnet. As far as the action of the contact goes, it is the same whether the leg of the fork is receding from the magnet or approaching it; and if the force depended only on the contact, and was symmetrical, no power would be supplied to the system. It would be like a pendulum which is acted upon by gravity equally whether the bob is going up or coming down. To make the pendulum work continuously, gravity would have to act more when the bob was coming down. As this cannot be arranged, a clock has to do the work instead. In the case of Lord Rayleigh's tuning-fork, the magnet pulls harder when the leg is coming towards it than when receding, and thus gives power to the fork. In other words, the effect of the magnet lags, and thus becomes unsymmetrical. This is a most important principle, and it applies to a large number of varied cases of great importance, and of more interest to engineers than even electrically-driven tuning-forks. Broadly speaking, all kinds of continued vibration may be said to depend on this principle. Among these cases is that of the hunting of governed engines.

If a governor really behaved as it does in most text-books, and admitted steam in exact accordance with the speed of the engine, there would be no such hunting; but, unfortunately, a governor does not follow the variations of speed instantaneously. Apart altogether from questions of friction, or movement of heavy valve or expansion gears, many forms of governor, especially what may be described as the relay kind, alter the steam admission with some delay. The friction of the various parts and their tendency to remain in one position until the disturbing force comes up to a certain value, and to then move suddenly and overshoot the mark, increases this action. The result of this time lag in the action of governors is that in many cases engines, especially on light loads, get into a state of vibration known as hunting.

The orthodox way of treating such a subject would be to begin with the discussion of an engine with a fly-wheel and a frictionless governor with a dashpot or something of the sort, following a simple law. A system might thus be imagined which would fit a differential equation such as that used to find the current when an electrical condenser is discharged through an inductive circuit; and it might be possible to calculate the load which would just prevent permanent hunting, or any hunting at all. There are immense difficulties, however, for there are so many small causes of disturbance that such treatment would probably give no useful information. It may be best, therefore, to discuss the question verbally only, without expecting to arrive at very definite results.

When the load of an engine varies, for instance, by decreasing, if the steam supply remains the same, the extra energy goes to increasing the speed of the fly-wheel. Whether the speed of the engine follows the steam supply quickly or not thus depends on the fly-wheel. It also depends on the load. If a 1,000-H.P. engine is working at full load, and 900 H.P. is suddenly thrown off, and the governor does not act instantly, 900 H.P. is devoted to increasing the velocity of the fly-wheel, and unless the wheel has an enormous moment of inertia, or is turning very quickly, this power will increase its speed, say, 2 per cent. in a very short time. On the other hand, if the engine is only doing 100 H.P., and this load is suddenly reduced to 10, there is only 90 to increase the speed of the fly-wheel, and to increase it 2 per cent. will take ten times as long as in the former case. Putting the matter the other way, the engine obeys variations of steam supply more slowly at light loads, or, in other words, it obeys its governor more tardily at light loads. In practice many engines which run steadily at full load, hunt terribly when worked light.

Turn now to the governor. It is generally treated as complete in itself, without reference to the fly-wheel or engine load. A simple Watt governor, and most of the governors on small engines, have no appreciable time lag, except a certain sticking, due to friction, or to the absurd practice of putting a comparatively small governor to work direct on to a heavy expansion gear, or a stiff stuffing-box. These matters have been discussed in an able Paper by Ransom‡ recently. There is not very much tendency to hunting with such governors. Their drawback is that as the steam must be nearly shut off at no load, and full on at full load, the valve gear must be in different positions, and the governor must therefore be in different positions too. This means that the engine will be governed at a considerably higher speed at light loads. To cure this the obvious course is to make the governor isochronous. The drawback to this is that an ordinary isochronous governor is

* A Paper read before Section G of the British Association.

† Royal Institution, March 15, 1878.

‡ *Proceedings* of the Institution of Civil Engineers. Vol. CXIII., page 194.

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not powerful enough if it has to move through a long range with a very small percentage of speed variation. It is likely to stick until the speed has varied a good deal, and then to move to its fullest extent. The result of this would be that the engine would be governed by having full steam and none at all alternately. I do not know why this method of governing should not be employed. If the governor works some light gear, such as the various modifications of the Corliss, this form of governor should work very well with a large fly-wheel. The cylinder would either get a charge of steam which would correspond to the full engine load, and which would, therefore, be expanded and worked in an economical way, or it would get none. This alternation of full load and no load is common in gas engines, and, for distinction, may be called the hit-and-miss method of governing. The only steam engine I know which employs it is the Parsons steam turbine. Of course, the great difficulty is the fly-wheel, especially in a slow-speed engine. If working at a tenth of its load it gets steam only every tenth revolution, and the fly-wheel must carry it round for nine. As high speeds are gradually coming in, it may be worth while to keep this method of government in mind, as it is most economical of steam, and as there is no time lag in the governor, there is no hunting.

Returning to the isochronous governor, the obvious method of overcoming the friction or weight of valve gear is to use some relay —to use a convenient electrical expression. The governor does not then act directly on the valve gear, but puts some screw or other mechanism into gear which works the expansion or throttle valve. Willans used a water relay. The governor worked a minute water valve, controlling a cylinder which worked the throttle valve. Such an arrangement can be made very accurate, as a very small movement of the governor, opposed by a very slight force, can be made to work the most obstinate valve gear. But we have at once danger from hunting, as there is considerable time lag in the governor. Suppose the load is suddenly decreased, the engine speeds up, and the governor begins to increase the expansion, but effects this slowly, and by the time the valves are right for the reduced load the engine is much above speed. The governor, therefore, goes on reducing the steam until the engine has far too little. It therefore slows down again. But the governor continues reducing the steam until the engine is slowed down to its normal speed. By that time the engine has far too little steam, so it goes on falling in speed. The governor then begins to turn on steam again, but it does it so slowly that the engine has fallen far below speed before normal steam supply is given, and the governor goes on turning up steam till the engine arrives at its normal speed, when it has far too much steam, and is again rapidly increasing in speed. This cycle of operations is repeated over and over again. It depends on the lag of the governor, the fly-wheel, and the load, whether the hunting is temporary, so that the variations of speed are less and less every time; or permanent, in which case the engine alternates between no steam and, perhaps, full supply. An engine which hunts permanently at very light loads often works perfectly over half-load.

An ordinary governor is thus apt to be insensitive and to allow the speed to vary with the load if designed not to hunt; and if arranged to work a relay, hunting results. An isochronous governor with a dashpot has, of course, a time lag too.

It is easy to make a governor which combines the advantages of both systems, and avoids the drawbacks.

A governor made by Messrs. Weyher, Richemond, and Co., of Pantin, may be cited as a good example. It is not isochronous, and it works directly on the steam control. I may mention that even in small engines the French arrange the valve gear so that it is very easily controlled. The variable detent is very common. In addition to working the steam control direct, any movement of the balls from the normal position puts a screw gear into motion, which slowly alters the intermediate gear, so that the engine finally runs at the normal speed whatever the load is. It is unnecessary to describe the particular gear employed; a typical case may be imagined. Suppose the expansion link is in connection with the middle of a lever, and the governor with one end A, the other end B being fixed; an increase of speed raises the end A of the lever and the middle, and you have an ordinary non-isochronous governor which gives a higher speed at light loads. Suppose, however, that any rise of the end A of the lever sets a train to work which slowly raises the other end, it will go on till the governor is in its normal position. We thus get a governor which does not hunt and gives the same speed at all loads. If the valve gear is heavy or stiff, the governor may work one end of the lever by means of a relay, but it must be a following relay, such as those employed in steam steering gear, so that the extent as well as the direction of the movement of the governor end of the lever is controlled by the position of the governor; and this gear should act as promptly as possible to avoid hunting. The other or relay gear then works slowly. In such a governor it will be seen that the end A of the lever eventually comes to its normal position in all cases, and only moves to counteract sudden variations of speed. The real control is effected by the slow-moving relay moving the other end B.

Instead of using one governor, a pair may be employed, one of which works direct on the valve gear, and the other by means of a slow-working relay. This method does not seem so simple as using a simple governor to do both.

These matters must have been worked out thoroughly by many engineers, and they appear so simple that one almost feels ashamed to bring them forward here; but in looking the matter up I find the governor is generally treated by itself, without reference to the engine. I have, therefore, thought it might be worth while to bring this subject forward, and trust you will bear with me for having put it in such a very elementary manner.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *August* 17, 1894.

The American Association for the Advancement of Science inaugurated its forty-third annual meeting at Brooklyn yesterday (August 16th). In the morning Prof. Daniel G. Brinton delivered a presidential address, and in the evening Prof. Harkness, the retiring president, read a Paper on "The Magnitude of the Solar System." The vice-presidents of the various sections delivered addresses during the afternoon, none of which was on an electrical subject. The officers of the sections of physics are Prof. W. A. Rogers, president, and Prof. B. W. Snow, secretary, and the corresponding officers of the section of mechanical engineering and science are Profs. Mansfield, Merriam, and John Kinealy. The only electrical Paper thus far read was one this afternoon by Prof. Snow on the "Directed Velocity of the Particles in the Electric Arc." But few of the Papers have been printed, and it is not probable that electricity will play a part any more considerable in this meeting than it has in past ones. The American Institute of Electrical Engineers and the periodical scientific press in this country are the means of publicity chosen by American electrical scientists, who rarely read Papers at the Association meetings.

Revival of Business.—The passage of the Tariff Bill by Congress promises greatly to stimulate electrical business, which has been in a most unsatisfactory state during the past year. During that time there have been numerous failures, the latest being that of Queen and Co., Philadelphia, who for more than a generation have occupied the same position in America that Elliot Bros. have in Great Britain. One of the notable features of this period of depression has been the fraternal spirit shown in the trade toward its weaker members, the contrast in this respect with other branches of business having been frequently remarked. As an indication of the upward tendency we may cite General Electric Stock, which is now quoted 42, a rise of more than 6 points in a short time.

Municipal Electric Lighting.—The experience of the municipality of Detroit in electric lighting has not been encouraging toward the adoption of this system in America. More than a year has passed by since the decision to erect a plant was made, and, though much money has already been spent, little progress has resulted. Politicians have eagerly taken advantage of every step for the purpose of gain; and, if the plant is finally finished, it looks as if it will be merely used for corrupt ends. The letting of contracts was bitterly contested by different factions in the Council in the interest of different firms, and it is stated that the dynamos of the firm who finally received the contract may be rejected in the interest of unsuccessful bidders. A local paper comments on the situation as follows:—"After the lapse of one year the city finds itself with an elaborate white elephant on its hands. The people cannot fail to realise that the creation of the new department has simply increased the opportunity for more wrangling in the city government, and the facility with which private parties may control public affairs to suit themselves." As the change was brought about by charges of corruption of city officials and councilmen under the previous system of private ownership, the outcome is a sad commentary on American municipal government.

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CORRESPONDENCE.

SINE CURVE ALTERNATORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With regard to the lately so-much-discussed question of "sine wave" or "not sine wave," I may give, to supplement my former statement, the results of some tests recently made of the core loss of a 200-kilowatt transformer, which very plainly bears out my statement. With the generator giving very closely a sine wave, the observed core loss was 3,300 watts; while with the wave of an iron-clad alternator, at the same voltage and same frequency, the core loss was found to be only 2,860 watts, giving an advantage of over 13 per cent. in favour of the distorted wave of the ironclad. I may add that in this case the distortion of the wave was larger than usual, the ironclad being speeded down to the low frequency of 25 cycles.—Yours, &c., CHAS. P. STEINMETZ.

Schenectady, N. Y., August 17, 1894.

DOUBLE v. SINGLE TROLLEY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: So much has been written on this subject that it would seem that experience is the only thing likely to settle it.

There is another suggestion, which has not yet to my knowledge been tried, and which seems to be a sort of intermediate step.

With the adequate metallic returns now required by the Board of Trade, the difficulties of the earth return will probably be almost entirely confined to the more extensive systems—such as we may hope to see shortly in some of our larger towns—and it is to such that the following suggestion is most suitable.

By applying the three-wire system to tramway work in such a way that, say, the up line formed one side of the system and the down line the other, the earth return forming the third wire, the earth current on an extended system could probably be reduced to a comparatively small quantity, the excess, if desirable, being arranged always on the positive side.

A thoroughly good bonding of the rails would still be necessary, but underground feeders would be saved, and the advantages of the three-wire system be gained.

It might appear at first sight to produce some complication in the generating plant; but these difficulties might be overcome on similar lines to the way they are met in some of our lighting stations—viz., by the use of accumulators, which need not all be placed at the generating station, and by the use of motor transformers, which could with advantage be combined with the mechanical storage.—Yours, &c., A. G. SEAMAN.

August 28, 1894.

HIGH-SPEED FLY-WHEELS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to your editorial remarks on my letter on this subject in your issue for last week, I think that most practical engineers will agree with me that in such a question as this actual experience, even if American, is a safer guide than purely theoretical considerations.

I may, therefore, mention that in the pattern of Howell torpedo adopted by the United States Government the 14in. fly-wheel runs at a peripheral speed of 611ft. per second, while in a larger type of similar torpedo manufactured by the Hotchkiss Ordnance Company, the peripheral speed of the 18in. wheel employed is 706ft. per second. Before leaving the shops these wheels are run up to a speed about 20 per cent. in excess of the above. Such test is not for flying to pieces, but only for the elastic limit, and the wheel must show no deformation after it. As a matter of fact, the wheels would not fly to pieces until above double the above speeds had been reached.

It may also be pointed out that the steam wheel in the small Laval steam turbine, running at 30,000 revolutions per minute, has a peripheral speed of 575ft. per second, although, having regard to the apertures cut in it, this wheel cannot be nearly so strong as a solid one. Moreover, in the Parsons turbines used at Newcastle, Cambridge, and Scarborough, the 27in. diameter low-pressure wheel, at 5,000 revolutions per minute, has a peripheral speed of about 590ft. per second, though this also has holes in it and is a thin disc, which would not stand so great a strain as a solid cylinder. Further, these Parsons wheels have been run experimentally at considerably higher speeds than the above, and they do not begin to show any deformation until nearly twice their normal speeds are reached.

With regard to the practicability of strengthening high-speed fly-wheels such as I have suggested by means of hoops shrunk on the outside of them or by means of tightly wound steel wire, it seems to me very doubtful whether such methods of strengthening would offer appreciable advantages over a solid steel wheel. These methods of strengthening are, of course, those ordinarily employed in the manufacture of big guns; but it must be remembered that the conditions of strain in a big gun and in a fly-wheel are very dissimilar. While in the former the whole of the strain is set up in the interior, and, assuming the material to be incompressible, reaches each succeeding concentric layer with a force inversely proportional to the square of its distance from the axis, in a fly-wheel the case is quite different, and the centrifugal force tending to rupture the wheel acts upon every portion of it. Consequently, in a wheel the outer circumferential layers are already pretty fully loaded, owing to their own tangential inertia, and it does not seem advisable to put extra strain upon them for the purpose of assisting the interior. —Yours, &c., A. A. C. SWINTON.

S.W., August 29, 1894.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," being four Lectures delivered before the Royal Institution in April-May, 1894, by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is in preparation, and will shortly be published.

"THE WORK OF HERTZ."—The lecture delivered by Dr. O. J. Lodge at the Royal Institution on June 1st is reprinted with corrections and additions, and many illustrations, price 2s. 6d. net.

"ELECTROMAGNETIC THEORY," by Oliver Heaviside, is now ready, price 12s. 6d. (abroad 13s.). Prospectus on application.

TENDERS INVITED.—The Corporation of Edinburgh invite tenders for the supply of arc lamp-posts in connection with the electric lighting of the city. Copies of the specification can be obtained from Mr. E. W. Monkhouse, the Resident Electrical Engineer, Dewar-place, Edinburgh, from whom all information may be obtained; as also from the Consulting Electrical Engineer, Prof. A. B. W. Kennedy, 14, Old Queen-street, Westminster, London, S.W. Tenders must be sent to Mr. William Skinner, Town Clerk, City Chambers, Edinburgh, not later than 10 a.m. on the 17th prox. Some further particulars appear in our advertisement columns.

——— The Government of Canada invite tenders for the manufacture, laying, and maintenance of a submarine electric cable across the Pacific, from Canada to the Australasian Colonies. Conditions can be obtained at the Office of the High Commissioner for Canada, London, S.W., and proposals must be sent in to the Minister of Trade and Commerce, Ottawa, on or before November 1st next. Proposals may be sent in under Forms A, B, or C. Form A provides for the cable to be owned and controlled by Government, worked under Government authority, and kept in repair by the contractor for three years; under form B the cable is to be owned, maintained, and worked by a subsidised company; and under form C the cable is to be owned, maintained and worked by a company under a Government guarantee.

——— The Portsmouth Corporation invite tenders for the purchase of certain electrical plant at the Town Hall, Portsmouth, which is no longer necessary now that the building is connected with the central electric lighting station. Tenders much reach the Town Clerk by Saturday, September 22nd. Some further particulars appear in our advertisement columns.

——— The Postmaster-General invites tenders for the purchase of a quantity of old copper and other metals, insulated wire, and other old telegraph stores. Tenders must be sent to Mr. Charles E. Stuart, controller of stores, Telegraph-street, London, E.C., by noon, on Thursday, September 13th. Some further particulars appear in our advertisement columns.

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TENDERS INVITED.—Our advertisement columns contain a notification that the proprietors of the Empire Palace of Varieties, Barnsley, require tenders for the lighting of the outside of the hall by electricity. These tenders must reach Mr. Edwin Haigh, the Manager, on or before Saturday, September 8th.

——— Tenders are invited for the erection of the electric light and power station at Shrewsbury, particulars of which can be obtained of Mr. A. E. Lloyd Oswell, Architect, Dana Chambers, Shrewsbury.

——— The Cheltenham Corporation invite tenders for the supply of junction boxes, covers, and other castings, which must reach the Town Clerk on or before September 8th.

TENDERS ACCEPTED.—The Electric Lighting Sub-Committee of the Edinburgh Town Council have accepted the tender of Messrs. S. Z. de Ferranti (Limited) for steam alternators, switchboards, and rectifiers, and that of the Silvertown Company for insulated cable, representing together between £4,000 and £5,000.

——— The tender of Messrs. Fletcher and Hirst, of Burnley, has been accepted by the Wolverhampton Corporation for putting the necessary wires and the selected fittings into the Corporation buildings to be lighted electrically, the amount of their tender being £609. The tender for the supply of the pendants has not yet been selected.

SALES BY AUCTION.—We would remind our readers that the sale by Messrs. Fuller, Horsey, Sons and Cassell, of the extensive manufacturing premises in the occupation of Messrs. Latimer Clark, Muirhead and Co., is to take place on Tuesday next at 11:30, and that the plant and machinery will be sold by them on Tuesday, Wednesday, Thursday, and Friday next at 11:30 precisely each day. Some particulars appear in our advertisement columns.

SALE OF PLANT.—Mr. F. D. Leslie, the Receiver and Manager of Messrs. Woodhouse and Rawson United (Limited) announces in our advertisement columns that the whole of the stock now at 88, Queen Victoria-street, E.C., and at Bradford, Glasgow, and Chiswick, consisting of dynamos, motors, electric and steam launches, and every requisite for electric lighting, will be on sale at considerably reduced prices until September 30th.

APPOINTMENT.—Mr. E. G. Jones, late assistant engineer to the St. James and Pall Mall Electric Light Company, has been appointed electrical engineer to the Corporation of Cape Town.

DISSOLUTIONS OF PARTNERSHIP.—Messrs. Sydney Cummins Smith and William Habgood, electrical engineers, Great Missenden, have dissolved partnership; all debts due to and owing by the late firm will be received and paid by Mr. W. Habgood.

——— In reference to the note in our last week's issue respecting the dissolution of the firm of Messrs. Donnison, Parmiter, and Barber, we are requested to state that the business is being carried on as usual at Manchester by Messrs. Parmiter and Barber.

BANKRUPTCIES.—Percy Hector Pitman, trading as P. Pitman and Co., hydraulic, electrical and general engineers, of 3, Park-road, Cheadle, Cheshire, has been adjudicated a bankrupt.

——— A first and final dividend of 3s. 4½d. in the £ in the estate of Selina P. A. Rowbottom, lately trading as S. S. Rowbottom and Co., electrical engineers, at 82, Abbey-street, Derby, is now payable at the Official Receiver's, Derby.

LIQUIDATIONS.—A petition has been presented for the winding up of Martiny (Limited), and is down for hearing at the Royal Courts of Justice, Strand, W.C., on October 24th.

——— The Ries Electric Specialty Company, of Baltimore, U.S.A., has made application for the appointment of a receiver to take charge and close up the business of the Company. Mr. Elias E. Ries, the President, states that this step is necessary, owing chiefly to internal dissensions amongst some of the stockholders; but he intends to shortly reorganise the Company under more favourable auspices.

POSTAL REGULATIONS FOR PRIVATE CARDS.—To-morrow (Saturday) the public will have the privilege of sending through the inland post, as postcards, private cards bearing halfpenny adhesive stamps. These cards must be composed of ordinary cardboard, not thicker than the material used for the official postcard. The form should be similar to that of the present postcard. The minimum size must not be less than 3¼in. by 2¼in., and the maximum size must correspond as nearly as may be to that of the inland postcard now in use. The regulation for the address side of the card is somewhat different to that now existing. Written or printed addresses may be placed on this side, and the words "immediate," "forward," "local," or similar instructions may be added, but no other written or printed matter will be allowed. On the reverse side any written or printed matter may be placed, but no adhesive matter other than a receipt stamp is permitted. The cards must not be folded, except, of course, in the case of reply postcards, to which the above regulations apply.

PERSONAL.—Messrs. G. E. Piggott and Co. desire us to state, in reference to a circular issued by Mr. Applegarth on the subject of a "Register" issued by them, that Mr. Piggott, on severing his connection with Mr. Applegarth, informed that gentleman of his intention of starting in business for himself and issuing a "Register," and that there is, therefore, no question of his having acted unfairly or improperly.

BRITISH EXHIBITS AT INTERNATIONAL EXHIBITIONS.—The British Exhibitors' Association have presented to the Secretary of State for the Home Department a petition containing an energetic protest against the failure on the part of the Department to appoint efficient executive officers at the late World's Fair at Chicago, to which reference is made elsewhere. The signatories point out that to exhibitors at foreign exhibitions, especially when held at a considerable distance from Great Britain, it is above all things necessary that efficient executive officers and assistants should be appointed to devote themselves exclusively to the interest and well-being of the British section, and to be in close touch and sympathy with individual exhibitors. This was most certainly not the case at Chicago. The petitioners also express strongly their opinion that the headquarters of the British section at these exhibitions should be regarded in future as the headquarters for the exhibitors also, who were at Chicago dependent on the generosity of the American authorities even for a room in which to hold their meetings. Owing to the very scanty decoration of the British Section, this was very much less attractive than other portions of the exhibition. This was especially noticeable, as every other nation exhibiting at the Fair were well catered for in this respect; and the petitioners (who represent nearly the whole of the British exhibitors at Chicago) conclude by calling the attention of the Home Secretary to the great importance of the above items to those firms who, at much expense and frequently at considerable inconvenience, participate in these exhibitions in order that British trade may be effectively represented.

CHLORIDE CELLS.—The Chloride Electrical Storage Syndicate (Limited), send us price lists and particulars of their traction (T_B) cells. The circular states that these cells can be employed for either high or low discharge rates, and are suitable for all classes of work where the cells are subjected to vibration.

MESSRS. E. DUCRETET ET L. LEJEUNE.—We have received from Messrs. Ducretet et Lejeune, of Paris, copies of pamphlets describing the electrical instruments manufactured by them. Among these we notice an ingenious system of long-distance thermometers, a recording pyrometer, and an electric meter.

ALLEGED THEFT.—On Monday, at the Glasgow Central Police Court, a man named Edward Morway, described as a Hungarian, was committed for trial for stealing a large quantity of platinum from premises occupied by Sir William Arrol and Co., by whom he was employed as an electrician, and for obtaining £64 from the firm's cashier by false pretences. It was alleged that he had sold the platinum to a Glasgow electrician.

BROMSGROVE.—The adjourned meeting of ratepayers to consider the question of lighting the town by electricity was held in the Town Hall on Thursday, last week, when a resolution in favour of permission being given to Messrs. Hemming and Co., of Birmingham, to erect the necessary plant was carried unanimously. Representatives of the Company were in attendance, and stated that, subject to receiving adequate promises of support, their proposals would be seriously pursued. It was proposed to use both steam and water power, the latter being utilised as much as possible.

BROUGHTY FERRY.—The Northern Electric Supply Company having informed the Police Commissioners of their intention to apply for a Provisional Order, the Borough Gas Committee have consulted an electrical engineer, and made inquiries, with the result that a special meeting was held on Monday to consider the advisability of the Committee applying itself for a Provisional Order. After some discussion the meeting was adjourned until Monday without a conclusion having been arrived at.

CHURCH LIGHTING.—St. Peter's, Eaton-square, S.W., is being installed for the electric light.

CLUB LIGHTING.—The Conservative Club, Glasgow, has entrusted the contract for the whole of the electric light fittings for the installation shortly to be completed, with Messrs. Rashleigh Phipps and Co., of London.

COLCHESTER.—Before coming to a decision as to the establishment of a central electric lighting station, the Lighting Committee of the Town Council have issued a circular to the inhabitants of the district proposed to be so lighted, with a view of ascertaining the probable demand for the current.

DENBIGH.—The Town Council have requested Mr. Vaughan Hughes to supply them with an estimate of the probable cost of lighting Denbigh by electricity, and the Town Clerk has been instructed to obtain what information he can as to municipal lighting generally.

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DUNBLANE.—The Police Commission have decided to oppose any application made for obtaining an Electric Lighting Order, and will themselves apply to the Board of Trade for an Order.

DUNDEE.—The Gas Commission have authorised the extension of the electric light to the police offices.

ECCLES.—The Tramways and Lighting Committee of the Town Council have received a report from Dr. J. Hopkinson on the proposed electric lighting of the main thoroughfares of the borough.

EDINBURGH.—At the last meeting of the Town Council the Cleaning and Lighting Committee recommended that George-street, Charlotte-square, and St. Andrew's-square, and the streets leading from these to Princes-street, should be lighted by electricity; but after some discussion it was decided to wait to see the result of the electric lighting in the streets already agreed upon.

HERTFORD.—The Lighting Committee of the Corporation have drawn up their report recommending that the proposed electric lighting scheme be carried out as speedily as possible; that the engineer be instructed to prepare the detailed plans for carrying out the scheme, and the requisite forms of tender; and that application be made to the Local Government Board for their sanction to a loan of £6,000 for carrying out the scheme.

LEEDS.—The Lamp Committee of the Corporation have appointed a Sub-Committee to consider an offer recently made by the Yorkshire House-to-House Electricity Company to light certain of the streets of Leeds by electricity.

LEICESTER.—The Gas Committee reported at the last meeting of the Town Council that the electricity supply works were proceeding satisfactorily, and it was hoped that they would be able to supply the current by the end of October. The price has been fixed at 6d. per unit.——A special meeting of the Town Council was held on Tuesday evening, when the Finance Committee recommended the creation of £135,000 of Leicester Corporation Three per Cent. Redeemable Stock for the purpose of raising the money for the construction of water and electric lighting works. It was stated that the larger portion of this sum would be required for water purposes, £17,574 being the balance of the amount sanctioned by the Local Government Board to be expended for electric lighting purposes. The report was adopted.

LONDONDERRY.—At a special meeting of the Corporation, held on Friday last, a report was read from Mr. Christie, the resident electrical engineer, detailing a list of occasions on which the electric cables had fused. After a short discussion the meeting was adjourned for a week to enable Mr. Blake, the electrical engineer, under whom the works were constructed, to draw up and submit a report on the subject generally.

NEWCASTLE-ON-TYNE.—The Tramways Committee of the Corporation have received a communication from Messrs. Ledbitter and Harvey, suggesting that an electric tram line be run from the central station to a point opposite the church in Church-street, Walker, which they propose to work on the overhead system. Another tramway scheme discussed at the same meeting was for the putting down of a cable line, but Mr. Eustace Smith pointed out that owing to the section of the line being only about four miles in length, the expenses of a cable line would be prohibitive, as he had estimated the cost of working at 10d. per mile. The Committee, however, favoured the cable scheme, and requested Mr. Smith to consider the matter, and report to a future meeting of the Committee.

NOTTINGHAM.—The new electric light works in Wollaton-street are rapidly approaching completion. The boiler-house, engine-room, and battery department are practically finished, and as the whole of the plant has also been laid down, there is every probability of the installation being completed at an early date.

PONTYPOOL.—The electric light is to be turned on in the new market to-morrow (Saturday). The installation has been supplied by a Bristol firm.

WARMINSTER.—On Tuesday the Local Board had before them a recommendation of the Electric Lighting Committee that the electric light should be extended to the top of Town Hall Hill. Mr. Brown, of Walsall, the electrical engineer, had been consulted on the matter, and had arranged to shortly visit Warminster, and it was decided to adjourn the further consideration of the matter until he had advised as to the suggested extension.

WHITECHAPEL (LONDON).—The District Board of Works for Whitechapel have now under consideration various schemes for lighting the district by electricity. Prof. H. Robinson is advising the Board on the subject. It is intended to follow more or less the policy adopted by St. Pancras in the use of a combined dust destructor and electric lighting station and plant. Several schemes have been submitted by Prof. Robinson, and these are marked A, B, and C. By scheme A it is proposed to give every public lamp in the district a light of about 10 c.p. more than at present. The estimate for an installation for the compulsory area (Whitechapel-road, High-street, Commercial-street, Leman-street, and part of Commercial-road) only was £44,500, and the total annual cost £8,266. There would then be current available for private use of the value of £8,333, at 5d. per unit; and Prof. Robinson, who has surveyed the district, and compared it with his experience of St. Pancras, is of opinion that the demand will soon exceed the supply. The total capital expenditure for this A system would be £72,250, and the annual cost £13,691, with an estimated income from private lighting of £10,433, leaving £3,258 to be charged to public lighting, which now costs about £5,000. Scheme B provides 500 arc lamps, each of 250 c.p., contrasted with 26,000 c.p. by the A scheme. The total outlay under this latter scheme is estimated at £74,750, the annual charge £16,059, and the income at £10,108, leaving £5,951 for public lighting, or an excess of £951 over the present cost. Scheme C provides 300 arc lamps, each of 1,000 c.p. The capital expenditure is estimated at £84,250, the annual cost £16,969, and the income £8,333, raising the sum to be charged to public lighting to £8,636, or £3,636 beyond the present cost. These schemes each include in annual cost the payment of interest and repayment of load in 42 years, and full allowance is also included for depreciation of plant. The Electric Lighting Committee of the Board are in favour of a comprehensive scheme; but are not prepared to recommend either of the three above until their investigations, which are being diligently pursued, are completed. Mr. Thomas Catmur, on behalf of the Committee, submitted the report embodying these schemes to the meeting of the Board on Monday last, and said that it was clear that, if they had electric light, twice or twenty times the amount of light which they had in the district now would be provided; but, of course, they would have to pay an extra cost, and what that extra cost would be was the speculative item in any scheme adopted. The report was favourably received by the Board, although some anxiety was expressed about the dust destructor, lest its efficiency should be in any way impaired by having extra duties to perform. Mr. Catmur, however, assured the meeting that on this point the most careful investigation had been made by the Committee and their expert (Prof. Robinson), and the conclusion arrived at was that the efficiency of the destructor as a destructor would be increased rather than otherwise.

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

August 20, 1894.

15,789. F. W. CROSSLEY and G. ATKINSON. Manchester. Improvements in thermo-dynamic motors.

15,825. H. BROCKLEHURST and H CONSTIEN. London. Improvements in constructing electric cartridges for fog signalling on railways.

15,843. L. BOUDET and PIERRE LACOMBE. London. An improved telegraphic apparatus for transmitting domestic orders or other signals.

15,858. G. CLARET and O. WINTTEUMIER. London. Improvements in permanent ways for electric railway and tramway vehicles.

August 21, 1894.

15,899. SIEMENS BROS. AND CO. (LIMITED). London. Improved means for preventing variations in the regulation of shunt arc lamps for alternating currents. (Messrs. Siemens and Halske, Germany.)*

15,900. SIEMENS BROS. AND CO. (LIMITED). London. Improved means for preventing variations in the regulation of shunt arc lamps for alternating currents. (Messrs. Siemens and Halske, Germany.)*

15,920. G. H. REID. London. Improvements in and connected with primary batteries.

15,921. A. G. NEW and A. G. MAYNE. London. Improvements in the electrical propulsion of boats and vessels.

August 22, 1894.

15,949. G. COCKING. Sheffield. An instrument for acquiring the art of telegraphy.

15,978. A. T. GRABHAM. Leeds. Improvements in electro medical appliances.

15,985. N. H. AKESTER and H. H. PRICE. London. Improvements in or connected with electric arc lamps.

16,000. H. A. HOUSE, H. A. HOUSE, JUN., and ROBERT R. SYMON. London. Improvements in apparatus for refining metal by electrolysis.*

August 23, 1894.

16,105. R. HEATHFIELD and W. S. RAWSON. London. Improvements connected with the electrical deposition of zinc and other metals.

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August 24, 1894.

16,106. A. Ford-Lloyd. London. Improvements in galvanometers.

16,112. F. C. Geary. Burton-on-Trent. An adjustable electric contact, specially designed for safe and strong-room doors.

16,131. W. D. Hawksey and T. M. Lamb. Manchester. Improvements in electric signs and advertisements.

16,145. Cornelius Hessel. London. Improvements in electrolytic processes and apparatus.

16,156. B. Lebrun. London. Improvements in, and relating to, electric winding engines, locomotives, and other electric motors, chiefly designed for use in mines.

16,162. M. Engel. London. Improvements in accumulators or secondary batteries.

16,163. G. H. Essberger and Alexius W. Geyer, both of the firm Union Electricitats Gesellschaft. London. Electrical apparatus for controlling the motion of cranes, travellers and other similar apparatus.

16,191. S. Quincey, P. Benns, and H. Belham. London. Improvements in, or relating to, electric bells and other sounding or indicating devices.

16,192. S. Quincey. London. Improvements in, or relating to, electric bells and other sounding or indicating devices.

August 25, 1894.

16,243. A. H. Brontnell. London. Improvements in the electric propulsion of cars.*

SPECIFICATIONS PUBLISHED.

Note.—All Specifications can now be obtained at the uniform price of 8d. each.

1893.

14,647. Anderson. Working electric tramways.

15,217. Dymond (Thompson). Electric cables.

15,231. Boult (Bureau). Electric arc lamps.

15,486. Mann and Hopwood. Electric switch.

18,602. Abel. (Société Générale des Telephones, Reseaux Téléphoniques et Constructions Electriques.) Telephone switchboards.

18,690. Picking. Conduits for electric conductors.

1894.

8,761. Archibald and Tarry. Electric fire alarms.

12,627. Abernethy and Graham. Switch signal apparatus.

12,875. Kelly and Stanley. Alternating current meter.

COMPANIES' MEETINGS AND REPORTS.

Crompton and Company (Limited).

An extraordinary general meeting of this Company was held on Wednesday, at the offices, Mansion House-buildings, E.C., for the purpose of considering, and if approved, of confirming the following special resolution passed on August 13th :—

"*That the capital of the Company be reduced from £300,000 to £280,000 by cancelling paid-up capital which has been lost, or is unrepresented by available assets, to the extent of £20,000 by cancelling 4,000 Ordinary fully paid-up shares of the Company, numbered 2,785 to 6,784 inclusive, which have been issued.*"

The SECRETARY (Mr. Francis R. Reeves) having read the notice calling the meeting.

The CHAIRMAN (Mr. R. E. Crompton), after reminding the shareholders that the objects of the resolution were fully explained by the Chairman (Viscount Emlyn) at the meeting at which it was passed, formally moved its adoption, which was seconded by Mr. H. C. HAWKINS, and carried unanimously.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "The Electrician" Electrical Trades' Directory and Handbook, 1894, pages 274-300, *&c., &c.*]

BIRMINGHAM STAMPING AND TOOL COMPANY (LIMITED).—This Company was registered on August 22nd, with a capital of £6,000, in £1 shares, to carry on the business of iron, steel and other metal stampers, piercers, spinners, drawers, tool makers, engineers, machinists, &c.

JOSEPH COOPER AND SON (LIMITED).—This Company was registered on August 27th with a capital of £7,500 in £5 shares, to acquire two businesses of tool makers and ironfounders carried on at Birmingham, and to carry on the business of ironfounders, mechanical engineers, tool makers, metal workers, &c.

EXPLOITATION (LIMITED).—This Company was registered on August 24th, with a capital of £1,250, in £5 shares, to acquire, develop, and turn to account patents, inventions, licences, concessions, &c., and to carry on the business of mechanical, civil, marine, electrical, hydraulic and general engineers, patent agents, &c.

FORUM CRUCIBLE SYNDICATE (LIMITED).—Registered August 22nd, with a capital of £1,500, in £5 shares, to carry on business as crucible manufacturers and dealers.

LYNTON AND LYNMOUTH ELECTRIC LIGHT COMPANY (LIMITED).—This Company was registered on August 27th with a capital of £8,000, in 1,000 £5 per Cent. Cumulative Preference and 7,000 Ordinary shares of £1 each, to acquire and take over as a going concern the electric lighting business now carried on at Lynton and Lynmouth by the Lynton and Lynmouth Electric Light Company, and to carry on the business of electricians, electrical and mechanical engineers, suppliers of electricity, and manufacturers of and dealers in electrical apparatus and materials. The subscribers (with one share each) are :—Harry E. Brougham, Charles J. Fox, Charles Geen, J. Hamilton Benn, H. S. Miller, W. T. Longstaff, and Hans H. Benn.

SAYCEE ELECTRICAL SYNDICATE (LIMITED).—This Company was registered on August 22nd, with a capital of £10,000, in £1 shares, to acquire the patent rights No. 14,056 of 1893, in respect of an invention for "Improvements relating to Primary Batteries," also the patent rights No. 21,420 of 1893, in respect of an invention for "Improvements in Primary Batteries," and the patent rights No. 3,674 of 1894, for "Improvements in Primary Batteries and the depolariser used therein," together with the full benefit of the said inventions in Great Britain and Ireland, Hungary, France, Italy, Belgium, Austria, Spain, and Germany. The subscribers (with one share each) are :—Henry Hall, Charles W. Bloomfield, Frederick Chipperfield, Richard Paris, Henry M. Bentley, William H. Rumball, and George M. Gordon.

SPENCER AND CO. (LIMITED).—This Company was registered on August 23rd, with a capital of £12,000, in £10 shares, to carry on the business of mechanical and electrical engineers, iron and brass founders, &c.

ELECTRICAL COMPANY (LIMITED).—The annual return of this Company, made up to August 14th, has been filed. The whole nominal capital of £15,000, in £5 shares, has been taken up, and all issued with £3 per share considered as paid. Upon each of these shares a call of £1 per share has been made.

ELECTRICAL POWER STORAGE COMPANY (LIMITED).—The annual return of this Company, made up to August 2nd, has been filed. The nominal capital of £100,500 is divided into 100 Founders' and 20,000 Ordinary shares of £5 each. 66 Founders' and 18,257 Ordinary shares have been taken up, and 15,120 of the latter class have been issued as fully paid. The full amount has been called on the Founders' shares, and a call of £3 per share has been made on the remaining 3,137 Ordinary shares. The calls paid amount to £9,386. 15s. 7d., leaving £354. 4s. 5d. as yet unpaid. £400 has been paid on 4 Founders' and 400 Ordinary shares which have been forfeited.

ELECTRIC SEMAPHORE SIGNAL SYNDICATE (LIMITED).—A letter from the Secretary states that this Company never proceeded to allotment, and that the only members are the signatories to the Memorandum of Association. Under these circumstances, therefore, it is not proposed to file a return.

ELECTRIC TRACTION COMPANY (LIMITED).—The statutory return of this Company, made up to August 3rd, has been filed. Only 7 shares of £10 each have been taken up out of a nominal capital of £300,000, divided into 29,880 Ordinary shares of £10 each, and 1,200 Deferred shares of £1 each. No calls have as yet been made upon these shares, and the original subscribers are the only shareholders.

EXCHANGE TELEGRAPH COMPANY (LIMITED).—The annual return of this Company, made up to August 15th, has been filed. The nominal capital is £246,250, divided into 8,125 "A" and 16,500 "B" shares of £10 each. Of these all the "A" and 16,200 "B" shares have been taken up, and all the latter have been issued as fully paid; while 2,125 "A" shares have been issued with £8 per share considered as paid. Calls amounting to £9 per share have been made on 6,000 "A" shares, and £1 per share has been called on the 2,125 "A" shares, resulting in the payment of £56,023, leaving £102 in arrears.

CITY NOTES.

CITY AND SOUTH LONDON RAILWAY.—The traffic returns of this Company for the week ended August 26th were £878, as against £719 in the corresponding period of 1893, being an increase of £159. The total receipts for the half-year amount to £6,942, as against £6,647 for the corresponding period of 1893, an increase of £295.

ELECTRIC CONSTRUCTION COMPANY (LIMITED).—Notice is given that the transfer books of this Company will be closed from Aug. 30 to Sept. 13, inclusive.

STOCK EXCHANGE NOTICES.—Application has been made to the Stock Exchange Committee to appoint a special settling day in, and to grant a quotation to the scrip and fully-paid scrip of £1,100,000 Three and a-Half per Cent. Debenture Stock of the National Telephone Company (Limited).

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended August 24th (after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited), were £2,545.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share	Last Dividend.	Name.	Previous Week's Price, Aug. 22.		Price Wednesday, Aug. 29.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Aug. 29. Highest	Lowest
			TELEGRAPHS.					£ s. d.		Highest	Lowest
£1,012,880	Stock	10 0	Anglo-American	40	43	40	43	5 4 8	Jan., Apr., July, Oct.	42	..
£2,933,560	Stock	20 0	Do. Preferred	76	78	76	78	5 15 5	,, ,,	77½	76⅝
£2,933,560	Stock	5/0	Do. Deferred	6¾	7¼	7	7½	..	,, ,,	7½	7⅛
£184,500	100	4%	*African Direct Teleg. 4% Deb. (Reg. & Bearer)	101	104	101	104	3 17 6	January and July	103	..
130,000	£10	3/0	Brazilian Submarine	12½	13	12½	13	5 0 0	Mar., June, Oct., Dec.	13	12 13/16
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1906)	107	111	108	112	4 9 11	June and December	109½	..
10,000,000	$100	$1¾	Commercial Cable Capital Stock	139	143	139	143	4 17 11	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	12½	13½	12½	13½	5 18 6	February and August	..	..
6,000	10	10%	Do. Preference 10 per Cent.	19½	20½	19½	20½	4 17 7	,, ,,	20⅜	..
12,931	5	1/7½	Direct Spanish (£4 paid)	4	4½	4½	5	3 4 0	April and October	..	..
6,000	5	10%	Do. Preference 10 per Cent.	9½	9¾	9½	10	5 0 0	,, ,,	9 11/16	..
£30,000	Stock	4½%	* Do. 4½% Debentures of £50 each	103%	106%	105%	108%	..	..	..	..
60,710	20	2/0	Direct United States Cable, 1877	8½	9½	8½	9½	5 5 3	Jan., Apr., July, Oct.	8¾	..
400,000	10	5/6	Eastern	15⅝	15⅞	15⅝	15⅞	4 1 11	,, ,,	15⅞	15 11/16
70,000	10	6%	Do. 6 per Cent. Preference	16½	17	16½	17	3 10 7	,, ,,	16⅞	16⅝
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	117	120	117	120	3 6 8	May and November	118½	117
£102,100	100	5%	* Do. 5 per Cent. Debentures, 1899	105	109	105	109	4 12 2	February & August	..	..
250,000	10	2/6	Eastern Extension	15¾	15⅞	15¾	16	4 7 6	Jan., Apr., July, Oct.	15 13/16	15⅝
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	115	118	115	118	3 7 10	February & August	..	..
£62,700	100	5%	* Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103	106	103	106	4 15 0	January and July	..	..
£95,100	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb., 1900	103	106	103	106	4 15 0	,, ,,	..	..
£300,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.)	103	106	103	106	3 15 8	February & August	..	..
£200,000	£25	4%	* Do. 4% Mauritius Sub. Debs.	108%	111%	108%	111%	3 12 11	May and November	..	..
180,227	10	3 9	Globe Telegraph and Trust	8⅝	8⅞	8¾	9	5 0 0	Jan., Apr., July, Oct.	8 13/16	8 9/16
180,042	10	6%	Do. 6 per Cent. Preference	15½	16	15½	16	3 15 0	,, ,,	16	15⅝
150,000	10	5 0	Great Northern	20	21	20½	21½	3 10 1	Jan., April, and July	..	..
£190,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	105	108	105	108	4 14 9	March & September	..	..
17,000	25	37/6	Indo-European	45	47	45	47	5 6 5	May and November	45½	45¼
37,548	10	5/0	London Platino-Brazilian	5	7	5	7	..	,, ,,	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	108	111	109	112	5 10 1	March & September	..	..
£100,000	£100	4%	*Pacific European Tel. 4% Guar. Debs. "Red" 1942	102	105	103	106	3 16 9	..	104½	..
11,839	8	4/0	Reuter's	3	5	3	5	..	April and October	..	..
3,381	£100 Cert.	25/0	*Submarine Cables Trust 6 per Cent.	108	113	107	112	5 8 1	,, ,,	108	107½
15,609	10	5/0	West African Telegraph	3	5	3	5	..	January and July	..	..
£249,900	100	5%	* Do. 5 per Cent. Debentures	102	105	102	105	4 17 7	March & September	104	..
30,000	10	2/0	West Coast of America	2½	3	2	3	..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	99	104	100	105	7 14 3	June and December	103	102
88,321	10	9d.	West India and Panama	1	1¼	1	1¼	..	..	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10½	10¾	10½	11	5 9 1	May and November	10 11/16	..
4,669	10	6%	Do. 6 per Cent. 2nd Preference	9	10	9	10	6 0 0	,, ,,	9½	..
£80,000	100	5%	* Do. 5 per Cent. Debentures, 1917	107	110	107	110	4 11 6	June and December	..	..
64,242	15	7/6	Western and Brazilian	6¾	7¼	7	7½	..	May and November	7⅜	..
33,129	7½	7/6	Do. 5 per Cent. Cumulative Preferred	5¾	6¼	6	6½	..	..	6 5/16	6¼
33,129	7½	4/6	Do. 5 per Cent. Deferred	1¾	2¼	2	2½	..	..	2⅛	..
£171,900	100	6%	* Do. 6 per Cent. Debs., Series "A" 1910	105	108	106	109	5 10 7	February & August	..	..
£214,800	100	6%	* Do. 6% Mort. Debs., Series "B" 1910	105	108	106	109	5 10 7	,, ,,	..	..
$1,211,000	$1,000	7%	*Western Union 7% 1st Mort. (Building) Bonds	115	120	115	120	5 17 11	May and November	..	..
£166,900	£100	6%	* Do. 6 per Cent. Sterling Bonds	100	104	100	104	5 18 10	March & September	..	..
			TELEPHONES.								
44,000	5	10/0	Chili Telephone (fully paid)	1	2	1	2	..	..	..	..
224,850	10/0	2⅞d.	Consolidated Telephone Const. & Maintenance	½	½	⅛	¼	..	May and November	⅛	..
171,504	£1	6d.	Oriental Telephone and Electric (fully paid)	½	⅝	½	⅝	..	Yearly	..	..
484,597	5	3/4	National	4⅞	5⅛	4¾	5	5 0 0	June and December	5⅛	4¾
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	14	15	14	15	4 0 0	,, ,,	14½	14½
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	13½	14½	13½	14½	4 2 9	,, ,,	..	..
119,234	5	3/4	Do. 5% Non-Cumulative 3rd Pref.	5½	5¾	5½	5¾	4 6 11	,, ,,	5⅝	..
1,000,000	Stock	4½%	* Do. Debenture Stock, 4½%	108	111	108	111	4 1 8	January and July	..	..
58,000	5	1/0	United River Plate	1	2	1	2	..	,, ,,	..	..
£146,733	Stock	5%	Do. 5 per Cent. Debenture Stock	85	95	85	95	5 5 3	,, ,,	..	..
			ELECTRICITY SUPPLY COMPANIES.								
40,000	£10	..	City of London Electric Lighting (fully paid)	12½	13½	12½	13½	..	..	13 1/16	12⅞
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	14	14½	14	14½	4 2 9	..	14½	14½
19,900	£5	..	Electricity Supply Co. for Spain	..		..		..	..	..	..
£30,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	4½	5½	4½	5½	3 12 7	..	..	..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	..		..		..	..	..	..
8,322	£5	..	House-to-House Electric	..		..		..	..	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	..		..		..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..		..		..	January and July	..	..
45,000	£5	2/6	Liverpool Electric Supply (fully paid)	6⅝	6⅞	6½	6⅞	..	..	..	..
111,000	5	..	London Electric Supply	½	⅝	½	⅝	..	..	..	..
49,900	£10	5/0	Metropolitan Electric Supply (fully paid)	8¼	8¾	8¼	8¾	2 17 2	..	8 11/16	8 7/16
£150,000	Stock	4½%	* Do. 4½% Debs. (Bonds of £10, £20, and £40)	4½	5½ pm	5	7 pm	..	June and December	..	..
6,452	£10	..	Notting Hill Electric	4½	5½	4½	5½	..	..	..	..
19,980	£5	2 0	St. James and Pall Mall	6¾	7¼	7	7½	..	..	7 3/16	7⅛
20,000	£5	7%	Do. 7 per Cent. Preference	8¼	8¾	8¼	8¾	4 0 0	..	8½	8 7/16
59,900	5	2/0	Westminster Electric Supply (fully paid)	6	6½	6¼	6¾	3 6 8	..	6⅝	6⅜
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
90,000	3	1/6	Brush Electrical Engineering	2¾	3	2¾	3	6 0 0	..	3	2⅞
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	2¼	2½	2¼	2½	4 16 0	..	2 7/16	2⅜
£125,000	Stock	4½%	* Do. 4½ per Cent. Debentures	110	113	110	113	4 1 3	March & September	..	..
20,000	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref.	1¾	2¼	1¾	2¼	..	January and July	2	..
12,139	5	..	Edison and Swan United	..		..		..	..	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	..		..		..	..	..	..
120,000	2	..	Electric Construction	½	¾	½	¾	..	..	..	..
12,845	2	..	Do. 7 per Cent Cumulative Pref.	1½	1¾	1½	2	..	..	..	..
91,195	2	10/0	Elmore's Patent Copper Depositing	1	1½	1	1½	..	..	1½	..
20,000	5	..	Fowler-Waring Cables (fully paid)	½	1½	½	1½	..	..	..	..
50,000	10	10/0	India Rubber, Gutta Percha, &c., Works	23	24	23	24	5 4 2	February & August	23¾	23½
£200,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	103	105	103	105	4 6 2	March & September	..	..
15,995	£10	6/4	International Okonite Ordinary	..		..		..	..	..	..
16,000	£10	..	Do. 8 per Cent. Preference	..		..		..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid)	—	¼	—	¼	..	..	..	..
78,949	5	3/6	Swan United (£3 10s. paid)	..		..		..	May and November	..	..
37,350	12	12/0	Telegraph Construction and Maintenance	40	42	40	42	5 14 3	March and July	42	41½
£150,000	100	5%	Do. 5 per Cent. Bonds	102	105	102	105	4 13 6	January and July	..	..
37,514	£5	..	Woodhouse and Rawson Ordinary (£3 15s. paid)	..		..		..	..	..	..
41,098	£5	..	Do. Preference (fully paid)	..		..		..	..	..	..
£63,570	10	10/0	W. T. Henley's Telegraph Works Ordinary	7	8	7½	8	6 5 0	..	..	..
£30,000	10	..	Do. Preference	..		..		..	..	..	..
			RAILWAYS AND TRAMWAYS.								
£630,000	Stock	1%	City and South London Railway	36	38	36	38	1 16 2	May and November	37¼	..
7,000	10	5%	Do. 5% Perpetual Preference	12½	13	12½	13½	3 14 1	May and November	13½	..
£67,130	Stock	4%	Do. 4% Perpetual Debenture	121	123	121	123	3 5 1	..	..	..
37,500	£10	1%	Liverpool Overhead Railway	7 13/16	7 15/16	7 13/16	7 15/16	1 4 5	..	..	..
6,295	10	5%	Do. 5% Preference	12¾	13	12¾	13	3 16 11	..	..	..
£125,000	Stock	4%	Do. 4% Debenture	111	113	111	113	3 10 10	January and July	..	..

* In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption.

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THE ELECTRICIAN:

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NOTES.

The wide and unique experience of Dr. Fleming in the manufacture and characteristics of glow lamps enables him to write on many points connected with the use of lamps with greater authority than, perhaps, anyone else in this country. The extract from his Royal Institution lectures, which we print this week, deals with the important question of efficiencies. Dr. Fleming carefully distinguishes between luminous efficiency, or the proportion of "eye-effecting radiation" to the total radiation, watts per candle-power of a new lamp, total watts per total candle-power over the whole life, and over the useful life. The reciprocal of watts per candle, the most popular idea of efficiency of a lamp, was at one time called the "strain" by Dr. Fleming, and is measured in decimals of a candle-power per watt, or candle-power per kilowatt or horse-power. The use of this reciprocal has been advocated by Mr. Swinburne and others; but the watts per candle seems likely to remain in common use. There is no end to the elaborate tests and experiments which may be made with lamps; but Dr. Fleming, in this portion of his lectures, discusses those only which bear on the value of the lamp to the user. The average consumer cannot be expected to study the relations between volts, candle-power, and life, to say nothing of resistance, and watts per candle, and load-factors; but there are a few practical considerations which electrical engineers can bring to his notice, both in the selection and in the use of lamps. Dr. Fleming qualifies the paradoxical "smashing point" in a very practical way, and he unhesitatingly asserts that no hard and fast comparison between the cost of electric lighting and of gas lighting is possible.

The mode adopted by Mr. T. Parker for calculating the power required for the service of the Liverpool Overhead Railway is of some interest, and the results which are described in his Paper, which we print this week, show that the expectations thus formed, were fully justified. We do not propose to revive the rope-driving *v.* direct-driving controversy here, and would only observe that it was a great pity that dynamos of such high commercial efficiency should be driven by ropes. The Eickemeyer system of armature winding, which has been used in building the motors, is undoubtedly a good one; but Mr. Parker rather implies that much of the success of the work is due to it. The chief points of this winding seems to be the good mechanical method of forming the coils instead of winding them, the neat way of putting them together, and the ease with which this operation can be reversed, thus detaching any injured coil. As far as standing the stresses of actual running is concerned, there are other windings which we think would be as good; and, fortunately, the work in this case has been so satisfactory that freedom from breakdown has not called the detachable feature into use.

Among a few of the illustrations in Mr. Parker's Paper, which we have not reproduced, are the indicator diagrams of the steam engines. We alluded some time ago, in connection with a lecture by Prof. Kennedy, to the way in which indicator diagrams are used and misused, and observed that while they are of the utmost importance to the engineer who makes the test, they are, as a rule, of very little use as illustrations to the report on the test. There can be no doubt that in this case some serious error or errors have crept in, and it seems nobody's business to discover them. Mr. Parker did not make the tests, but has simply published them. Mr. Greathead assumes no responsibility for them. He does not agree with us that the results are too good to be true. Some light is thrown on them in the discussion on the two Papers, which we intend to reprint. Fortunately—very fortunately—these efficiency tests do not in any way affect the cost of working, which is, after all, the most important feature of the work. The Railway Company soon found after carefully watching the outlay, and noticing that the trains were running with perfect regularity and without breakdown, that the contractors were making money out of the contract for running the line at 4d. per train mile; and accordingly they terminated the arrangement, and at once effected a considerable saving. Many a contract of this kind for electric traction has been made, but we know of no previous instance of a voluntary termination resulting in a saving to the proprietors, and it is this which stamps the Liverpool Overhead Railway as a thorough success.

We print this week the second half of the Paper by Rössler and Wedding on alternate-current arcs. It is, perhaps, somewhat unfortunate that an attempt has been made by means of a reflector to imitate the distribution of candle-power of a continuous-current arc. Curves similar to those which we reproduce from the magnificent book issued by the Helios Company would be more instructive, though the photometric work would be more than doubled. The photometrical results are considerably inferior to those of continuous-current arcs, and part of this deficiency must be

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attributed to the use of the reflector. The alternate-current arc has its uses where light is wanted above as well as below, and it seems better to measure it under these favourable conditions. A good deal yet remains to be written about alternate-current arcs, and no doubt much remains to be investigated. While it seems clear that a flat-topped current curve gives most light, the hum which such a current produces is, quite possibly, principally the fault of the lamp. Nothing is said in this Paper about the cause of or cure for the violet band which encircles the globe of most alternate-current arcs, and but little information is given about the lag of phase or its cause, or how a lamp may be made to run off a machine for which it has not been adjusted. The Hefner unit employed in these photometric measurements is the amyl-acetate lamp, and is about 0·98 of an English candle-power.

A proposal to revive an abandoned electrical unit may seem strange, but we none the less think that there is room for the volt-ampere under certain conditions. In the tests of Helios arc lamps, which will be found in another column, no attention has been paid to the small lag between volts and current, which is produced by an arc. The elaborate tests of Rössler and Wedding take this displacement of phase into account, and in the portion of their Paper which we printed last week, it was given at about one-eighteenth of a half-period. Where the lag is neglected, the product of volts and amperes might be called volt-amperes as of old, and thus be distinguished from true watts. We have adopted this expression in our reprint of the Helios tests.

It would be decidedly instructive if one could ascertain the exact amount of influence which the diminutive premiums annually offered by the Société d'Encouragement pour l'Industrie Nationale actually have on the industrial development of France. The Grand Médaille à l'Effigie d'Ampère, which this same Society recently presented to Lord Kelvin in recognition of his life's labours, may very possibly encourage others to deserve a similar reward. But the premiums of the Société d'Encouragement appear to be quite distinct from its medals; the latter are, apparently, meant to be honorary recognitions of scientific work of great ultimate or immediate utility; the former are evidently intended to stimulate invention. Inventors, it is true, are, like the rest of mankind, stimulated by nothing so effectually as by hard cash; but what useful purpose can be served in offering a few thousand francs for the "complete solution" of problems, the complete solution of which would any time these last 10 years have made the fortunate solver rich beyond the dreams of avarice?

In the list of premiums offered by the Société d'Encouragement for the years 1895-96, we note, firstly, one of £80 for the "complete solution" of the problem of economically producing ozone on a commercial scale. Now, if ozone possesses one half the advantages claimed for it as a bleaching and disinfecting agent, an £80 stimulant is quite superfluous. Similar amounts are to be presented to any gentleman who can devise a method of rapidly measuring the insulation of an electric supply network, or who can invent a 1-candle, 100-volt, 5-watt glow lamp. The *pièce de résistance*, however, is the premium of £120 offered to the individual who by scientific chemical synthesis, by the method of empirical messes, by burrowing into the bowels of the earth, or by any other means whatsoever, discovers—a substitute for gutta-percha. We have no desire to raise undue hopes, but if the individual who solves *this* problem completely will approach, say, the Telegraph Construction and Maintenance Company, we venture to think that that £120 premium will vanish from the inventor's mind, if ever it were present there.

The announcement made by the *Western Electrician* that there is a possibility of the National Electric Light Association and the American Street Railway Association being before long combined, may be taken as a sign of the predominant position which the electric tramway business has assumed in the States. The National Electric Light Association is, it has always seemed to us, an organisation which might be reproduced with advantage in this country, since it is such a happy medium between the ultra-commerciality of the Electrical Trades' Section and the severe science of the Institution of Electrical Engineers. The probability of such an organisation being formed in England is, however, somewhat remote, and were anything of the kind brought into being, we are afraid it would have to hold its "conventions" with closed doors, as is the case in America, notwithstanding the plaintive wail of the technical journals, with the Association of Edison Illuminating Companies. If the general public, for instance, were allowed to become familiar with all the practical details of alternate-current distribution, all the mystery, and, therefore, half the attractiveness of that system would be gone.

There was some ambiguity in part of our article on "The Sine-Curve Controversy" last week. We contend, with Mr. Steinmetz, that the flat-topped curve of magnetism is better than the sine curve. This means a peaked curve of volts. Our American friends, on whose side Prof. H. J. Ryan places himself, prefer the sine curve. When they speak of a sine curve of volts they assume, of course, a sine curve of magnetism also.

Hampstead.—October 1st has been fixed as the date for the public "inauguration" of the electric light at Hampstead.

Cable Interruption:

	Date of Interruption.
Zanzibar-Mombasa	September 4th.

The Late Werner Siemens.—The monument to the late Werner Siemens is to be erected at the corner of the Markgrafen and the Lindenstrasse in Berlin.

The Royal College of Science, Dublin.—The autumn session of this college commences on October 1st. Courses of instruction in the sciences applicable to the industrial arts are provided. Further particulars with regard to fees, &c., will be in our advertisement columns.

Long Distance Telephony in Servia.—A telephone line has just been completed between Belgrade and Nisch. The line is 125 miles long. It is only intended for use between the Government authorities in Belgrade and the King, whose residence is at Nisch.

Telephonic Development in New England.—Great activity among the local telephone exchanges is reported from New England. A great number of the systems are being entirely

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rebuilt, with new and heavy poles, new wire, and improved construction generally, while the number of trunk-lines between the principal business points is being largely increased.

Obituary.—The death is recorded of Mr. Charles Wood, Chief of the Mechanical Engineering Department at the Silvertown Works. Mr. Wood was only 55 years of age, but had done 23 years' useful work for the Silvertown Company. Whilst at Silvertown Mr. Wood was largely responsible for the construction of the Company's cable machinery and electric lighting machines.

The Budapest Electric Motor Exhibition.—The Exhibition of electrically-driven machine tools, which we announced some months ago as about to be held at Budapest, has resulted in the getting together of 32 alternate-current motors and 42 continuous-current motors driving printing-presses, saws, ventilating fans, sewing machines, and ice-making machines, as well as drills and lathes.

Exports of Telegraph Wire and Apparatus.—During July the value of these exports reached a total of no less than £303,483, exports during the corresponding months of 1893 and 1892 being, respectively, £77,305 and £25,906. The following figures show the exports during the first seven months of this year as compared with similar periods in 1893 and 1892:—1894, £1,187,224; 1893, £556,500; 1892, £701,741.

The Electric Light in Japan.—According to a correspondent of the *Engineer*, electric lighting is progressing fairly rapidly in Japan, and two new plants have recently been put down—one at Okayama, and one at Maebashi, the former having a steam plant, and the latter a water-wheel. Both these places are now important towns, and the authorities, in adopting the electric light, have only followed an example set by other towns of the same standing.

The American Post Office and Electric Tramcars.—The two new postal trolley cars for Brooklyn, whose trial trips took place recently, will, says the *Electrical Engineer* of New York, greatly facilitate the free mail deliveries in the suburbs recently annexed to Brooklyn. The mail bags will be received from the stations through an open window on each side of the car and deposited in the same manner. The cars are both lighted and heated by electricity.

A Brave Telegraphist.—Among the acts of heroism reported by the newspapers in connection with the American forest fires is that of a young telegraph operator named Thomas Dunn, who stood by his instrument, although the flames were fast surrounding him, in order to despatch a message ordering a train to proceed to Hinckley to convey 300 persons to a place of safety. He got his message through, and the people were saved, but he himself perished.

City and Guilds Programme.—Messrs. Whittaker and Co., of Paternoster-square, have just issued a programme of technological examinations of the City and Guilds of London Institute for the session 1894-95. The programme contains regulations for the registration and inspection of classes in technology and manual training, a syllabus of subjects, a list of prizes for 1895, a list of teachers of the registered classes, and the examination questions for 1894.

Asbestos.—It appears that, owing to the presence of impurities, certain kinds of asbestos possess marked magnetic qualities. Mr. A. A. Campbell Swinton writes to say that not only can asbestos millboard be lifted by a strong magnet, but the individual fibres of soft asbestos packing are affected. He finds it possible to permanently magnetise a piece of asbestos millboard. It is clear, therefore, that this material is not suitable for use in connection with delicate instruments.

Heriot-Watt College, Edinburgh.—It is announced that the session 1894-95 extends from Tuesday, October 9th next, to Friday, May 31, 1895. The classes are suitable for students who have previously passed through the curriculum of a secondary school, and include physics and chemistry, mechanical engineering, and electrical engineering. A calendar giving full particulars may be obtained from the librarian at the college, or from the treasurer, 20, York-place, Edinburgh.

Aberdeen.—The municipal electric light accounts, which have just been issued, show a net loss for the period dealt with (eight months) of £292. The total capital expenditure comes out at £21,061. The working expenses for the eight months under review amounted to £289, the revenue coming short of this by £52. The total quantity of electricity generated was 9,833 units, of which 1,589 was used by public lighting, 6,581 by private consumers, and 261 in the works, leaving 1,402 units, or 14 per cent., unaccounted for.

Scottish Scientists and American Reviewers.—Transatlantic reviews of technical books have until very recently always been cast in a uniformly eulogistic mould, but we do not recollect having ever before seen quite so complete an abnegation of his function as is evinced by the reviewer in the following:—"In treating of a work like this, criticism would be out of place, and the reviewer will have done his work if he conveys to the mind of the reader a correct idea of the scope of the book. This can best be done by repeating the table of contents." The work which is here considered beyond criticism is Vol. II. of Lord Kelvin's "Popular Lectures and Addresses."

Lightning Conductors.—An evening newspaper, given to answering all manner of absurd questions in an appropriately absurd manner, recently addressed the following reply to an inquiry *re* the efficacy of lightning conductors:—"The efficiency or otherwise of lightning conductors is scarcely a matter which comes within the range of the subjects ordinarily dealt with in this column under the head of 'Money Matters,' and we do not claim to have any special qualification for expressing an opinion. Take it for what it is worth, our impression is that lightning conductors properly fixed and properly dealt with, when carried into the earth, are not 'a source more of danger than safety.' If improperly fixed they may certainly be a source of great danger."

Terrestrial Magnetism.—At a recent meeting of the Vienna Academy of Science Herr J. Liznar read a Paper on the 26-day period of the earth's magnetism. In a previous communication the author had compared the diurnal variation at stations in middle and high latitudes. In the present Paper the magnitude of the 26-day period variation for declination and inclination at the stations of Pulowsk and Jan Mayen were compared, and it was shown that the amplitude of the variation at the northern station is four times as great as at the southern. The author also considers that the small variations which constitute the 26-day period variation are not due to a direct magnetic action of the sun, but that they must have their origin in some secondary action of the same.

Magnetic Nomenclature.—In advocating the use of iron wire on the armatures of small dynamos, an esteemed New York contemporary is enabled to pen the following convincing sentence, which should be read and re-read by all who wish to be abreast of the very latest nomenclature developments:—"It is certain that the winding of an armature with iron wire will materially reduce the reluctance of the gaps, and, therefore, will economise in exciting power, for two reasons: First, directly, by lessening the total reluctance of the magnetic circuit, of which the air gap is the most prominent portion; and, second, indirectly, by reducing the magnetic leakage of the machine, which is the quotient of the sum of the permeances of the stray paths by the permeance of the useful path, the latter being practically equal to the reciprocal of the reluctance of the gap spaces."

The Future of the Oil Engine—The *Engineer* is of the opinion that we are probably destined to see in a comparatively short time a great development in the construction and use of the oil engine, and the rapid progress of the past year or so warrants the belief that another year will witness equally great strides. The oil engine offers so many advantages for small powers and for portable and traction purposes, that even an increase in the price of oil will not much decrease its rapidly extending application. The fact that it needs no boiler, no fire, no gas holders, and very little water, and that its fuel can be bought everywhere, must make it the future motor for very many purposes, not excepting launches. The objections with respect to smell will gradually pass away with the improvements which will make the engine as clean as a corporation water works pumping engine, and as free from offensive smell.

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The Indo-Chinese Land Line.—For some time, says the *Pioneer*, negotiations have been in progress with China to secure the linking-up of the telegraph lines which have their termini in the Bhamo district and Yun-nan respectively. The Indian system has approached within a few miles of the extreme western frontier of China, while the Chinese wires have been carried well into Yun-nan. There is probably a gap of less than two hundred miles between the stations, and this could be bridged over in a few months if the Pekin Government and the Foreign Office came to an agreement on the point. Then there would be overland communication between India and China, and the cost of telegraph messages between the two countries would be considerably reduced. Both from a commercial and a political point of view it is most desirable that this through line should be completed ; but there is likely to be further delay now that China has her hands full with the war in the Corea.

Gas-Motor Cars in Chicago.—According to Mr. Roach, superintendent of the North Chicago Street Railway Company, gas-engine cars have there been found impracticable for street railway service. Speaking of his company's experience, Mr. Roach said: "Gas engines are all right in theory, but they are away behind the times. Our Company has spent $75,000 in buying, building, and improving gas motors, all to no purpose. It now has gas motors to sell. They made too much noise. The link-belt machinery and the exhaust of the engine was too much for even the Chicago public. So we took the motors off of the cross lines, where we were using them, and employed horses again." The Company's experience with steam motors was equally unsatisfactory, and finally it was determined to discontinue experiments in this line. Several types of storage batteries were also tried, but these were not adapted to the heavy business of the lines. The Company is at present wedded to the cable and horse systems.

Prof. von Helmholtz.—The following paragraph, which appeared in the *National Zeitung* of Friday last, and which we have good reason for believing to be absolutely correct, will reassure all those who have heard with concern of the recent severe illness of Prof. von Helmholtz :—To-day Hermann von Helmholtz completes his 73rd year. But the rejoicing natural on such an occasion will be sadly diminished owing to the severe illness which has struck down the aged *savant*. However, already the worst fears of the first weeks may be dismissed, for the general condition of the patient has of late so far improved that he once more follows with lively interest the progress of the work of the Physical-Technical Institute, over which he presides. The paralytic symptoms also have so far disappeared that remedial measures have been begun under the skilful superintendence of Prof. Renvers and Dr. Kirchhoff. There are good grounds for hoping that Herr von Helmholtz will before long resume his place as active head of the Reichsanstalt. May this anticipation be fulfilled, and his powers remain at the disposal of science for a long time yet.

High Speed v. Slow Speed Engines.—In a Paper recently read before the Iron and Steel Institute, Mr. D. Selby-Bigge gives some interesting figures relating to the performances of a 500-H.P. slow-speed horizontal compound condensing Van der Kerchove and a 300-H.P. Willans engine. The former runs at 66 revolutions, and drives direct on to a 20-pole fly-wheel Pieper continuous-current dynamo ; the latter runs at 350 revolutions, and is also coupled direct to a Pieper dynamo ; both combinations are at work at the National Arms Factory at Herstal, near Liége. The efficiency of the Van der Kerchove combination at full load is about 77 per cent., the dry steam consumption of the engine per I.H.P. per hour = 14·34lb., and the dry steam consumption of the engine per E.H.P. per hour = 18·75lb. On the other hand, the highest efficiency is got from the quick running plant. The efficiency of the Willans engine and the Pieper dynamo combined at full load is about 85 per cent., the dry steam consumption per I.H.P. per hour = 15·41b., and the dry steam consumption per E.H.P. per hour = 18·19lb.

Electroplating on a Large Scale.—Perhaps the largest piece of electroplating ever carried out is that which is being done in regard to the protection from rust of the iron and steel structure of the tower of the new City Hall of Philadelphia, now in process of erection and nearly completed. This work is being carried out by the Tacony Iron and Metal Company. It is a double process ; the object of the first stage being the protection of the metal from rust by electroplating it with copper to a weight of 14oz. per square foot of surface, and the finish being an electroplate coat of an alloy of aluminium and tin weighing 2½oz. per square foot—the purpose of this being to give colour, and also to prevent oxidation of the copper into a green skin of verdigris. The plan was adopted in preference to paint, on the score that the periodical renewals of the latter would cost £2,000 per annum. The total weight of wrought and cast iron to be protected is about 500 tons, extending to 100,000 square feet of surface. This process is, in effect, an attempt to remove the reproach of perishableness from structural iron and steel, and to make these materials last for ever without further protectionary measures of any kind.

Solar Electrical Energy.—According to Dr. M. A. Veeder (*Proceedings* of the Rochester Academy of Sciences, Vol. II., July, 1894), there is conclusive evidence that magnetic perturbations are not of thermo-electric origin, and are not connected with heat and light radiations. He holds, in short, says *Nature*, that there is no correspondence whatever between the behaviour of magnetic storms and the manner in which thermal and luminous radiations are originated and propagated from the sun to the earth. His idea is that electrical disturbances upon the sun are transmitted to the earth not by radiation but by conduction through the impalpable dust and *débris* with which interplanetary space is filled. Such meteoritic particles are composed of good conducting material, and an examination of a large number of meteorites has shown Dr. Veeder that they all possess magnetic properties which might have been produced by long-continued induction. Therefore he thinks that the origin of magnetic storms is as follows :—"Particular portions of the sun's surface and cooler immediate surroundings are electrified by what has every mark of being volcanic action. The motion of rotation of the sun carrying forward these charged portions of its surface, develops currents dynamically which act inductively along lines of force wherever there is conducting material within their scope. There is no conveyance by radiation or in a manner similar to that in which heat and light are conveyed from the sun. The laws governing the process are entirely different from those of radiation, and have reference to the principles of conduction as they appear under the conditions existing in interplanetary space. It is a mode of solar action that is distinct, and that must be considered by itself."

A War Balloon Struck by Lightning.—An alarming accident, happily not attended with fatal results, occurred on Wednesday afternoon at the Aldershot School of Military Ballooning. A new balloon, larger than any of its predecessors, was to have been "christened" by the Duchess of Connaught. This balloon had been inflated during the morning, and stood ready. It had been arranged that the Duchess was to cut the rope retaining the balloon, and that Lieut. Baden-Powell, of the Scots Guards, and two sergeants of Royal Engineers were to make a free ascent. The "Flo," the smallest military balloon, containing 4,700 cubic ft. of gas, was also inflated and bore a large Royal Standard. As soon as the Duke and Duchess of Connaught and staff arrived on the ground, this smaller balloon was sent up captive as a Royal salute. Lieut. Blakeney had intended to ascend in it ; but, as at this moment a strong wind arose, it was decided to send up the balloon without anyone in the car. As the rain began to descend more heavily the party repaired to the storehouse, and very shortly afterwards the accident happened. The balloon was held by a wire cable about 200ft. long, fixed to the drum on the balloon waggon. Suddenly it was seen to be struck by lightning, flare up and collapse. Loud shouts from the sappers forming the detachment at the waggon attracted attention, when it was seen that three of them were rolling on the ground, apparently in intense pain. It seems that the men were about to haul the balloon down by winding on the winch, the handles of which are covered with brass, when suddenly all who had hold of the winch were struck down. Every assistance was immediately rendered to the injured men. It was soon seen that, though evidently in great agony, none of the sufferers were very seriously injured.

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THE EFFICIENCIES OF GLOW-LAMPS.

An electric glow lamp is a machine for transforming energy from one form, viz., the energy of an electric current, into another form, viz., eye-affecting radiation. As explained in my first Lecture, it transforms the electric energy into radiant energy, or energy of ether waves, only a fraction of which can impress the eye as light. This fraction varies from 3 to 7 per cent. This numerical expression for the "luminous efficiency" can be determined by suitable experiments in which the relative amounts of luminous and dark heat sent out by a glow lamp are separately measured. If a glow lamp **L** (*see* Fig. 1) is immersed in water in a transparent vessel **V** the water absorbs or stops nearly all the dark or non-luminous radiation, but permits a large fraction of the luminous radiation or light to pass out. By photometering the lamp both when in and when out of the water the fraction of the luminous radiation which is absorbed can be determined. By measuring the rise of temperature of the water which is created by the absorption of the radiation, both when the luminous radiation is allowed to pass out and when it is wholly stopped by blackening the lamp, we can determine the ratio between the amount of the radiation which affects the eye as light and that which cannot affect it at all. A well-devised series of experiments of this kind have been carried out by Mr. E. Merritt, at Cornell University, U.S.A. The result has been to show that, on an average, about 5 per cent. of the energy supplied to the

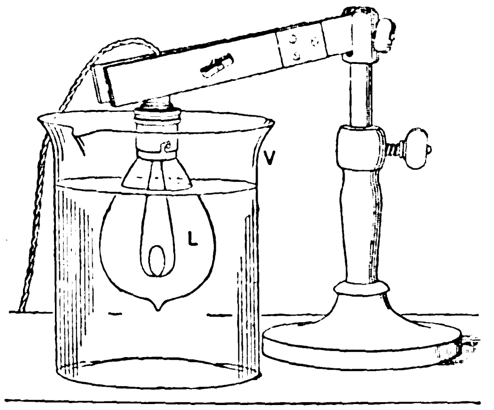

Fig. 1.—Glow Lamp Burning under Water.

glow lamp as ordinarily used is utilized to make light, and the other 95 per cent. is non-effective as far as the eye is concerned. Hence, if a glow lamp is supplied with 60 watts and gives 16 candles light, only 3 watts are really transformed into light, and the mechanical value of the light so produced is rather less than a quarter of a watt per candle.

This luminous efficiency varies with the temperature of the filament. At a low red heat it is not more than 1 per cent., but increases to about 5, 6, or 7 per cent. at the normal working temperature. Thus, for an Edison 16-c.p. lamp Mr. Merritt found the following figures when the lamp was worked at various pressures so as to give different candle-power.

It will be seen that the luminous efficiency increases as the "watts per candle-power" decreases—that is, as the temperature of the filament increases.

The "luminous efficiency" must be carefully distinguished from that which is sometimes called "the efficiency" of the lamp, and which is the reciprocal of the watts per candle or the number of candles light yielded per horse-power or per watt expended in the filament.

It will be convenient for me at this stage to enter a little more fully into the changes that go on in an incandescent electric lamp during its life. We have pointed out above the causes which are at work to change the surface and ultimately to destroy the carbon filament. These causes com-

Luminous Efficiency of a 16-c.p. Edison Glow Lamp.

Working volts.	Candle-power.	Power absorbed in watts.	Watts per candle-power.	Luminous radiation in watts.	Luminous efficiency as a percentage.
74·2	0·9	34·6	38·0	0·18	0·5 per cent.
91·6	4 8	56·2	12·0	0·68	1·2 ,,
97·3	7·3	64·6	9·0	1·13	1·7 ,,
100·3	8·9	69·3	7·8	1·62	2·3 ,,
107·6	14·6	81·6	5·6	2·97	3·6 ,,
109·3	16·3	84·4	5·2	4·57	5·4 ,,
124·1	38·2	115·4	3·0	7·46	6·5 ,,

mence to act from the very moment when the lamp begins to be used. If a carbon filament electric glow lamp is placed upon a circuit of perfectly constant pressure, and if the constants of the lamp—namely, the candle-power, the current, the resistance of the filament, the power taken up in watts, and the watts per candle-power—are measured at intervals, say of every 100 hours, it will be found that the changes which go

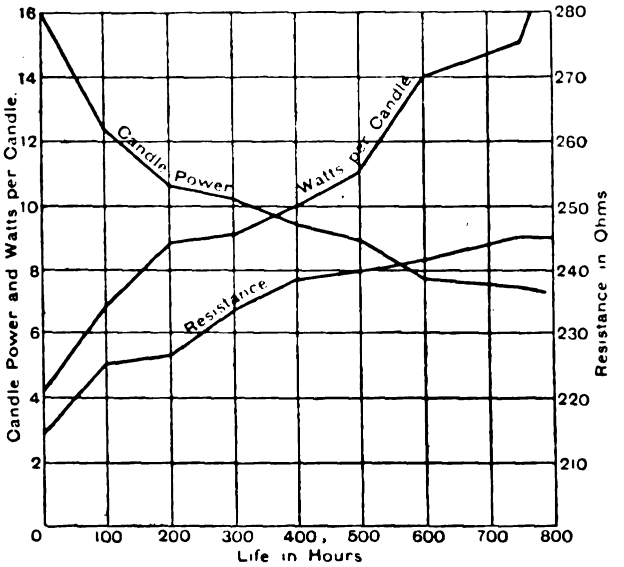

Fig. 2.—Curves showing the increasing resistance and diminishing candle-power of a Glow Lamp during its life.

on in the lamp are somewhat as follows:—During the life of the lamp there is a progressive rise in resistance, a progressive diminution in candle-power, and a progressive increase in watts per candle-power. An illustration of these changes is diagrammatically shown for certain forms of ordinary vacuum lamps by the curves given in Fig. 2. These curves are deduced,* not from observations on one lamp alone, but from the average of a large number. If, instead of working the lamp at its marked volts or normal pressure, we raise the voltage, say, 10 per cent. above the normal, changes of the same character take place, only they are very much accelerated, and the result for a collection of lamps worked at 10 per cent. above the normal pressure is given in Fig. 3. On the other hand, if we desire to keep the candle-power always constant, we have to continually raise the pressure, and at the same time we are increasing the watts per candle and the resistance of the lamp. These progressive changes are illustrated in the two curves in Figs. 4 and 5, in the first of which a 16-c.p. lamp was worked at continually-increasing pressures sufficient to keep the candle-power always constant, and in the second of which the candle-power was raised to four times its normal value and kept constant.

The value of a lamp to a user is not to be measured merely by the watts per candle-power it takes at the commencement of its life, but also, to a large degree, by the extent to which this consumption of energy and production of light remains

* From a forthcoming work on "Electric Lamps and Electric Lighting," by Dr. J. A. Fleming, to be published by *The Electrician* Printing and Publishing Company. All rights in text and illustrations are reserved.

* These curves are borrowed from a very instructive Paper by Prof. Nichols, of Cornell University, U.S.A., on "The Artificial Light of the Future."

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constant during the life of the lamp. This is best expressed by the percentage of the variation of the candle-power during the life of the lamp when taken at equal intervals of time. A 16-c.p. glow lamp, taking say 60 watts at the commencement of its life, but which after two or three hundred hours in use is giving no more than 8 candles light, although taking the same power, is costing the consumer twice as much per candle at the end of this time as at the beginning. Some

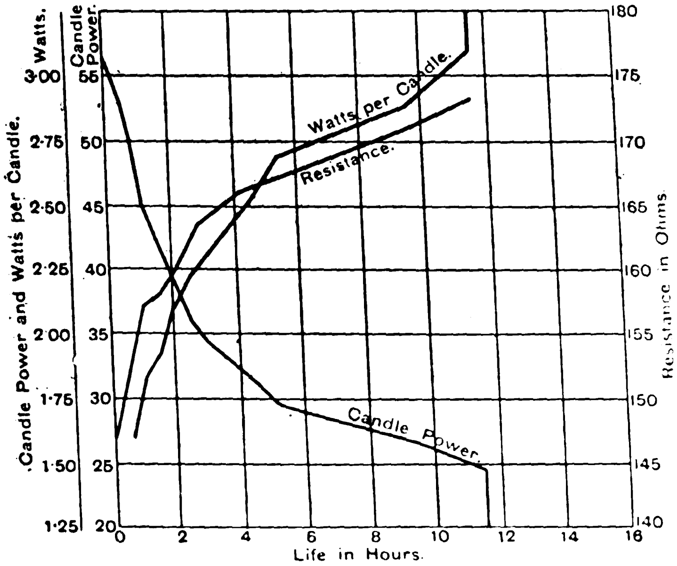

FIG. 3.—Curves showing the rapid decrease in candle-power and increase in resistance in a Glow Lamp worked at 10 per cent. above its normal pressure.

writers have, therefore, suggested that at the end of a certain period, when the candle-power has suffered a definite diminution in value, say, of more than 30 per cent., the lamp should be "smashed," and a new lamp put in its place. This, however, is not always advisable or necessary. If the lamp in the position in which it is being used is giving light enough for the purpose for which it is required, then, although its candle-power may be diminished, if the total

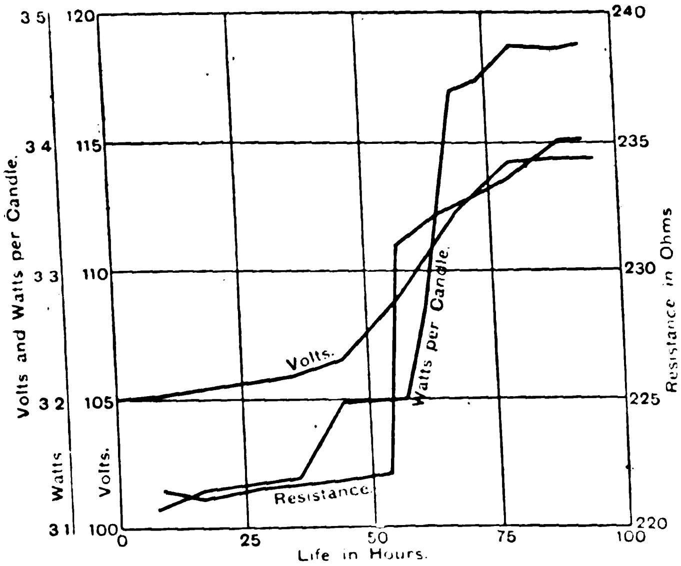

FIG. 4.—Curves showing the increase in Voltage required to keep the candle-power of a Glow Lamp constant.

power taken by the lamp is diminished also, the total sum which is being paid by the consumer for the energy supplied to that lamp is on the whole diminished, and therefore the lamp is costing the consumer less *on the whole* to maintain in action than a new lamp would do if it replaced the old one, although at the same time the cost of the lamp per candle-light may be considerably increased. Generally speaking, users of electric glow lamps have an idea that the lamp which lasts the longest is necessarily the best. From what has been stated above, it will be seen that it is not merely long life, but constancy of candle-power, combined with high luminous efficiency and low cost, which are really the factors determining the value of the lamp to the consumer. The duration of the lamp is intimately connected, apart from accidents, with the temperature at which the carbon filament is maintained, and this is determined by the watts per candle-power being expended in the lamp. Makers of glow lamps sometimes make statements which lead the uninitiated to believe that there is a certain "efficiency" or peculiarly low value of the watts per candle-power belonging especially to a certain make of lamp. It should be, however, clearly understood that any glow lamp may be worked at values of the watts per candle-power varying over very wide limits, but experience has shown that carbon filaments, as at present made, cannot be worked at temperatures higher than those corresponding to about 2 to 2½ watts per candle-power without very rapidly being destroyed.

A number of tests have been made by Messrs. Siemens and Halske on lamps of various types, and in which groups of these lamps were worked at different watts per candle-power from 2 to 4 and upwards. The lamps were measured at intervals of 100 hours, and the diminution in the observed

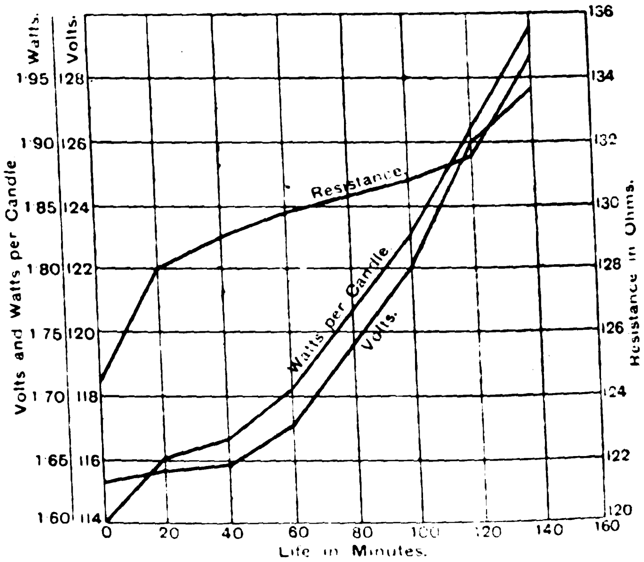

FIG. 5.—Curves showing the increasing Voltage necessary to keep the candle-power of a Glow Lamp constant and equal to four times its normal amount.

candle-power expressed as a percentage of the original candle-power was laid down in the form of curves. The results of these tests seemed to show that, on the whole, lamps worked at from 3 to 3½ watts per candle-power had a greater average constancy in candle-power than those worked at a lower number of watts per candle-power. That is to say, if we take a 16-c.p. glow lamp and work its filament at such a temperature that it is taking on the whole 32 watts, or 2 watts per candle-power, it may take less power to begin with, but it will not preserve nearly the same constancy of candle-power as if it had been worked at such a temperature that it absorbed from 48 to 56 watts at the commencement of its career; in other words, absorbed 3 to 3½ watts per candle-power. No hard and fast rule, however, can be laid down about these matters. No deductions can be made which have any great value from tests made upon a very small number of lamps. As I have previously stated, the lives of electric lamps are in this respect like human lives, and just as the insurance companies have to draw their deductions and to make their calculations for life insurance on the results of figures obtained from a very large number of human lives, so inferences made from the results of statistical tests carried out on incandescent lamps are only of use if they are made on a very large number of lamps. Broadly speaking, however, the duration

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of an incandescent lamp is dependent upon the electric pressure at which the lamp is worked, and if a lamp is marked to be used on a 100-volt circuit, then if it is used on a circuit at a pressure of 105 volts, its life would be greatly abbreviated, probably to one quarter or one fifth of the time which it would last if worked at the normal pressure. On the other hand, if it is worked at a pressure of 95 volts, its duration, accidents apart, will be very greatly increased. It is useful, therefore, to have, under these circumstances, a general knowledge of what would be the variation in candle-power if the same lamp is employed at different voltages. The tables on the next page give the candle-power yielded by two particular electric glow lamps when worked at varying pressures, the first table being for a 100-volt 16-c.p. lamp, and the second table being for a 100-volt 8-c.p. lamp. A very cursory examination of these tables will show that the light given by the lamp varies enormously with the pressure, and that a very small diminution of pressure suffices to deprive the user of a very large fraction of the candle-power for which the lamp is constructed.

Tables *showing the Candle-power of certain nominal 8 and 16 Candle-power Incandescent Lamps when worked at various pressures in Volts.*

A 16 Candle-power Lamp.		An 8 Candle-power Lamp.	
Worked at	Yielded a candle-power of	Worked at	Yielded a candle-power of
105 volts.	22·8 c.p.	102 volts.	7·9 c.p.
100 ,,	16·7 ,,	100 ,,	6·9 ,,
95 ,,	12·2 ,,	98 ,,	6·1 ,,
90 ,,	8·7 ,,	96 ,,	5·35 ,,
85 ,,	5·9 ,,	94 ,,	4·7 ,,
80 ,,	4·0 ,,	92 ,,	4·2 ,,
75 ,,	2·5 ,,	90 ,,	3·65 ,,
70 ,,	1·5 ,,	88 ,,	3·2 ,,
65 ,,	0·8 ,,	86 ,,	2·8 ,,
60 ,,	0·6 ,,	84 ,,	2·35 ,,
		82 ,,	2·2 ,,
		80 ,,	1·7 ,,
		78 ,,	1·4 ,,
		76 ,,	1·15 ,,
		74 ,,	0·9 ,,

THE POTENTIAL AND CURRENT CURVES OF DIFFERENT TYPES OF ALTERNATORS, AND THEIR INFLUENCE ON THE CANDLE-POWER OF ALTERNATE-CURRENT ARCS.*

BY G. RÖSSLER AND W. WEDDING.

(*Concluded from page 526.*)

Part II.—Photometrical.

The lamp, as above described, was run with 10 amperes, and carried close above the arc the universally-employed white enamelled reflector, thus lighting only the space below it. The lamp was carefully regulated for each machine, and it was found possible, after some practice, to regulate with such accuracy that the maximum deviations were not more than 0·3 volt. That pressure was chosen for the measurements which kept the lamp in the most stable condition, the observations being always made at the same pressure, which kept very constant, and which varied on different days and for different machines from 28·8—31·1 volts. In order to attain an even consumption of the carbon during each set of observations each was begun after running the lamp for two hours, and the carbons used were cored carbons of the Siemens A type, 10mm. thick.

The photometric arrangements were those usual in the Berlin Electro-technical Laboratory. As comparison, a glow-lamp was used on each side, run at high efficiency to make it as white as possible, and whose pressure was controlled by a Weston voltmeter. After each set of observations the candle-power of each lamp was tested by comparison with a Hefner lamp. In order to determine as accurately as possible the distribution of illumination in two adjacent quadrants lying under the horizontal plane, about 17 observations for each quadrant, the angles being taken close together at about 45°, and further apart at the horizontal and vertical planes, and 6—12 observations were made on each photometer for each angle.

In circuit with the arc lamp was an inductionless resistance, on which, by means of an electrometer, the pressure for the determination of the current curve was read, a regulating resistance for the lamp, an ammeter by Schuckert, a Thomson balance to standardise it by, a Helios wattmeter, and a Cardew voltmeter. This last was on the terminals of the lamp, and in parallel with it the pressure coil of the wattmeter, also a connection for determination by the electrometer of the pressure curve (see Fig. 7). The standardisation of the voltmeter was done by the electrometer, of the ammeter by the Thomson balance, and of the wattmeter by both; and as ultimate standard the well-known compensation apparatus of the Reichsanstalt. It was found that the Schuckert ammeter readings had to be multiplied by 1·311 for the Ganz machine, with 40 volts; with the Wechsler machine the factor fell to 1·018, and for the Siemens to 1·013.

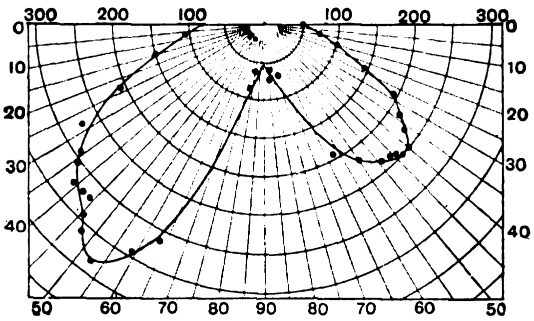

Fig. 12.

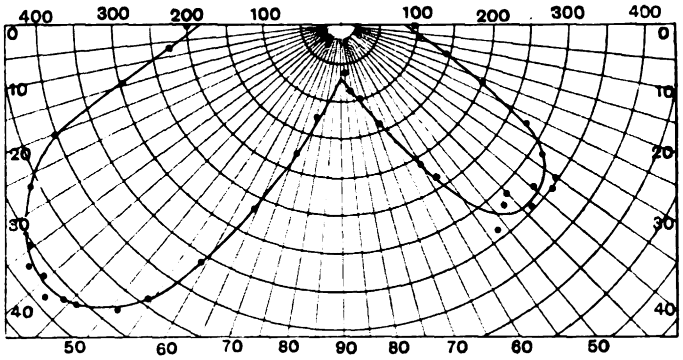

Fig. 13.

There are nine sets of observations for the Ganz machine, Table IV. gives the complete values for the various angles of one of these sets. The figures are the mean of from 6—10 observations.

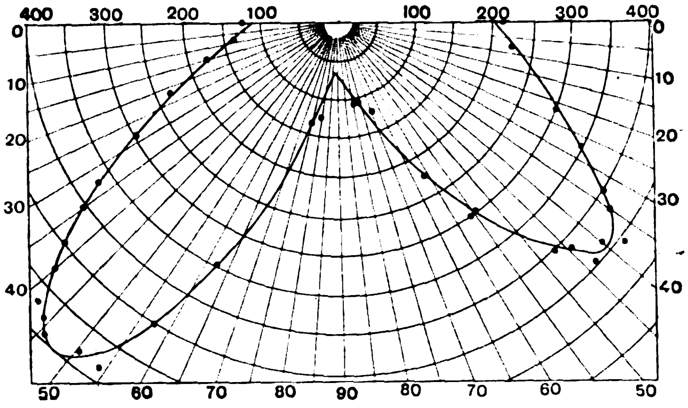

Fig. 14.

In the first three columns we find the electric quantities, allowing for the energy consumed in the instruments. The next four columns give us the photometrical measurements for each angle, which were made in pairs in the opposite quadrants. The last column shows the mean spherical intensity under the horizontal reduced to one watt between the lamp terminals as found by the usual geometrical construction. The variations occurring in the measurements of the candle-power between 30°—60°, are due partly to the reflector and partly to uneven consumption of the carbons.

* Paper read before the Verband der Elektrotechniker Deutschlands, 1894. Slightly condensed.

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The first three of the following tables relate to the curves given in Figs. 8, 9, and 10 of the preceding part of this Paper.

Table I.—*Ganz Machine.*

Position of contact. Degrees.	Pressure. Volts.	Current. Amps.	Power. Watts.	Remark.
65	−23·3	− 3·6	+ 85	Between 55°—250° the Maximum. Pressure is 72·3 Volts.
60	−36·7	− 6·9	+ 254	
55	−66·0	−15·2	+1004	
50	−61·0	−23·9	+1442	
45	−44·0	−18·0	+ 790	
40	−36·3	−11·0	+ 397	
35	−26·0	− 6·6	+ 173	
30	−16·9	− 4·3	+ 72	
25	−12·4	− 2·9	+ 35	
20	− 9·3	− 1·9	+ 17	
15	− 7·2	− 1·2	+ 8	
10	− 3·5	− 1·0	+ 4	
5	+ 0·9	− 0·3	− 0·3	
360	+ 6·2	0·0	0·0	
355	+10·3	+ 0·3	+ 4	
350	+13·9	+ 0·9	+ 13	
345	+17·1	+ 2·2	+ 37	
340	+20·8	—	—	
335	+25·3	+ 3·8	+ 95	
330	+36·3	+ 6·1	+ 221	
55	—	−15·0	—	Final repetition of Current Measurement.
50	—	−23·9	—	

Table II.—*Weschler Machine.*

Position of contact. Degrees.	Pressure. Volts.	Current. Amps.	Power. Watts.
180	+36·5	+12·8	+467
185	+32·1	+10·6	+341
190	+23·8	+ 8·3	+199
195	+13·1	+ 5·7	+ 74
200	+ 6·2	+ 3·3	+ 21
205	− 6·4	0	0
210	−10·3	− 3·2	+ 45
215	−16·1	− 5·0	+ 81
220	−19·7	− 6·8	+133
225	−22·5	− 8·1	+182
230	−29·7	− 9·4	+274
235	−35·3	−10·3	+364
240	−40·8	−11·0	+447
245	−42·4	−11·8	+501
250	−43·5	−12·1	+528
255	−45·0	−12·9	+580
260	−44·4	−13·1	+580
265	−41·3	−12·7	+524
270	−39·5	−11·4	+450
275	−35·5	− 9·1	+324
280	−27·7	− 7·0	+195
285	−13·5	− 4·8	+ 65
290	− 5·9	− 2·6	+ 15
295	+10·6	+ 1·2	+ 13
300	+15·7	+ 3·3	+ 52
305	+17·6	+ 5·2	+ 92
310	+20·0	+ 7·0	+140
315	+24·0	+ 8·4	+202

Table III.—*Siemens Machine.*

Position of contact. Degrees.	Pressure. Volts.	Current. Amps.	Power. Watts.
225 +	+16·7	+ 4·8	+ 79
$225 + \frac{5}{3}$	+ 4·2	+ 2·5	+ 11
$225 + \frac{10}{3}$	− 3·5	+ 0·4	− 1
230	−10·4	− 1·4	+ 15
$230 + \frac{5}{3}$	−18·7	− 3·9	+ 73
$230 + \frac{10}{3}$	−25·7	− 8·5	+219
235	−28·6	−10·0	+286
$235 + \frac{5}{3}$	−31·0	−10·5	+325
$235 + \frac{10}{3}$	−34·0	−10·6	+361
240	−36·1	−10·5	+378
$240 + \frac{5}{3}$	−37·3	−10·4	+387
$240 + \frac{10}{3}$	−38·1	−10·4	+396
245	−37·9	−10·0	+379
$245 + \frac{5}{3}$	−37·4	− 9·7	+362
$245 + \frac{10}{3}$	−39·0	− 9·7	+378
250	−41·7	−10·5	+435
$250 + \frac{5}{3}$	−42·6	−11·3	+483
$250 + \frac{10}{3}$	−26·0	− 7·5	+196
2-5	− 9·9	− 4·5	+ 45
$255 + \frac{5}{3}$	− 1·9	− 1·9	+ 3

Table IV.—*Ganz Alternator, 40 ∼.*

Volts on lamp.	Current in lamp.	Watts in lamp.	Angle to horizontal to left.	Illumination H. U.	Angle to horizontal right.	Illumination in H. U.	Mean spherical intensity per watt below horizontal.
			Deg.		Deg.		
29·7	9·4	257	0·0	78·3	0·0	51·8	0·716 H. L.
,,	9·3	259	8·4	101·0	8·8	70·3	
,,	9·3	262	15·6	148·0	16·4	103·0	
,,	9·4	262	22·0	211·0	22·9	148·0	
,,	9·4	262	28·0	270·0	29·0	191·0	
,,	9·4	262	33·8	285·0	34·5	219·0	
,,	9·4	262	36·2	303·0	37·1	234·0	
,,	9·3	260	38·7	324·0	39·6	249·0	
,,	9·4	262	41·4	316·0	42·1	249·0	
,,	9·4	263	43·7	320·0	44·8	242·0	
,,	9·4	263	45·5	340·0	45·9	240·0	
,,	9·6	264	47·5	360·0	48·8	240·0	
,,	9·4	265	52·4	380·0	55·2	219·0	
,,	9·4	265	59·0	342·0	62·7	187·0	
,,	9·4	265	63·4	314·0	75·9	73·7	
,,	9·4	265	78·6	87·7	83·1	60·7	
,,	9·4	263	—	—	85·8	69·9	
Av. 29·7	9·4	262					

Table V.—*Weschler Alternator, 40 ∼.*

Volts on lamp.	Current in lamp.	Watts in lamp.	Angle to horizontal to left.	Illumination H. U.	Angle to horizontal right.	Illumination in H. U.	Mean spherical intensity per watt below horizontal.
			Deg.		Deg.		
31·1	9·5	283	0·0	203	0·0	96·1	1·003 H. L.
,,	9·4	294	7·5	227	8·2	105·0	
,,	9·5	292	14·5	294	15·8	136·0	
,,	9·5	292	20·6	400	21·9	198·0	
,,	9·3	286	26·6	466	27·7	269·0	
,,	9·3	282	32·0	499	33·2	310·0	
,,	9·3	286	34·6	504	35·5	349·0	
,,	9·3	286	37·1	521	38·2	354·0	
,,	9·3	282	39·5	511	40·8	327·0	
,,	9·3	283	41·8	533	43·0	349·0	
,,	9·3	283	43·9	521	45·6	310·0	
,,	9·3	283	46·2	511	47·8	316·0	
,,	9·3	283	51·4	485	52·6	341·0	
,,	9·3	283	54·7	443	57·6	233·0	
,,	9·3	283	58·7	370	61·3	219·0	
,,	9·3	284	64·3	262	68·6	138·0	
,,	9·3	286	71·0	179	75·8	102·0	
,,	9·3	286	78·8	126	81·8	90·8	
,,	9·3	286	—	—	87·6	60·8	
Average 31·1	9·3	286					

Table VI.—*Siemens and Halske Alternator. Freq. = 80 ∼.*

Volts on lamp.	Current in lamp.	Watts in lamp.	Angle to horizontal to left.	Illumination H. U.	Angle to horizontal right.	Illumination in H. U.	Mean spherical intensity per watt below horizontal.
			Deg.		Deg.		
31·0	9·1	268	0·0	132	0·0	217	1,078
,,	9·2	268	8·1	139	7·5	223	
,,	9·1	269	15·4	174	14·6	262	
,,	9·1	270	22·0	231	22·1	300	
,,	9·0	269	28·0	293	27·2	348	
,,	9·1	270	33·2	367	32·6	405	
,,	9·1	270	35·6	405	35·1	421	
,,	9·0	269	37·9	449	37·5	457	
,,	9·1	270	40·1	474	40·0	442	
,,	9·2	270	42·1	521	42·5	448	
,,	9·1	268	44·1	528	44·7	415	
,,	9·0	268	46·2	542	47·0	405	
,,	9·0	267	51·4	527	53·8	298	
,,	9·1	269	54·2	530	56·6	302	
,,	9·1	269	58·1	453	61·7	226	
,,	9·0	268	62·8	352	70·2	126	
,,	9·1	267	74·5	135	76·2	107	
,,	9·1	268	79·5	129	80·7	107	
Av. 31·0	9·1	269					

NOTE.—For Table IV. referred to in fifth line from the end of this article, read Table VII.

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Table VII.

Machine.	Frequency.	Mean volts on lamp.	Mean current in lamp.	Mean energy consumed.	Illumination in H.U. Hori-zontal.	Vertical.	Maxi-mum.	Mean spherical intensity under horizontal.	Mean value H.U.
Ganz and Co..	4800	29·9	9·8	271	74	50	341(50°)	0·684	0·710
	,,	29·9	9·8	275	75	55	323(51°)	0·699	
	,,	29·9	9·8	273	78	55	330(54°)	0·729	
	,,	29·9	9·6	267	75	50	343(51°)	0·736	
	,,	29·9	9·6	269	58	55	3 0(53°)	0·719	
	,,	28·8	9·6	259	70	45	310(50°)	0·722	
	,,	28·8	9·5	256	58	47	310(51°)	0·685	
	,,	29·7	9·4	262	66	57	312(48°)	0·716	
	,,	29·9	9·3	264	53	60	323(51°)	0·703	
Wechsler	,,	31·0	9·5	286	157	80	463(42°)	1·058	1·024
	,,	31·1	9·3	286	145	70	487(42°)	1·003	
Siemens and	,,	31·1	9·4	288	160	70	417(43°)	1·010	
Halske	7200	31·0	9·5	272	155	80	423(43°)	1·057	1·050
	,,	31·0	9·5	277	130	75	475(44°)	1·047	
Siemens and	,,	30·9	9·5	268	157	55	430(43°)	1·046	
Halske	9600	31·0	9·1	269	160	80	500(44°)	1·078	1·110
	,,	31·0	9·0	269	145	80	500(47°)	1·143	

Wechsler..................	0·906	0·906	0·90	0·907
	0·906		0·914	
Siemens and Halske ...	0·897		0·911	

The reflector is not to be regarded as a perfect mirror, and the carbons are, of course, not perfectly uniform. These variations are only photometrically observable, and are not of practical importance. The curve derived from these observations is given in Fig. 12. The spherical intensity is calculated for each direction, and the mean of these two values taken.

In the next Table are the results of the Wechsler machine, to which Fig. 13 is the curve. The mean spherical intensity has risen from 0·716 to 1·003 Hefner units per watt. The next Table gives the same curve for the Siemens machine, with Fig. 14 as its curve. The spherical intensity is here 1·078 H.U. In Table VII. is given a summary of all the experiments made on the machine.

It is seen from these results that the development of light does not perfectly follow the sharp ascents and descents of the curve of E.M.F. given by the Ganz machine, and, consequently, the energy is not fully utilised. Smoothing out the curve, as in the Wechsler, immediately increases the light given per watt by 44 per cent. ; or, put more vividly, if the Ganz machine were replaced by a Wechsler, one in every three lamps might be removed for the same illumination.

The third machine, that of Siemens and Halske, could only give the required volts at a higher frequency. When the frequency is raised 33 per cent. the light rises about 6 per cent. It is not impossible that the light evolved rises with the frequency, and Blondel holds it for certain, but our experiments do not furnish any very clear evidence one way or the other. On the other hand the observations on the third machine also show the same kind of difference in intensity of illumination when compared with the first.

From the form of the curves certain important conclusions may be drawn with regard to the illuminating power of arc lamps. If we take the ratio of the simple mean current M(J) to the value measured $\sqrt{M(J^2)}$, and similarly for the E.M.F., we find

	$\frac{M(E)}{\sqrt{M(E^2)}}$		$\frac{M(J)}{\sqrt{M(J^2)}}$
Ganz and Co	0·783	....	0·656
Wechsler.....................	0·906	....	0·907
Siemens	0·897	....	0·911

For a true sine curve the value should be 0·900. Since the value 0·907 differs by 28 per cent. from 0·656, and the photometrical measurements, which cannot be made with the same accuracy, give a ratio of 30 per cent., we may consider these as equivalent. There is thus ground for the conclusion that the development of light of an alternate current arc lamp is proportional to the simple mean value of the current.

If we try to make $M(J)/\sqrt{M(J^2)}=1$, then the current curve must have the shape shown in Fig. 15, which approaches that of the Siemens machine ; and the extra illuminating power may be partly due to this, as well as to the increased frequency ; unfortunately there is only one curve to be dealt with, giving the value $M(J)/\sqrt{M(J^2)}=0{\cdot}911$, and for the photometric observations there are only two sets, giving a value of 1·110, so that no definite conclusion can be drawn. But falling back on the first two results, we see that if the light varies as the simple mean value of the current, the quantity of light should rise from 1·024 to 1·13 ; and the lamp would give for a current maximum of 10 A a quantity equal to 1·13. Apparently it would be best to build machines whose curves approach the shape of Fig. 15.

There is, however, an objection to the universal use of such curves ; for if we take into consideration other phenomena we find that while with the Ganz machine the ordinary hum of the arc is increased to a rattle so loud as to make its use impossible in a room, the Siemens machine only makes an ordinary, but loud, humming, while the Wechsler machine makes the lamp burn almost silently. The same phenomena occurred with a Helios lamp. Taking this into consideration, we see that the sine wave gives the best results ; the development of light is fair, and the arc is silent.

In conclusion, we draw a comparison between the amount of light developed on direct and alternating currents. The experiment was made with a Siemens differential lamp, using a cored carbon 10mm. in diameter and a homogeneous one 3mm. The method and arrangement were as before, the current being supplied by accumulators :—

Mean volts in lamp.	Mean current in lamp.	Mean watts in lamp.	Mean spherical intensity under horizontal per watt.	Mean.
46·85	9·26	433·8	2·80	2·84
46·85	9·29	435·2	2·90	
46·85	9·25	433·4	2·82	

We have an average value of 2·84 H. U. per watt, which is very high, partly because of the very small lower carbon, and secondly, because we are dealing with higher amounts of power. If we avoid this by taking a case of a lamp of about the same power, as taken

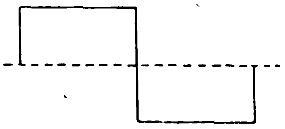

Fig. 15.

from the Table on page 149 of Herr Heim's book, "Die Einrichtung Elektrischer Anlagen," we should have a value of 2·64 H. U. per watt. It is, therefore, evident that for a given consumption of energy the illuminating power of a direct current arc is considerably higher than that of one run by an alternate current. This result confirms that already published as the results of experiments at Frankfort. A large part of this unfavourable result is due to the reflectors, which only reflect about 70 per cent. of the light evolved ; and there lies here some room for improvement.

If we put in series on a 110-volt circuit two of these direct current arcs taking 6·8 amperes at 42·4 volts ; and, on the other hand, with an alternate current circuit at the same pressure, use four alternate current arc lamps, we have the following output of light :

The direct current has an energy of 748 watts, of which $2\times288\cdot3=577$ watts are used in the lamps, and 171 in the resistances, and the light evolved is $577\times2{\cdot}65=1528$ H. U. mean spherical intensity under the horizontal.

With alternate current arcs taking 9·42 A., and using about the same power, all the energy is used for production of light, and with a sine curve (using Table IV.) we produce

$$4\times286{\cdot}8\times1{\cdot}024=1175 \text{ H. V.}$$

mean spherical intensity under the horizontal. Thus this arrangement also is more efficient with direct than with alternating currents.

Electrical Standards.—The British Association Committee appointed to conduct experiments for improving the construction of practical standards for electrical measurements, reported at Oxford that the work of testing resistance coils at the Cavendish Laboratory had been continued, a list of 43 coils tested being given. The report comprises several appendices, amongst others being those relating to experiments on the value of the ohm, by Prof. J. Viriamu Jones, and a comparison of some of the standards of the Board of Trade with those of the Association, by Mr. Rennie. The Committee report that the insulation of some of the coils referred to in their last report, which had been selected for the new standards of resistance as defined by the resolutions adopted at Edinburgh, had proved defective. The insulation of some of the other standard-ohm coils was also stated not to be satisfactory. In consequence of the difficulty met with in the insulation of some of the coils, it has been thought well to defer the purchase of other coils for which the grant of £25 was obtained last year. The Committee were of opinion that it was desirable to complete their set of standards by obtaining from Germany certified copies of the standards of the Reichsanstalt.

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REFLECTORS AND REFLECTION.

The elementary idea of the business of an electric light engineer is to sell a dynamo, some lamps, switches, wire, and perhaps a steam engine, and to erect the plant and set it running. The result to the customer is that he gets some light, and if all goes well the engineer gets paid. A conscientious engineer will take care that the lamps are of good quality; he probably does not make them, but buys them. He takes care that the wire shall be of at least 98 per cent. conductivity, and of sufficient size to carry the current without appreciable drop of volts. Perhaps he makes the dynamo, and he justly prides himself on an efficiency well into the nineties. He may, if he is fastidious, see that the diagram taken from the engine has a sharp cut-off; all these little one or two per cents, he will tell you, go to make up an efficient and economical plant. The steam engine runs well, the dynamo works cool and without sparking, the wiring is in accordance with all regulations, and the lamps are up to candle-power. Nothing more can be done, the engineer and his customer are satisfied, and there is an end of it. If someone then tells the engineer that, by a simple and perhaps inexpensive improvement, the illumination would be increased 10 or 15 per cent., or that an equivalent saving of fuel might be effected, some attention might be given to it; but if the customer became convinced that by a simple and perhaps inexpensive improvement his light might be doubled, trebled, or more, he would surely blame the engineer for having neglected it.

Dr. SUMPNER has measured the reflecting power of white paper and other dull reflectors, and, in an article contributed by him to *The Electrician*, in February last year, he showed that when the reflecting power of the walls of a room is 50 per cent., the effect of the successive reflection doubles the illumination; and if walls and ceilings were well whitewashed the light would be increased fivefold. The engineer would probably excuse himself by saying that his work begins at the boiler or dynamo, and ends at the lamp; that he is not a painter or decorator; and that his customer can do what he pleases about whitewashing. Reflectors are to be found in his

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price list, and will be "extras." He might further add that no book on electric lighting, on physics, or on photometry discusses the subject of diffused reflectors, or the reflecting power of dull surfaces, and that he, therefore, has not committed any fault in neglecting to recommend this improvement. Nevertheless, he would do well, we think, to regard a reflector as an actual source of light, and a very cheap one, too. If it is the business of an electric light engineer merely to sell dynamos and lamps, there is no more to be said; but it is his business to provide *light*, it is his duty to attend to the use of reflectors and reflection.

The summation of fractional series which Dr. Sumpner discussed gives very remarkable results when the reflecting power is 50 per cent. or more; but with a reflecting power of 20, which may perhaps be obtained from brick or stone outside walls of houses, the reflection will add only about 25 per cent. to the original source of light, and it is to be observed that where there is no ceiling—that is to say, in open spaces—the useful reflected light is very much less. Though the reflecting power of dull surfaces is, indeed, a true reflection and not as has been asserted, a mere diffusion, whatever that may mean, the reflected light leaves the surface in all directions. It is easy to produce a dull white surface in which no visible trace of direct reflection can be detected, even at high angles of incidence; but even with ordinary surfaces of stone and paint the direct reflection may be disregarded. Any direct reflection—as, for example, from the higher windows of houses—in street lighting means an entire waste of light, for the light is reflected skywards, and about one-half of the whole diffused reflected light is thus wasted. If, then, an addition of only 25 per cent. could be gained by yellowish walls and ceiling, the gain due to house fronts in an open street would be almost imperceptible.

The natural and direct distribution of light by continuous current arcs on fairly high pillars is excellent, and reflectors are of no use whatever in connection with them. Now, while this is excellently adapted for the lighting of open spaces where illumination on the ground is the chief consideration, there are not a few cases in which light is required on walls, or for purposes of diffusion by reflection on ceilings. In such cases it seems that alternate-current arcs would be very useful. It is clear that where the walls or other surroundings have but poor reflecting power, it is useless to cast light on them for the purpose of general illumination. Where no surroundings exist—as, for example, on one side of a sea-front or "marine parade"—it is difficult for anyone but an alternate-current enthusiast to see the sense of throwing a large proportion of the light upwards to the sky. The walls of railway stations and the façades of houses in most towns are not as a rule good reflectors, and it is, therefore, in general, useless to illuminate them, unless, perhaps, in some parts of Aberdeen, Nottingham, and Paris, where light-coloured stone or plenty of white paint is used.

Hitherto we have discussed the actual photometrical value of the illumination, but that is not the ultimate object of street lighting. Partly on account of circumstances connected with the contraction of the iris of the eye, to which we have recently alluded, and partly on account of the perfectly general desideratum of a pleasant bright appearance, the lighting of house frontages is, no doubt, useful. A comparison between two streets, one with a well distributed illumination of, say, three candle-feet, on the ground, with continuous current arcs, sending but little light on to the houses; and another with only two candle-feet on the street, and one candle-foot or so on the houses, would probably result in a verdict in favour of the latter: not because it would be more usefully lighted, but because the effect would be more pleasant.

The alternate-current arc as usually employed sends as much light upwards as downwards, it is practically equivalent to two small continuous-current arcs, one being inverted. For ordinary street lighting, especially where the houses are of a dingy colour, the light from the lower carbon—that is to say, the light sent upwards—is of hardly any use at all. In interiors, of course, the conditions are very different; but not all alternate-current lamps are silent enough to use indoors. This question of loss and waste of light has led to the use of rectifiers, and the only drawback to this method is that it reverts from low-pressure distribution with arcs two in series on 100 volts, or four on 200 volts, or five in series on 230 volts, as at Brighton, and employs a considerable number of lamps in series, thus increasing the risk of breakdowns. An attempt has been made to save some of the waste light by reflectors, and if alternate currents must needs be used, these reflectors will no doubt prove of considerable service.

In view of the calculations of Dr. Sumpner of the increase of illumination due to the successive reflection of good white reflecting surfaces, engineers who profess to supply light cannot afford to neglect such valuable assistance. The Paper by Herr Wiener, which we reprint from *Wiedemann's Annalen*, is perhaps of more scientific than practical interest; but so little has been written on the subject that every contribution to our knowledge of the reflecting power of white surfaces is of importance.

THE ALTERNATE-CURRENT ARC.

Very little has been published about the alternate-current arc. It is well known that most good arc lamps may be made to run with alternate currents if the core of the main solenoid be laminated, and slight alterations made in the windings and weights; but very little is generally known about the behaviour of the arc. Among other very interesting matter which is to be found in the remarkable book recently issued by the Helios Company, of Cologne, is a brief account of some photometric tests of alternate-current arcs. We extract the following curves and tables relating to them.

Fig. 1 shows the distribution of candle-power of arcs of about the same current, viz., 10·5 and 11 amperes; but in the one case taking 28·5 volts and in the other 32·5 volts. With continuous current the higher volts would give a longer arc, and much more light would be emitted, simply by reducing the shadow of the negative carbon. But with alternate currents a very different and hitherto unexplained result is produced. An increase of 14 per cent. in the volts, and nearly 10 per cent. in the volt-amperes, is accompanied by a decrease of more than 15 per cent. in spherical candle-power. The outer curve shows the candle-power at 28·5 volts, and the inner curve at 32·5 volts. It will be noticed that the increase of volts has evidently lengthened the arc a little, for the candle-power at 50° below the horizon has been increased by about 50 per cent., and at 60° it has been more than doubled; but in the more horizontal directions it has been greatly reduced.

The next diagram shows the candle-power with different currents, the volts being in each case maintained at the best pressure for the particular current. In the table which follows the figure it will be noticed that the volts diminish from 30 to 25, while the current rises from 8 to 50 amperes. It seems from these curves that a 10-ampere arc is very inefficient, compared with the larger ones, but the descriptions accompanying the tests do not give much information about the carbons or other details of the experiments. The irregular shapes of the curves are no doubt due to the conscientious plotting of actual observations with no attempt at "smoothing." The average

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shape probably resembles the well-known loop or oval of the continuous current candle-power diagram. There actually appears to be more light thrown skywards than on the ground with 50 amperes, but this may be accidental.

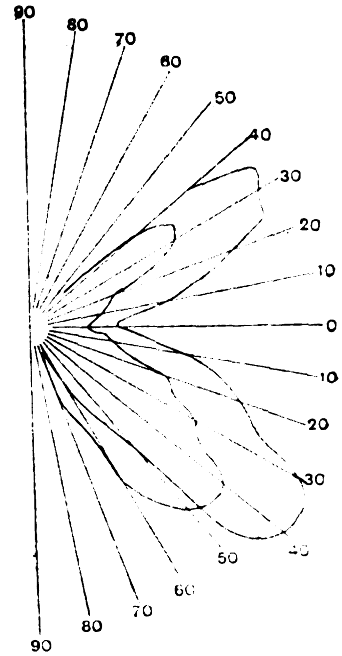

FIG. 1.—Curves showing the candle-power of an alternate-current arc measured at different inclinations with the horizon, and the reduction of candle-power produced by an increase of volts.

—	Volts.	Amps.	Volt-amperes.	Horizontal c.p.	Maximum c.p.	Sperical c.p.
Outer curve ...	28·5	11·0	313	150	550	275
Inner curve ...	32·5	10·5	343	93	423	205

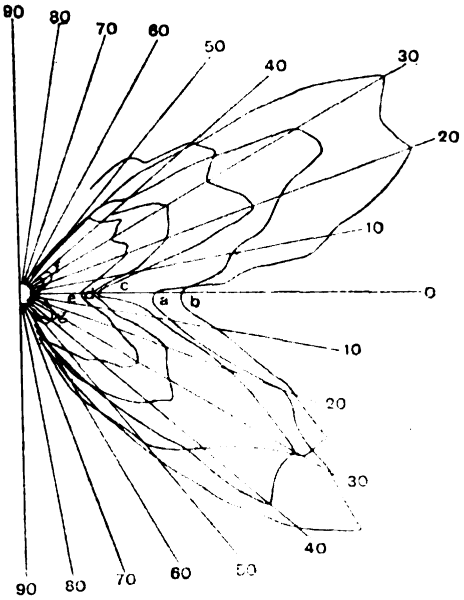

FIG. 2.—Curves showing relation of current to candle-power in an alternate-current arc.

Curve.	Current. Amperes.	Watts.	Volts.	Horizontal c.p.	Greatest c.p.	Spherical c.p.
a	50	1,250	25·0	1,630	4,840	2,625
b	30	825	28·0	1,800	3,880	2,200
c	20	500	27·5	940	3,760	1,500
d	16	468	28·0	925	2,160	1,200
e	15	413	27·5	670	1,570	870
f	10	313	28·0	150	550	275
g	8	250	30·0	92	530	250

The third diagram shows the remarkable effect of the Helios reflector. The inner curve is the candle-power without the reflector, the slightly reduced size of the upper dotted loop being, we suppose, accidental. The outer curve represents the distribution of candle-power with the reflector. This would show a very satisfactory result for a silvered reflector, whether of glass or of polished metal, but we were surprised to learn on

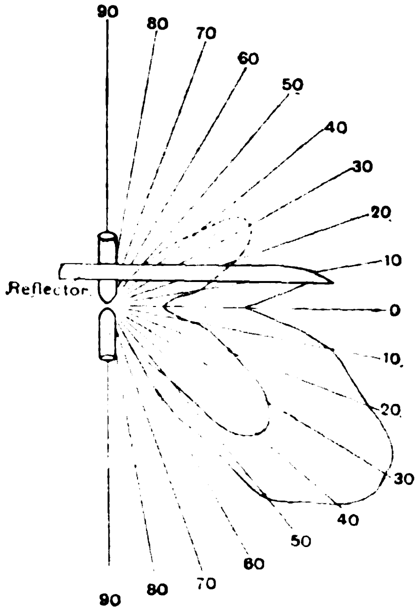

FIG. 3.—Candle-power of alternate-current arc, with and without reflector.

—	Lamp for	Consumption in watts.	Horizontal c.-p.	Greatest c.-p.	—
Inner curve	10 amp.	310	150	550	275 spherical c.-p.
Outer curve	10 amp.	310	372	912	498 hmisphricl c.-p.

making inquiries that it consists of a white enamelled iron disc with a slightly curved edge. Ten Helios lamps, with these reflectors, are being used at Newcastle for street lighting.

In connection with Mr. Dobson's Paper on workshop lighting by inverted arcs (see *The Electrician*, Vol. XXXI., Oct. 27, 1893, p. 701, we called attention to the necessity for arranging the reflector to subtend a large angle to the source of light. In order to carry out this condition and at the same time to avoid a large and clumsy reflector the Helios Company place it very close to the arc, and accurate focussing of the lamp is therefore necessary. A silvered reflector would soon be ruined by the heat if fixed in this position.

INTEGRATORS, HARMONIC ANALYSERS, AND INTEGRAPHS.*

BY PROF. O. HENRICI, F.R.S.

The first planimeter, properly so called, was invented by a Bavarian—Hermann—who, however, published no description of his instrument. A little later, Gonnella, of Florence, re-invented practically the same instrument; but, from the want of skilled labour in Italy, he was compelled to send his designs to some of the watchmakers in Switzerland in 1825. In the following year a Swiss engineer, Oppikofer, brought out practically the same design.

According to an estimate made by Bauernfeind, of Munich, at this period a billion areas had to be estimated annually in Europe, so that the practical importance of getting a reliable instrument was very great.

An instrument on Oppikofer's design was made in France by Ernst, and was there known as Ernst's planimeter. In England, about this time, Sang's planimeter was made. In Germany improved instruments of the same type were known as Wetli-

* A Paper read before joint meeting of Sections A and G, British Association.

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Hansen planimeters. They are all practically of Gonnella's and Oppikofer's design, with very little difference.

In 1854 Amsler made his first planimeter, which created quite a revolution in this class of instruments. His first paper on the subject was published in 1856 and contains a great mass of information on various types of planimeters.

Classification of Planimeters.—Professor Hele-Shaw in his paper on "Mechanical Integrators"* bases the classification of planimeters on the mechanism used, and particularly on whether slipping or no slipping takes place. A better classification seems to me to rest on their geometrical properties.

Sir Frederick Bramwell, at the Brighton meeting of this Association, gave the first account in English of the theory of Amsler's planimeter, and then expressed his surprise and wonder at the fact that there could be any connection between the area of a closed curve and the motion of a tracing point

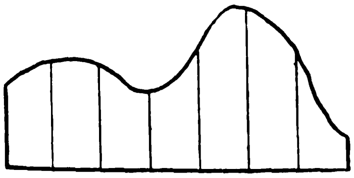

FIG. 1.

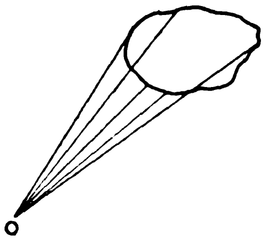

FIG. 2.

moving round its boundary. At first sight there is apparently no connection. But consider the given area as generated by the motion of a straight line. A line moving in its plane has two motions possible, translation and rotation; the line itself may either be of fixed or variable length. Adopting this as the basis of classification there are three types of planimeter:—

(1) In instruments of the first type, or orthogonal planimeters, the area is generated by the motion of a line of variable length which moves without turning (Fig 1); corresponding to a system of rectangular co-ordinates.

(2) In planimeters of the second type, the generating line is of variable length, and always passes through a fixed point (Fig. 2); corresponding to a system of polar co-ordinates.

(3) In the third type, the area is swept out by a line of fixed length.

Planimeters of the third type.—Let Q T (Fig. 3) be a rod of fixed length l; its motion into any neighbouring position Q′ T′ may be decomposed into a motion of translation into Q′ T″,

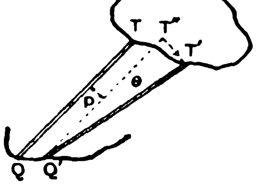

FIG. 3.

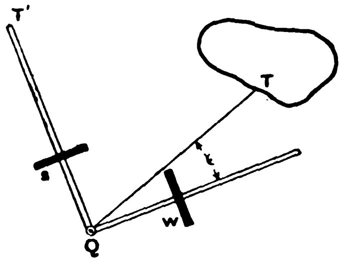

FIG. 4.

and a motion of rotation through the angle T″ Q′ T′ = θ. The area swept out by the rod is $lp + \frac{1}{2}l^2 \theta$, where p is the length of the perpendicular between the two neighbouring parallel positions of the rod. Now, if the rod ultimately return to its initial position, its ends Q and T will have described closed curves. There is a geometrical theorem, which I shall not attempt to prove here, that the area swept out by the rod in a complete cycle is the difference of the areas of the curves described by its ends. Now, if Q moves to and fro along a curve, the area described by it is zero, and the straight line sweeps out an area exactly equal to the area of the curve (T). Therefore area of given curve $= l \Sigma p + \frac{1}{2} l^2 \Sigma \theta$.

But by coming back to the initial position of the rod, $\Sigma \theta = 0$, and

$$\text{Area} = l \Sigma p.$$

* Proceedings of the Institution of Civil Engineers, Vol. 82.

Now suppose on the rod there is fixed a wheel which can turn with its axis parallel to the rod, as the rod moves the turning of the wheel will be equal to p; and if the total rolling of the wheel be w,

$$\text{Area} = l\,w.$$

This is the whole theory of the Amsler planimeter. In the Amsler planimeter the point Q is guided by the pole-arm in an arc of a circle.

I have dwelt at length on this part of the subject because of its importance with regard to the errors of the instrument. It does not matter where the wheel is fixed along the bar, or whether it be on a bar parallel to the original bar, provided its axis is parallel to the bar. In the Amsler instrument non-parallelism is one of the most important errors; the magnitude of the error can be determined as follows:—

Let the axis of the wheel (Fig. 4) make an angle ϵ with Q T; let Q T′ be equal to Q T and at right angles to the axis of the wheel; and let another wheel, whose total rolling is s, be fixed with its axis parallel to Q T′; then it is easily proved that the area

$$(T) = l \cos \epsilon,\ w + l \sin \epsilon,\ s.$$

Hence, unless s or ϵ is zero there will be an error, which is sometimes very serious.

Now the rolling s measures the slipping of the wheel w, due to the motion of translation of Q T′, and this slipping introduces a still more serious error. In 1855, Clerk-Maxwell pointed out slipping was a serious drawback, and he proposed, but did not carry out, an integrator without slipping.

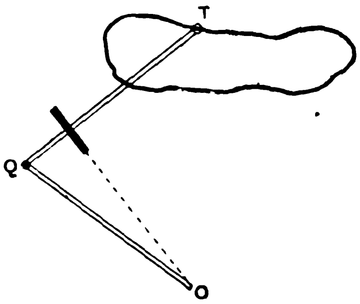

FIG. 5.

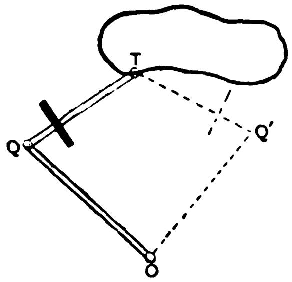

FIG. 6.

The Amsler instrument of 1856 has been improved, especially by Coradi of Zürich. In Coradi's "precision-planimeter" the wheel rolls on a prepared surface, with the object of avoiding the errors due to slipping. The errors due to slipping depend upon:—

(1) The resistance to the slipping of the wheel, and therefore on the nature of the surfaces of contact;

(2) The resistance of the wheel to turning, including the bearings resistance of the rolling wheel and the counter gear;

(3) The amount of slipping of the wheel on the paper.

The errors due to slipping will be reduced, therefore, by reducing these resistances. Again, if the plane of the wheel passes through o (Fig. 5), in moving T on a circular arc with centre o, the wheel will not roll at all, but slip. Hence, in using the instrument, the pole should be chosen so that such positions are avoided. Coradi has found that by varying the position of the pole the area registered varies, and has given rules for obtaining the best results. It should be remembered that the Amsler planimeter, by skilful use, is capable of very great accuracy.

Improvements by Coradi.—The Amsler instrument cannot be turned round; but, in a recent instrument by Coradi, the rod and the pole arm are connected by a spherical joint, so that it can be used with the joint first on one side, then on the other side (Fig. 6). The effect of this is to eliminate the error due to obliquity; in one position ϵ is positive, and in the other negative; thus the most important error in the Amsler planimeter is eliminated.

A number of new constructions have been made with the object of avoiding the slipping altogether. Clerk-Maxwell devised an instrument, which has never been carried out. Amsler, also, in his Paper of 1856, had foreshadowed a great

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many schemes which have been afterwards re-designed by others. In his Paper of 1884 he designed an instrument with no slipping, but had not carried it out.

A planimeter to be successful commercially must be (1) easily handled, (2) accurate, (3) cheap.

Coradi's Spherical Planimeter.—In this the slipping is reduced to a very small amount, and for ordinary purposes the instrument is of greater accuracy than is really wanted. For engineering purposes the simple Amsler planimeter is accurate enough. For special purposes the spherical planimeter is very convenient.

Another Planimeter is that in which the distance moved normally by the rod is measured by the *slipping* of the wheel. A knife-edged wheel rolls on the paper, and can slip along a spindle at right angles to the arm (Fig. 7), thus taking the place of the Amsler recording wheel. Amsler described an instrument of this kind, in which, however, the knife-edged wheel was fixed to the spindle, which again slipped through the rod.*

This instrument has been made in America especially for measuring the areas of indicator diagrams. Now it follows from what I have said about the Amsler planimeter that the sliding rod must be at right angles to the arm. In the Hine-Robertson planimeter this is not the case, and I can conceive no reason for the construction actually used. (Fig. 8.) The rod is bent, and the sliding bar is at right angles to the straight portion of the rod, instead of being, as it should be, at right angles to the straight line Q T. Prof. Perry tells me that in the hands of his students it gave an accuracy greater than the ordinary Amsler planimeter. That the instrument gives good results is due to the fact that the areas measured are small,

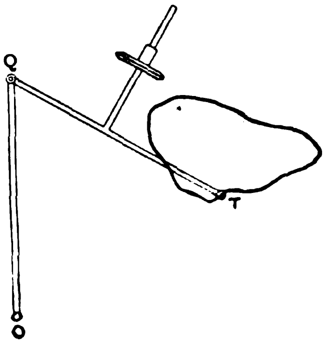

Fig. 7.

and that if the indicator diagram be low down the error due to obliquity is very small. In fact, one can get one position for a given area in which the error is zero.

Integrators are not used so much by engineers as they might be. Amsler's moment-planimeter gives—for one tracing round a given curve—the area, the first moment about a given straight line, and a third reading, by means of which with a little arithmetic the position of the mass centre and the moment of inertia about an axis through the mass centre are obtained. These are just the three quantities an engineer wants in determining the strength of a beam. Shipbuilders use it a little more, but not so extensively as it deserves. Amsler has made a few hundred moment-planimeters, while he himself had made over 12,000 planimeters up to 1884.

To return to instruments of Type 1, this planimeter gives always the area from the starting point to any point one likes. If a recording pencil could be attached to the instrument it would be an *integraph*, which draws the integral $\int y\,dx$, y as a function of x being given not as an expression, but as a curve drawn on the paper.

The integraph of Abdank-Abakanowicz was one of the first conceived, and is similar to that of Mr. Vernon Boys, a model of which is exhibited. The history of this instrument is rather interesting. Mr. Boys, one evening, had been reading a book on the Integral Calculus, went to bed, but instead of going to sleep invented the instrument; the next day he began to make it, and on the third day he finished it. A knife-edged wheel rolls on the paper, and is guided so that the tangent of the angle its plane make with the axis ox (Fig. 9) is equal to the corresponding ordinate y of the given curve. The ordinate Y of the curve, described by the knife-edged wheel, is then such that $\frac{dY}{dx} = \tan\phi = y$, and therefore $Y = \int y\,dx$, or the curve described by the knife-edged wheel, is such that its differential co-efficient is equal to the ordinate y of the given curve. To make the wheel actually draw the curve on the paper, a piece of thin blackened paper is placed blackened side downwards between the wheel and the drawing paper: a very clearly defined curve is the result.

Abdank-Abakanowicz introduced the same principle in his design, which he submitted to Coradi, and the instrument exhibited is the result. If one is given a function—not by an expression, but by a curve—the instrument will give the integral of the function as a curve; so that, for engineers, I think integraphs have a great future.

I think the first conception of an integraph is due to Lord Kelvin; but in the instrument suggested by him the integral is recorded on a cylinder and not on a drawing board, which is more convenient. He also mentioned that it would be possible to design instruments to give integrals of certain differential equations. His brother's cylinder-ball-and-disc integrator forms the basis of this design.

Sharp's integrator is not based on the *tangent* principle, but on what might be called the *sine* principle. It is curious to consider how the mechanism of this integrator reduces to somewhat the same thing as in *tangent* integraphs, but the geometry is essentially different. I have had this model made, it was only finished a few days ago, so that practical tests have not been made. It is essentially an integraph; but by the addition of the third carriage, as in the model, one can integrate the differential equation

$$\frac{dy}{dx} + ay + f(x) = o$$

a being a constant and $f(x)$ being given by a curve. If I move the tracer over the given curve $f(x)$, the pencil draws the

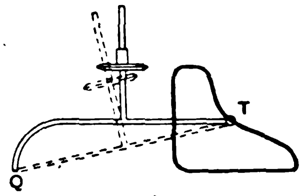

Fig. 8.

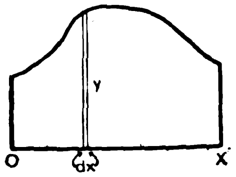

Fig. 9.

integral of the differential equation. If one wants to integrate differential equations of higher order, additional integrators must be added to the instrument. Any linear differential equation of the second order might be integrated by Sharp's instrument; the mechanism would not be too complex.

A great many observations are obtained by physicists and recorded as curves. It seems to me that to be able to work with these curves, as with expressions, is very desirable. I have no time to enter into this now; to see what means there are in existence for dealing with curves the results of observations, and to see whether these means cannot be generalised.

It would be desirable to have differentiographs, but the mechanical differentiation of a given curve seems so far impossible. The only way I think possible is to have the given curve engraved on a plate of metal, so that the tracer follows the curve accurately. It is quite impossible to get a satisfactory differentiator in which the tracing point is guided by hand.

Harmonic Analysers will give the equation to a curve if the curve itself is given. Amsler, in 1856, gave designs for a harmonic analyser; but the first carried out was by Lord Kelvin for the analysis of tides. One of his design is at the Meteorological Office, and has been used for years. This is quite a large, heavy instrument, and cannot be moved about.

Some years ago I thought, in following Clifford's remarks on Fourier's theorem, that a simple harmonic analyser could be got, and devised the instrument here shown, in which an Amsler planimeter rests with its pole and recording wheel on a plane surface subjected to a simple harmonic motion in its own plane, while the tracer moves along a fixed straight line.

* See *The Electrician*, Vol. XXVI., p. 432.

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I then, by transforming the integral, designed another instrument, which gave two coefficients for one tracing of the curve. I then adopted an inversion by Mr. Sharp, and got another instrument made by Coradi. Last year he proposed the addition of a sphere, and the mechanism comes very near that of Professor Hele-Shaw. This instrument works so very easily that I cannot express my admiration sufficiently for the skill which the instrument maker has put into it. That the instrument is so perfect is altogether the work of Coradi. It will give the first five terms of Fourier's series, *i.e.*, ten integrals for going once round the curve.

Applications.—Obvious applications are to the analysis of meteorological observations, and to the analysis of dynamo curves of varying strength, &c. Professor Perry, for instance, tells me that his knowledge of valve gears of steam engines has been greatly increased by submitting their motions to harmonic analysis.

APPENDIX.

Harmonic Analyser.—Fig. 10 is an illustration of an harmonic analyser with one integrator by Coradi of Zurich. This has already been described by Prof. Henrici in "On a new

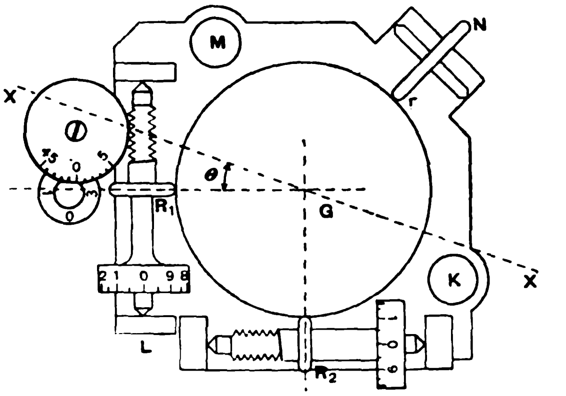

FIG. 11.

Harmonic Analyser," *Philosophical Magazine*, July, 1894. The long rectangular frame of the instrument rests with three wheels on the drawing-board. One of these, D, in the middle of the front serves merely as a support. The other two, E E, are fixed to the ends of a long axle which runs along the back of the frame. This may be called the "shaft." It is placed parallel to the axis of x. The instrument can therefore roll over the paper in the direction of the ordinates y. If thus can be moved through a distance equal to the base c to which the curve is drawn. To the carriage a silver wire is attached, which is stretched along the front of the frame, and then, by aid of the guide pulleys l l over the pulley H on the top of the spindle S. By giving the pulley H a suitable diameter the spindle can be made to turn n times round, whilst the tracer describes the whole base. If the tracer on following the curve has reached a point P then the spindle will have turned through an angle $n\,\theta$, where θ corresponds to the x of P.

The spindle has firmly attached to its lower end a square frame K L M N (Fig. 11) by aid of two solid rods K and M. This frame holds two registering wheels R^1 and R^2, with axes K L and L M at right angles. Between these lies the glass sphere G, resting with its lowest point on the cylinder belonging to the shaft. A third wheel r at N is, by aid of a spring, pressed against the sphere to secure contact between the latter and the registering wheels. If now the tracer follows the curve the frame will turn with the spindle, and the three wheels will carry the sphere with it, which will turn pivot-like on its lowest point. If, as in Fig. 11, the plane of one wheel R^1 makes with the axis of x an angle $n\,\theta$, and if in this position the tracer, and with it the whole instrument, is moved through the distance $d\,y$, the shaft will turn proportionally to $d\,y$, as will also the sphere about its horizontal diameter $x\,x$ parallel to the shaft. The turning communicated to R^1 will be proportional to $\sin n\,\theta,\ d\,y$, and that communicated to R^2 will be proportional to $\cos n\,\theta,\ d\,y$. If the tracer moves round the whole curve, these two wheels will therefore register numbers proportional to A_n and B_n. The dimensions are so chosen that the readings give $n\,A_n$ and $n\,B_n$ in centimetres.

Fig. 12 illustrates an analyser with five spindles, giving the first five pairs of coefficients A, B, in Fourier's expansion, for *one* tracing of the curve. The integrators are the same as in Fig. 10. The pulleys at the top of the vertical spindles have their diameters in the ratio $1;\ \frac{1}{2};\ \frac{1}{3};\ \frac{1}{4};\ \frac{1}{5}$; so that the angular velocities of the spindles are in the ratio $1;\ 2;\ 3;\ 4;\ 5$. When the instrument is not in use each of the glass spheres is held firmly between two celluloid rings, placed one above and one below it. The same screw which is used to press the wheel r against the glass sphere serves to release the sphere from the celluloid rings.

Sharp's Integraph.—The mechanism of the integrator has been described in a Paper read at the Physical Society, June 22, 1894. Fig. 13 is a diagrammatic plan of the instrument exhibited. The frame, rectangular in plan, rests by three wheels w, w, and w, on the paper; two of these wheels are fixed on the same shaft, which is set parallel to the direction

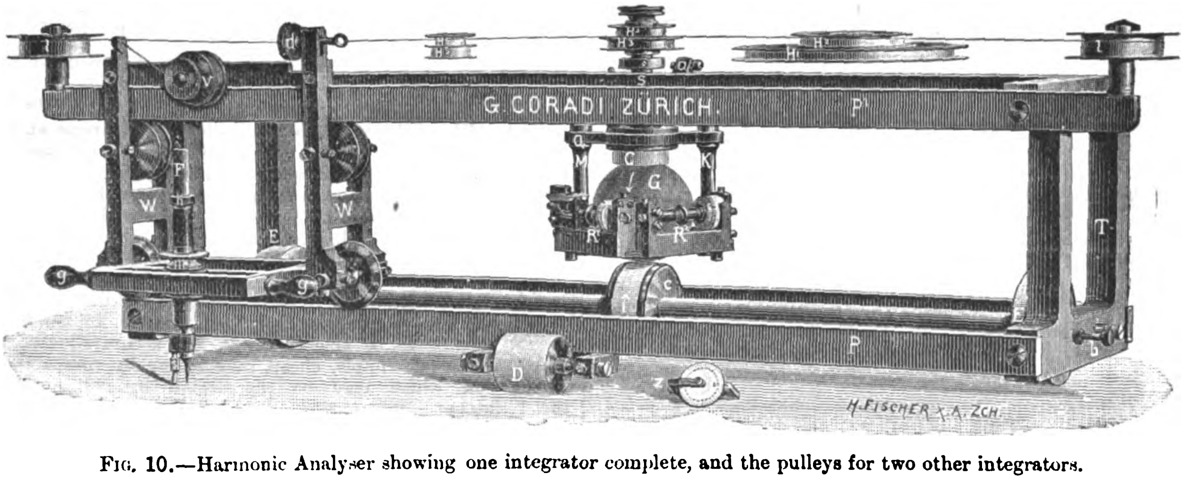

FIG. 10.—Harmonic Analyser showing one integrator complete, and the pulleys for two other integrators.

moved through a distance, $d\,y$, the shaft will turn through an angle proportional to $d\,y$. The shaft carries a short "cylinder," C, above which is a vertical "spindle," S, whose geometrical axis cuts that of the shaft. A pulley, H_3 or H_4, is fixed near the top, and the integrating apparatus proper near the lower end of the vertical spindle.

The spindle is turned as follows: Along the front of the frame runs a carriage, W, to which the tracer F is fixed. This of the ordinates y. On this shaft is formed a spherical enlargement b, on the top of which rests the horizontal cylinder c. This cylinder is pivoted on a frame carrying also the pulley p_2 with vertical axis; the frame can run on rollers on another frame which forms one rigid piece with the lever l, and which can turn about the axis of the vertical spindle s. The vertical spindle s is carried by a bridge, B B, underneath which the integrating cylinder c and its frame can swing freely. A carriage

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carrying the tracer T_1 can run freely along the rail R_1, parallel to the axis of y. A pin t at the end of the lever l engages in a slotted groove of the tracer carriage parallel to the axis of x.

Let the axis of x pass through the axis of the vertical spindle s, let ϕ be the angle the axis of the cylinder makes with the axis of y, and let c be the length of the lever l, then

$$\sin \phi = \frac{y}{c}.$$

If, while the lever is in this position, the tracer T_1, and with it the whole instrument, be displaced a distance dx, the turning

cessively round the pulleys $p_1, p_2, p_3, p_5, p_6, p_7$ and then fastened to the tracer carriage T_2. If the tracer T_2 move over a given curve $f(x)$, then evidently the pencil P will draw a curve which is a particular integral of the differential equation

$$\frac{dy}{dx} + cy + f(x) = 0,$$

c being a constant.

In order to avoid the use of springs or weights for keeping the wires taut, the wires and guide pulleys are duplicated as shown.

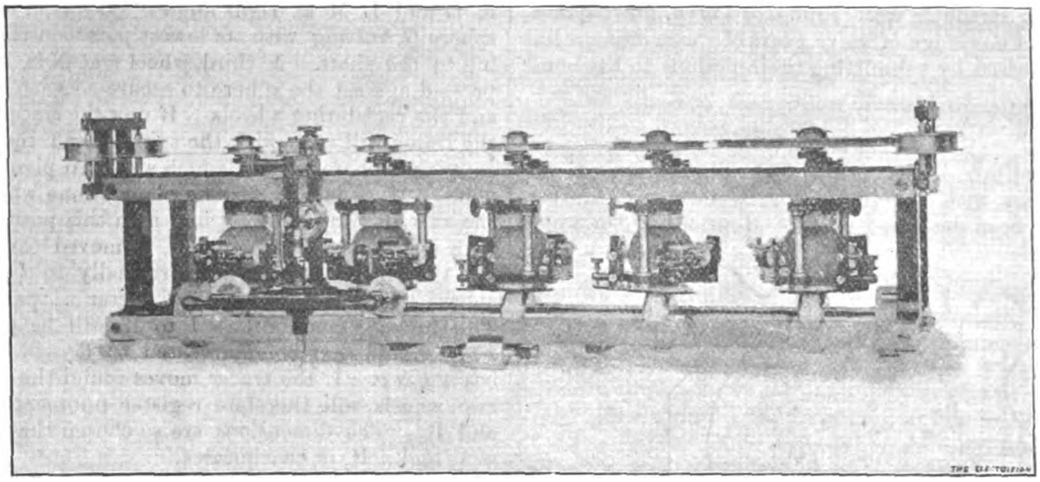

Fig. 12.—Harmonic Analyser with five integrators.

of the sphere b will be proportional to dx, and if there is no slipping between the sphere b and cylinder c, the turning of the cylinder about its axis will be proportional to $\cos \phi \, dx$, and the travel of the cylinder along its own axis will be proportional to $\sin \phi \, dx$, *i.e.* to

$$y \, dx$$

That is, the displacement of the cylinder carriage, and with it the pulley p_2, along its axis is proportional to the area of the given curve.

This displacement is transmitted to the carriage carrying the pencil P as follows: A pulley p_1 co-axial with the vertical

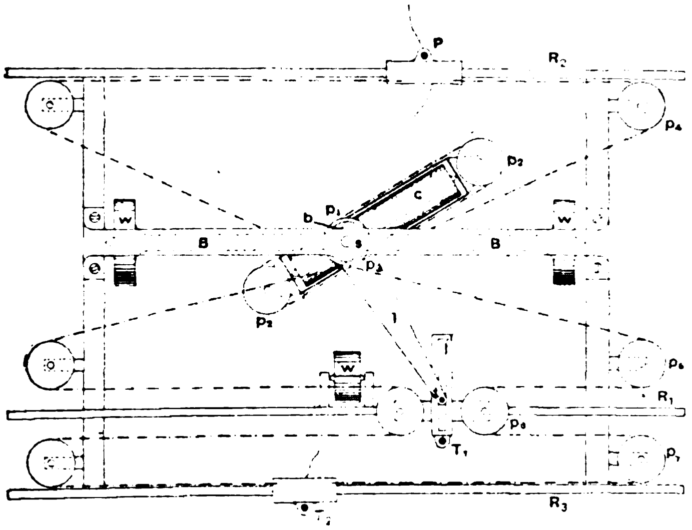

Fig. 1

spindle s, is *fixed* to the bridge B, a silver wire is wound round p_1, round the loose pulley p_2, round a *loose* pulley, p_3, co-axial with s, then round a guide pulley p_4, and fastened to the pencil carriage, which is free to move along the rail R_2 parallel to the axis of y. Thus, if no motion be given to the instrument in the x direction, a motion of the tracer T_1 in the y direction will produce no motion of the pencil P.

A third carriage carrying a tracer, T_2, moving along the rail R_3 is added to the instrument. A second wire is wound suc-

DISCUSSION.

Prof. EVERETT said that the first account of Amsler's planimeter of which he knew was given in Rankin's "Applied Mechanics." The treatise on "Mensuration" in Weale's series, published 1864, contained three different proofs of the property of the instrument. One of these proofs was due to J. R. Hyde, and consists in reducing it to particular case of Guldin's theorem: The length of a line multiplied by the normal distance moved through by its middle point is equal to the area swept out by the line. He had taught his classes for some years previous a similar proof, considering the bar to revolve about the point where the wheel is. A rigorous proof is obtained as follows: If any polygon moves in its own plane, the change in the area of the polygon is equal to the sum of the areas described by its sides. In the present case the polygon reduces to a triangle, of which two sides are of fixed length, and the length of the third side is variable. The change of area of the triangle—after the tracing point has moved once round the given curve—is zero, and therefore the area swept out by the three sides in zero. The area swept out by the pole-arm is, of course, zero; and therefore, with proper attention to sign, the area swept out by the bar is equal to that swept out by the third (variable) side of the triangle. But the area swept out by the variable side is $\frac{1}{2}\int r^2 d\theta$, the area of the given curve; which is therefore equal to that swept out by the bar, and registered by the wheel.

Prof. HELE-SHAW: It is impossible in the time at our disposal to properly discuss the Paper. The classification of planimeters which Prof. Henrici has adopted, and which admirably explains their action, is a geometrical one; the classification given by myself is a mechanical one. It is, perhaps, only natural that a mathematician should give a geometrical and an engineer a mechanical classification. I should like to discuss at length—but cannot on account of time limits—the question of classification. What we are interested in is the obtaining of a practical working instrument. There seems to be two distinct and different kinds of instrument; the one, expensive, complicated, difficult to use and requiring a special training to be able to use it, but accurate; the other, a workshop instrument, simple, cheap, easy to use by comparatively unskilled hands, and which may be represented by its latest development, the "Hatchet" planimeter. I think it would be desirable to have on some other occasion a discussion on this instrument.

Prof. C. V. BOYS: The only point to which I would like to refer is the question of making differentiators, and on this point, unless I have misunderstood him, I venture to differ from Prof. Henrici. The process of integration smooths off angles and irregularities, and if the given curve is irregular in outline the integral curve will be smoother and more regular. The process of differentiation, on the other hand, magnifies any irregularity in the given curve. I agree with Prof. Henrici that it is impossible to make a differentiator moved by a tracing point guided over a given curve. But take the case of my own integraph, consider the rolling wheel which draws the integral curve; it may be viewed as the front wheel of a bicycle. If the rider of the bicycle can so control his steering that the front wheel follows exactly a curve drawn on the ground, the case would be analogous to the conversion of the integraph into a differentiator. Let the given curve, the differential of which is required, be drawn on the paper, and let

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the instrument be guided by moving the tracing point up and down in the y direction as the instrument moves in the x direction, so that the rolling wheel moves over the given curve; the tracing point will then describe a curve which is evidently the differential of the given curve, since the given curve is the integral of the curve described by the tracer.

THE DIFFUSION OF LIGHT BY DULL SURFACES.*

BY CHRISTIAN WIENER.

Historical Data, and Nature of Dispersion.

The investigations concerning the dispersion of light by dull surfaces described and discussed in the following Paper, were suggested to me by the problem, appertaining to my teaching subject of descriptive geometry, of representing bodies with their appropriate degrees of brightness. The richest sources of theoretical and experimental investigations capable of affording a basis for the solution of this problem are even now found in two works dating from the middle of last century, viz., Lambert's *Photometria* (Augsburg, 1760), and Bouguer's works on optics (Paris, 1729 and 1760). These works have, up to the present, hardly been utilised for that purpose, and I have, in my treatise on descriptive geometry, attempted to draw upon them to a greater extent. Now, whereas the intensity of illumination of an element of the illuminated surface is known to be proportional to the intensity of the source divided by the square of the distance from the element and multiplied by the cosine of the angle of incidence ϵ, the brightness of the element as it appears to the eye is proportional to that intensity of illumination and to the reflective capacity (Lambert's *albedo*). But the direction along which the element is seen may also have some influence. This influence is determined, according to Lambert, by the cosine or *Lambert's law*, according to which a surface element which diffuses the light received, reflects under an angle of reflection a an amount of light which is proportional to cos a. But since the apparent size of the element is also proportional to cos a, the brightness of a dull surface is, according to Lambert's law, independent of a, or the surface appears with the same brightness from whatever point it may be observed.

But that Lambert's law is not generally true was already shown by Bouguer's observations. He found, in a manner also adopted in my own experiments, that when the direction of incidence and of vision were nearly parallel, the brightness was not proportional to cos ϵ, as it should have been according to Lambert; but that with increasing ϵ it decreased more rapidly than cos ϵ.

In drawings, Lambert's law, although not strictly correct, is employed almost exclusively, and with good effect, the brightness being taken as proportional to cos ϵ. On the other hand, it has been proposed to make the brightness equal to cos ϵ . cos a, and again to cos ϵ : cos a. The substitution of cos ϵ . cos a is, however, certainly incorrect. For that would make the brightness zero for $a = 90^\circ$, or for places where the lines of vision touch the surface, *i.e.*, at the boundary. This is in direct opposition to common observation. The substitution of cos ϵ : cos a was proposed by Brisson (in his edition of Monge's *Géometrie Descriptive*, 1827). According to that law the boundary should appear brightest, and Brisson really refers to the circumstance of the full moon's limb appearing brightest, although containing the terminator between light and darkness, and therefore the least illumination. But Bouguer and Zöllner explain this phenomenon by the obvious consideration of the strong inequalities of the moon's surface, and as a matter of fact a body with a smooth but matt surface does not show a brighter contour (as will also be shown later on), especially if the contour is also the boundary between light and shade.

Herr Lommel† has also made some theoretical investigations into the diffusion of light by starting with Fourier from the supposition that this diffusion does not proceed from the surface, but from volume elements of the mass of the body, as is demanded by the colouring of the diffused light. For opaque, solid-glowing bodies he thus arrives at the cosine law; for the length of the path described in the interior of a body by a ray of light before its complete absorption depends only upon the absorptive power, but not upon the angle of emergence a, so that the vertical depth of this diffusing layer, and hence also the amount of the diffused light must be proportional to cos a. This result was confirmed by Herr Möller‡ by observations of glowing metal plates. In a later Paper§ Herr Lommel investigated the brightness of diffusing bodies, and followed up the gradual absorption of the light penetrating to a certain depth and its emergence. He thus arrived at a formula for the intensity of the reflected light, which depends, after the absorptive and diffusive power of the substance and the thickness of the diffusing layer—the latter only of importance when very thin—only upon the angles of incidence and emergence ϵ and a, and is symmetrical with respect to these, so that the quantity of the light reflected by an element of the surface is not altered by exchanging the incident and emergent rays.

These results are based upon the tacit assumption that no reflection takes place, and that the surface is perfectly matt or rough. And for such surfaces they are perfectly cofirmed by Angström's extensive observations on the diffusion of radiant heat carried out at Strasburg.* By smoking with various substances, or by decantation from liquid suspension he produced perfectly matt or rough surfaces, which showed no reflection even at high angles of incidence, and found the above laws confirmed within a fair approximation. But other bodies, such as paper and cast gypsum showed increased brightness in the direction of reflection. . . .

The explanation of the diffusion of light by dull surfaces has been based upon two assumptions. The first is that of the penetration of the disturbance to a certain depth, and the radiation in all directions of this disturbance out of the layer penetrated. This view is supported by the colour possessed by the dull surfaces, and by many experiments, such as those of Angström, according to which the diffusion increases, within certain limits, with the thickness of the dull layer laid upon a previously smoked surface; thus, in the case of magnesia 0·26mm. thick it was, *ceteris paribus*, about double what it was with a thickness of 0·05mm.

It was upon a different hypothesis that Bouguer based a detailed theory of the diffusion of light. He supposed the rough surface to consist of a large number of small plane-reflecting surface elements lying in all directions. The total area of these surfaces in a given direction is greatest in the direction of the general surface, and decreases as the angle to it increases, thus producing a preponderating reflection in the sense of the effect of the general surface. To determine the amount of the surface elements in a given direction, Bouguer measured for different bodies the brightness observed when the directions of incidence and emergence very nearly coincided. Since in this case, according to his assumption, it is only the surface elements perpendicular to this direction which have any effect, and these are always at the same zero angle of incidence and emergence, the total area of the surface elements thus arranged is proportional to the brightness produced. . . . In making the amount of reflected light only dependent upon the direction of the bisector of the angle between the incident and the emergent ray, but not upon the magnitude of this angle, he neglected the fact that with a large angle of incidence the reflection is much stronger than when it is small, although on another occasion he proves it experimentally in the case of pure mirrors. His limited experiments with dull surfaces did not bring him face to face with the contradictions of his theory by the facts, as he only observed with the incident and emergent rays coinciding.

We therefore arrive at the result that in the case of dull surfaces we have to deal both with a penetration of the rays and with a diffusive reflection by small surface elements. But these circumstances are so different with different degrees of roughness and with the different forms of the prominences that in each case nothing but observation will give a clue to the actual state of things.

Let me therefore now describe the observations made in 1883 with the assistance of my son Otto in the case of cast gypsum, as well as the surfaces of brightness resulting from these observations.

The Diffusion of Light by Cast Gypsum.

I procured two equal square plates of 25cm. side, made of the best white gypsum, and illuminated them in an otherwise dark room by one stearine candle (six to the pound) each. I could enlarge their flames by bending the wicks into the interior of the flame, and kept the flames as much as possible of equal size. As a unit of brightness I adopted that shown by such a plate when illuminated perpendicularly by a candle at a distance of 1 metre, and seen perpendicularly. The directions of illumination and vision could not really coincide, but since the brightness does not change much with small deviations from the angles of incidence and emergence, both angles could be taken as equal, and equal to zero. The distance of the observer's eye from the plate has no influence upon the brightness. The light was shaded from the eye by a screen. When the distance of the light from the first plate (which we shall denote by I.) was altered from 1m. to am., with $\epsilon = a = 0^\circ$, the brightness changed in the proportion 1 : a^2, and this served as a measure of brightness for the second plate (II.). The latter was placed so that its margin and that of I. apparently coincided, and that it was observed by the eye under the angle of emergence a. It was then illuminated by a second candle at a distance of bm. at an angle of incidence ϵ in such a manner that the azimuth (the angle between the plane of incidence and that of emergence) was ν. The two sources of light were screened in such a manner that each of them only illuminated one of the plates, and that neither

* *Wied. Ann.* Vol. XLVII., p. 638.

† "On Fluorescence," *Wied. Ann.*, Vol. X., p. 449, 1880.

‡ "The Law of Light Emanation from Glowing Bodies," *Wied. Ann.*, Vol. XXIV., p. 266, 1885.

§ "The Photometry of Diffused Reflection," *Wied. Ann.*, Vol. XXXVI., p. 473, 1889.

* "On the Diffusion of Radiant Heat by Plane Surfaces" *Wied. Ann.* Vol. XXVI., p. 253, 1885.

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shone into the eye. Then plate I. was shifted until both plates appeared equally bright at their apparently coincident edges, so that their images coalesced, and observation was aided by holding in front of the eye a screen with a hole through which one could only see small and apparently nearly equal portions of the two plates. Then on measuring the distance of Plate I. from the light, and finding it $=a$, the brightness of the two plates was $1:a^2$, and the brightness H of Plate II. would, with the light at 1m., be $H=b^2:a^2$. But this is the quantity required, viz., the brightness exhibited by Plate II., at an angle of incidence ϵ, an angle of emergence a, and an azimuth ν, when illuminated by a light at a distance 1m.

To measure these last three angles, or rather to produce certain magnitudes of them, I cut a circular disc of cardboard of about 18 cm. radius, cut it through along one radius, and made a light cut along the radius produced, and along another radius at right angles to it, so that by bending a solid angle could be produced (Fig. 1), with two right-angled sides and angles, but so that the third side and angle could be changed together from 0° to 180°. On placing this variable side upon the plate of gypsum, the edge not lying on it represented the normal to the surface, the rectangular sides bounded by it were used as planes of incidence and emergence, and the third or variable side gave its azimuth. The azimuth angles being divided from 30° to 30°, the angles of incidence and emergence from 15° to 15°, and also indicating 82½° and 86¼°, and a string attached to the vertex being directed in those planes towards the eye and towards the light, it gave the angle of incidence and emergence, while the basal semicircle showed the azimuth. The movable right angle was sometimes fixed on a certain azimuth by paper strips stuck on, so that all measurements could be taken for that azimuth in succession.

In this manner the brightnesses were measured for the values of ν, a, and ϵ referred to, two or more readings—in rare cases only one reading—being taken for the same angles. Thus, for $\nu=30°$, $\epsilon=30°$, and $a=75°$, the distance of Plate II. from the light was $b=1·225$m.; then Plate I. was shifted under perpendicular incidence and emergence until it appeared to fuse with II., and its distance from the light was then found to be $a=1·465$m. At a

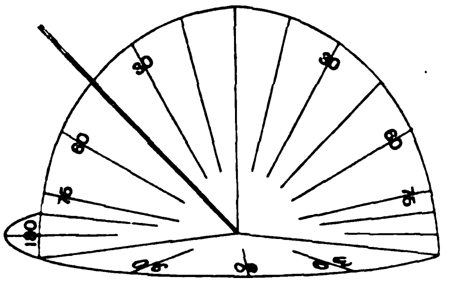

Fig. 1.

distance of 1m. the brightness of II. would then have been $H=(1·225:1·465)^2=0·701$. A second reading gave $a=1·225$m., $b=1·405$m., whence $H=0·762$.

To obtain a measure of the accuracy attained, I placed the two plates of gypsum side by side, and exposed them at their edges to vertical illumination by the same source. Then I had one of them shifted until the images appeared to fuse, measured the distances of the movable one, and found them to vary between the extreme limits 0·746 and 0·774m., and therefore their brightness between $(1:0·746)^2$ and $(1:0·774)^2$; *i.e.*, between 1·797 and 1·666, or by 0·131. The greatest relative variation was, therefore, $0·131:1·738=0·075$, where 1·738 was the mean brightness. But the greatest departure from the mean was 0·072, and the relative departure $=0·072:1·738=0·0406$. The mean relative error was, therefore, $=0·0196$. The uncertainty was greater when two lights were employed, whose difference was then brought into play. The differences between two measurements could then amount to 0·1 of the brightness; in rare cases to 0·15. On the average the relative departures of two measurements from each other was 0·06, hence the departure from the mean 0·03. If, on the other hand, differences of brightness of 0·01 and less could be observed—as in the case of a feeble grey ring on a white background, produced on a rapidly rotating white disc by a black streak—it must be borne in mind that in this case only one source of light was brought into play, and that the eye is peculiarly sensitive to such a ring surrounded by white spaces.

Considering the error attached to the measurements, their comparison had to be undertaken with all the greater care. This was done geometrically according to the law of continuity. Surfaces of brightness could be drawn, after Bouguer's example, in various ways. If, for a certain incident ray—that is, for a certain value of ϵ—the brightness H is cut off along each ray proceeding from the same point, F, of the surface, the terminals of these lines representing the apparent brightness of the surface form a surface called the surface of brightness. By Lambert's law this brightness would be uniform and $=\cos\epsilon$, and therefore the surface of brightness a hemisphere of this radius. But if along these rays are cut off the quantities of light radiated from the same surface element, taken as the unit of surface, these quantities being $=H\cos a$, we should obtain another surface, that of radiated quantities of light, and this would by Lambert's law be another sphere, but touching the surface in F, and of a diameter equal to the radius of the first hemisphere. Finally, we may draw from F a fixed emergent ray, with constant a, and cut off along each ray incident upon F of the same intensity, the brightness imparted to the surface under its influence. This might be called the *surface of illumination*, since for every direction of illumination it gives the brightness along a fixed line of vision. It differs from the surface of brightness by touching the illuminated surface in F, whilst the surface of brightness cuts it along an extensive curve, because for glancing rays of light the brightness becomes zero, but remains finite for glancing visual rays. By Lambert's law we should have to cut off the brightness $\cos\epsilon$ along each incident ray, hence the surface would be a touching sphere of unit diameter; it would be independent of a, and, therefore, the same for every direction of the emergent ray. In the following we shall only consider the brightnesses, but not the quantities of light radiated by unit surfaces, so that we shall only have to deal with the surfaces of brightness and of illumination.

Now, these surfaces are continuous, and by means of their continuity we may correct the errors of the measurements. In the surfaces of brightness ϵ is invariable; and on laying a plane through the normal to the surface we obtain a curve of intersection for whose two halves we have the azimuths ν and $180°-\nu$ with constant ν, in which H only varies with a. We shall call such a curve a *meridian curve*. But if we describe an intersecting cone with F for its apex and the surface normal for its axis of revolution, *i.e.*, with constant a, H will vary with ν. Such a curve we shall call the *cone curve*. In the same manner the surface of illumination gives meridian curves and cone curves.

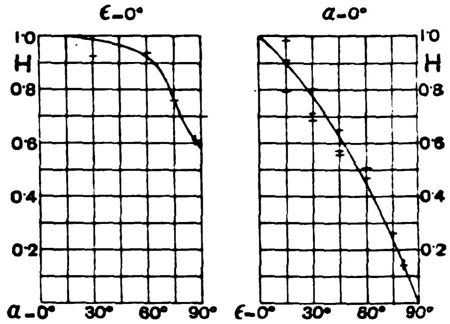

Fig. 2.

Since H depends upon the three independent variables ϵ, a, and ν, we obtain these curves by leaving two of the latter quantities constant; then H is only dependent upon the last of the three variables. Since ϵ, a, and ν are angles, and H a ray, each of the curves is given by polar co-ordinates. Cutting off on these rays the values of H obtained by measurement, the curve drawn through their terminal points will not be continuous on account of the errors of measurement, and we must then draw a continuous curve as far possible approximating to the points derived from observation. Thus we attain three species of curves:

(1) With constant ϵ and ν, the meridian curve a H.
(2) With constant a and ν, the meridian curve ϵ H.
(3) With constant ϵ and a, the cone curve ν H.

The last curve lies on a cone of revolution, and takes two forms, since in one case the constant ϵ denotes a fixed incident ray, and the curve lies on the cone $a\,\nu$, and in the other case a denotes a fixed emergent ray, and the curve lies on the cone $\epsilon\,\nu$. But the determining elements ν H are the same in both cases. Thus we obtain essentially only the three kinds of curves enumerated above. If one of these curves, *e.g.*, that for a H, belonging to a certain ϵ and ν, is kept continuously in the neighbourhood of the observed points, then we have a fixed system of four co-ordinate values of ϵ, a, ν and H for each ray of this curve. But the curves ϵ H and ν H contain the value of H for the same ray, and must yield the same value of H for it. Hence we are given the difficult problem of drawing three groups of curves, a H, ϵ H, and ν H which approximate to the points derived from observation, which are continuous, and in which the three values of H corresponding to the same a, ϵ, and ν are the same. The number of curves depends upon the intervals chosen. For measurement I usually chose intervals of 30°, for drawing usually 15°; in the measurements I chose for ϵ and a the angles 0, 30, 60, 75, 82½, 86¼, and 90°—the last angle being the limiting angle, obtained by con-

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tinuous extrapolation—for ν the angles 0, 30, 60, 90, 120, 150, 180°. I drew 41 such curves by their polar co-ordinates, this producing true meridian curves, and the cone curves on the developments of the cones. But I found that the sensibility of the eye for continuity was not as great as could be desired, and I, therefore, proceeded to rectangular co-ordinates. A constant H gives with polar co-ordinates a circle, in rectangular ones a straight line. The deviations from a straight line can be more delicately perceived than those from a circle, and also in other curves deviations were more readily detected in rectangular than in polar co-ordinates.

To give an idea of the latter curves I have reproduced some of them. Fig. 2 gives the two most important ones, that for $\epsilon=0°$, *i.e.*, for the vertically incident ray, and for $\alpha=0°$, or the vertically emergent ray, for both of which ν is without influence. Fig. 3 gives the series of curves ϵ H for $\alpha=75°$, and for ν successively

2. As α further increases from 60° to 90°, the brightness on the whole diminishes, and at the limit of $\alpha=90°$, or with a glancing visual ray, it is about 0·6 times that at $\alpha=0°$.

3. On the side opposite to the incident ray—*i.e.*, on the side of reflection—the brightness is greater than at the corresponding points of equal α on the same side.

4. The reflection is more pronounced and evident the larger the angle of incidence ϵ. With $\epsilon=45°$, and even more with $\epsilon=60°$, it is shown by increased brightness, but not as yet by a clear reflected image or by superior brilliance. The greatest brightness H amounts for $\epsilon=60°$ to 1·03, whilst the mean brightness is somewhat smaller than cos ϵ or 0 5, and this applies to $\nu=180°$ and $\alpha=67°$, *i.e.*, in the case of an angle of emergence which is greater than the angle of incidence (60°). Even with an azimuth less than 180° a decided increase of luminosity is perceptible, up to $\nu=162°$. For $\epsilon=75°$

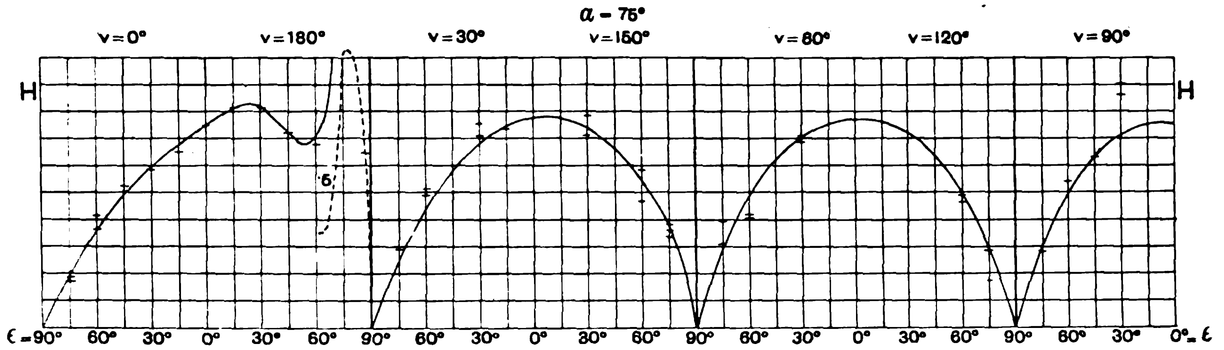

Fig. 3.

=0 and 180, 30 and 150, 60 and 120, and 90°. The ordinates H are filled in for the given values of ϵ, and the observed values of H are indicated by small dashes. Thus we obtain an idea of the degree of accuracy. Here we see that the observations for $\alpha=75°$, $\nu=90°$, $\epsilon=30°$ strongly diverge from the curve drawn, so that these observations are useless; perhaps in this case the sources of light had become very unequal. When $\nu=180°$ we observe the pronounced effect of reflection; the curve in this case could for some distance only be given in half ordinates. Twenty-three such series were drawn. These curves, like those for polar co-ordinates, had to be drawn so that they most closely approximated to the points of observation that they were continuous, and that each ordinate H, recurring in each of the three groups, had the same value at least three times. Thus the transition between neighbouring curves also became continuous. . . .

reflection and brilliance becomes evident, between $\alpha=73°$ and 90°, strongest with H=2·2 when $\alpha=79°$ and cos $\epsilon=0·26$. When $\epsilon=82\frac{1}{2}°$, reflection extends from $\alpha=73°$ to 90°, and is greatest with H=5·2 when $\alpha=85$ and cos $\epsilon=0·13$. For $\epsilon=86\frac{1}{4}°$, reflection extends from $\alpha=78\frac{1}{2}°$ to 90°, and is greatest with H=14·4 when $\alpha=88°$ and cos ϵ =0·07.

We notice, therefore, that reflection is always greatest with an angle of emergence α, always somewhat larger than ϵ. If we assume with Bouguer (confirmed by these results) that the area of the reflecting surface elements becomes larger as the angle between them and the general surface decreases, the phenomenon of α being larger than ϵ for strongest reflection is easily explained. For perceptible reflection α and ϵ are angles which exceed 60°, and do not differ much among themselves. If we now leave ϵ constant and make α exceed ϵ somewhat, then $\alpha-\epsilon$ and $\alpha+\epsilon$ will also increase as

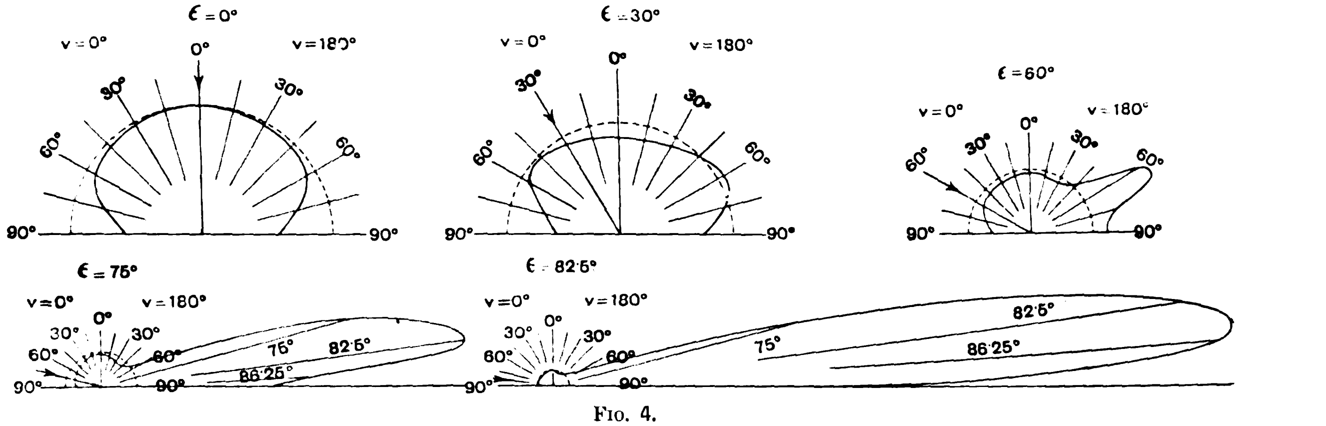

Fig. 4.

In Fig. 4 are given the meridians of incidence upon the surfaces of brightness, *i.e.*, for $\nu=0$ and $=180°$, and for $\epsilon=0$, 30, 60, 75, and $82\frac{1}{2}°$; the dotted semicircles are put in with radii cos ϵ, and therefore belong to the surfaces of brightness corresponding to Lambert's law, which are hemispheres.

In Fig. 5 are drawn the meridians of the planes of emergence for those surfaces for $\alpha=0$ and $=60°$; the dotted circles belong to the surfaces of illumination according to Lambert, which form equal whole spheres of unit radius independent of α. . . . .

From these results I have in the introduction drawn conclusions respecting the process of diffusion of light by cast gypsum and by dull but not rough surfaces in general. Concerning the observed strength of diffusion by cast gypsum we can draw the following conclusions from the tables, or from the diagrams and models :—

1. With a constant angle of incidence ϵ and an angle of emergence varying between 0° and 60°, the brightness is pretty uniform, and usually somewhat smaller than that demanded by Lambert's law.

α increases. But the angle between the reflecting surface elements and the general surface is $\frac{1}{2}(\alpha-\epsilon)$, and the total area of these surface elements decreases as α increases, but not much, since $\alpha-\epsilon$ always remains small. But $\frac{1}{2}(\alpha-\epsilon)$ is the angle of incidence and reflection for these surface elements, and as it increases the amount of reflection also increases, especially, of course, with higher angles of incidence as here supposed. This increase therefore exceeds the former decrease, so that the strongest reflection takes when $\alpha > \epsilon$.

As regards, therefore, the imitation of brightness in painting, we see that fairly true results are obtained by observing in general Lambert's law, by reducing the brightness to 0 6 times that obtained according to Lambert at high angles of emergence, especially with glancing visual rays; but, on the other hand, by employing higher lights as the point of reflection is approaching, which pass into shining spots as the angle of incidence ϵ increases

It is very desirable that further investigations should be undertaken with different bodies of different qualities of surface, and

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with more delicate means than those at the disposal of the author, and that the surfaces of brightness should be determined in each case. For the art of painting such experiments would be of special

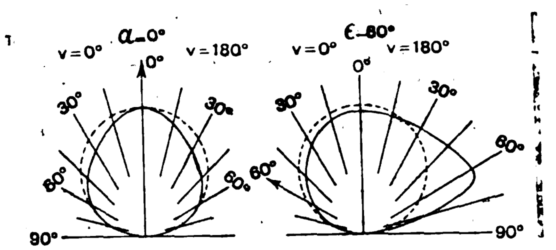

Fig. 5.

value in the case of dress materials, such as linen, cotton, silk, and velvet; and, further, the establishment of colour scales based upon these values.

THE ELECTRICAL EQUIPMENT OF THE LIVERPOOL OVERHEAD RAILWAY.

BY THOMAS PARKER, M. INST. C.E.

(*Continued from page 523.*)

When the Overhead Railway Company in 1891 decided to employ electric traction for their trains, the Electric Construction Corporation of Wolverhampton tendered for the equipment of the line, and secured an order for the complete installation, comprising boilers, engines, steam-pipes, dynamos, rolling-stock, station-lighting and signals. The plant was required to run a three-minutes' service on a double line 6 miles in length, and to accomplish this distance in twenty-nine minutes, including stops of half a minute at each one of thirteen stations. Each train was to consist of two cars, each car carrying fifty-six passengers, and being of an estimated weight of 12 tons 10 cwt. without motors.

To meet this service, twenty trains running at one time would be necessary, and in considering the power required at the dynamos, the subject was approached from its elementary basis. Curves were drawn to show the energy absorbed by one loaded train at every point in the whole length of the line, assuming various accelerations and intervals during which the brakes might be applied to bring the train to a standstill, the weight of a loaded train, with motors, being assumed to be 34 tons. These curves were modified and checked by the results of experience on ordinary railways, until results were obtained which would meet the service required. In most cases the stations were so near one another (in one instance under 300 yards, and in others 400 yards) that the brakes had to be applied long before the train could attain a uniform speed, the greater part of the energy supplied to the motors being expended in accelerating the motion of the train, which was required by the specification to attain a speed of 30 miles per hour, if necessary. From these curves it was an easy matter to calculate the power required for the whole service. This gave, allowing for the various electrical losses which were capable of being estimated, 1,200 to 1,400 amperes at 500 volts, which was the electrical pressure decided upon, or nearly 900 E.H.P. This was split into three units, and to allow for one spare, it was decided to use four dynamos for the generating plant, each having a normal output of 475 amperes at 500 volts, at 420 revolutions per minute, or, say, 1,200 E.H.P. in all.

Dynamos.—These are of the double limb type, with a magnetic circuit above and below the armature, the poles being cut through horizontally along the centre line to allow the upper part to be lifted readily. They are shunt-wound, of "drum" type, with stranded conductors. The resistance of the armature is 0·01 ohm, and that of the shunt is 75 ohms, the electrical efficiency of the machines being 97·7 per cent. The armature and shaft weigh 3 tons, and the complete machines 21½ tons each. Each dynamo is driven by nineteen 1¼-inch cotton ropes, from a horizontal compound engine, indicating 400 H.P. at full load.

The armature shaft carries a half-coupling, by which it is connected to the pulley shaft, which runs between two bearings; the armatures can thus be easily removed without disturbing the pulley and ropes. The dynamos are built on lines sufficiently massive to be capable of producing a much greater output than the normal for a short period without injury. They can check the engines, in the event of too heavy a call being made upon them, and so prevent any serious damage occurring to them in case of a continuous short circuit on the line.

Switchboard.—The switchboard was designed to ensure safety and simplicity in working. The current from each dynamo is connected to common omnibus bars through an ammeter and automatic magnetic cut-out, so that all can work in parallel. These cut-outs, which protect the generating plant, are also used as switches, and are thus always kept in working order. They are adjusted to break the circuit automatically when the current exceeds double its normal value, *i.e.*, 1,000 amperes, and have proved most effective. They came into frequent use whilst the trial runs were being made, before the contractors for the permanent way had finished their work on the overhead structure, when trolleys and materials lying about the line were continually causing short circuits. An iron bar could also be used in case of necessity at any part of the line as a main switch, to cut off the current by short-circuiting the conductor to the rails, without any other communication with the generating station, and it is probable that this was resorted to many times unnecessarily. A similar form of switch is used on the cars, and the guard can, independently of the driver, by applying the brakes, cut the current off the motors, and bring the train to a standstill.

From the omnibus bars the current passes through a main magnetic cut-out (adjusted to break circuit with a current of 3,000 to 4,000 amperes) to the centre conductor, from which the moving trains collect their current, by four $\frac{37}{13}$ "Callender" lead-sheathed and steel-armoured cables laid under the road between the generating station and the overhead structure.

Conductor.—The main conductor is of steel, 4 sq. in. in section (Fig. 1), rolled in lengths of 32ft. 6in., and weighs about 40lb. per lineal yard. It is supported between the main rails on wooden cross-sleepers, and rests on porcelain insulators. The insulators were designed for use with oil, but as the average leakage over the whole line is only 2 to 3 amperes this has been thought to be an unnecessary refinement. The steel channel is not rigidly

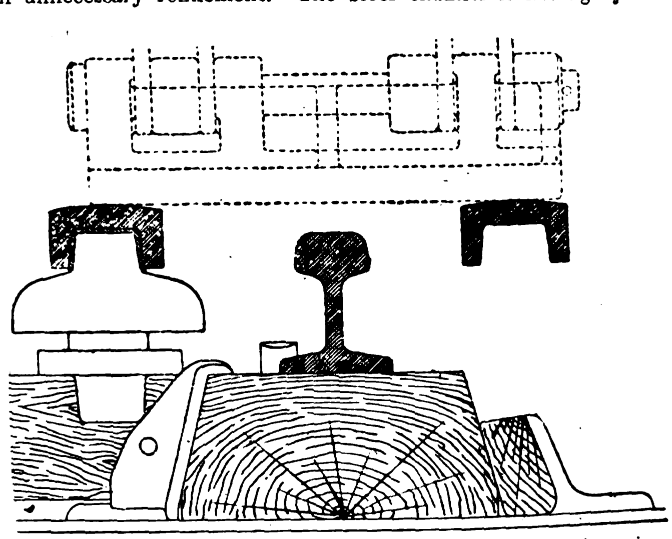

Fig. 1.—Section through main-conductors, rail, and sleepers at a crossing.

attached to the insulators in any way, and is supported by them at every 7ft. 6in., except where joints occur in the conductor, in which cases the insulators are 2ft. 6in. apart. The lengths of conductor are electrically connected by flexible copper straps. There are no feeders, and the return circuit is through the rails, which are united by wrought-iron bonds riveted to the web and bridging across the fish-plates. All four rails are cross-bonded at the stations, but are insulated from the structure by longitudinal sleepers. They weigh 56lb. per lineal yard. The return circuit has thus a sectional area of, approximately, 22 sq. in. At each station there is a cross-over road, and, in order to surmount the difficulty of carrying the charged conductor past the main rails at these points, it was broken, and each end was bent parallel to the main rail for some distance on each side of it (Fig. 2), being electrically connected under the rail, and fixed ⅜in. each above it. The collectors on the cars were made wide enough to bridge across the gap thus formed, without breaking the circuit.*

Cars.—The cars are of the "double-bogie" type, each car being an independent unit. To meet the conditions of the work, a motor was built with the armature direct upon the axle (of the type usually adopted by the author's firm for traction work) to give the torque effort required with ordinary "drum" winding four layers deep. Although this machine did all that was required of it in a test in the shops, the armature winding appeared so unsatisfactory mechanically that it was decided to experiment with a coil winding, and, after some practice, an armature was built with coils on Mr. Eickemeyer's system, described as a "winding composed of detachable counterpart coils, each of which is placed in immediate contact

* For illustration of these collectors, and for views of the line and engine room, see *The Electrician*, Vol. XXX. p. 422.

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with the periphery of the armature core." This allowed a thoroughly mechanical construction, and gave entire satisfaction, the actual results having so far borne out expectations, and no one of those built has shown any signs of weakness or of deterioration. The motor occupies the front half of the bogie truck. The magnets (which are of the horizontal "double-circuit" type) are maintained in correct relation to the armature axle by two cast-iron flitch frames, carried by forged extensions of the magnet yokes (Figs. 3, 4 and 5). The weight of the magnets is taken off the axles by means of adjustable springs suspended from the bogie-frame and attached to brackets at each end of the motor. To retain the magnets in a correct horizontal position, a lever arm projects from the inside end of the motor, and is attached to the bogie-truck beyond the bolster by rubber spring pads, top and bottom. The motors are series-wound, and develop 40-H.P. for any length of time without undue heating. The armature resistance is 0·67 ohm, and that of the field-magnet coils is 0·37 ohm. A large torque effort in this case was the chief object aimed at, the motors being coupled at the time of starting in series across the 500 volts without any resistance in circuit. The tractive force of each motor at the rim of the wheels (2ft. 9in. in diameter) with 100 amperes exceeds 1,450lb. (about 87lb. per ton of trains). Fig. 6 gives curves of torques and saturation of the magnets with various currents. The weight of each motor with its axle, but without the wheels, is 3 tons, and that of the motor-truck complete is 5 tons 7cwt.

That these motors will stand any stresses they are likely to be called upon to bear has been proved, and this fact has been found to be of great service in actual running; for, before the drivers were properly educated to their work, they frequently, on finding any difficulty with either motor on the train, such as brush-leads working loose, or brushes making bad contact, cut that motor out of circuit by means of a plug provided on the driving switch, and continued the traffic with one motor to the end of the line.

Control of the Trains.—The cars are furnished with both compressed-air and hand brakes. The switch gear is so arranged that when two cars are coupled together to form a train (Figs. 7 and 8, p. 520 ante). there is a driving-box at each end. But only one set of handles is provided for manipulating the switches, and these the driver takes with him from one end of the train to the other, when he arrives at the end of the journey. Either the driving or trailing motor can be plugged into circuit at will. The switches comprise a magnetic cut-out switch for making and breaking circuit, a driving switch which arranges the two motors, first in series and then in parallel (with a resistance in series with each), and, to attain a speed of 30 miles per hour as required by the specification, inserts a resistance in parallel with the field windings. A reversing switch is also interlocked with the driving switch, which must be turned to the series position before the currrent can be reversed.

Lighting and Signals.—The stations are lighted by 50-volt glow lamps worked by accumulators fixed underneath the platforms. The signals are automatic, and are worked from the same source. These accumulators are charged from the main dynamos in two loops, those of the northern portion of the line being charged in series in one loop, and those of the southern end in another one. At each station two independent batteries are fixed, coupled to a switchboard, so that either battery can be connected to the charging, or to the lighting circuit. These switches are so interlocked that both batteries can never be cut off the station circuit at the same time, although both can be run in parallel on to it. In this

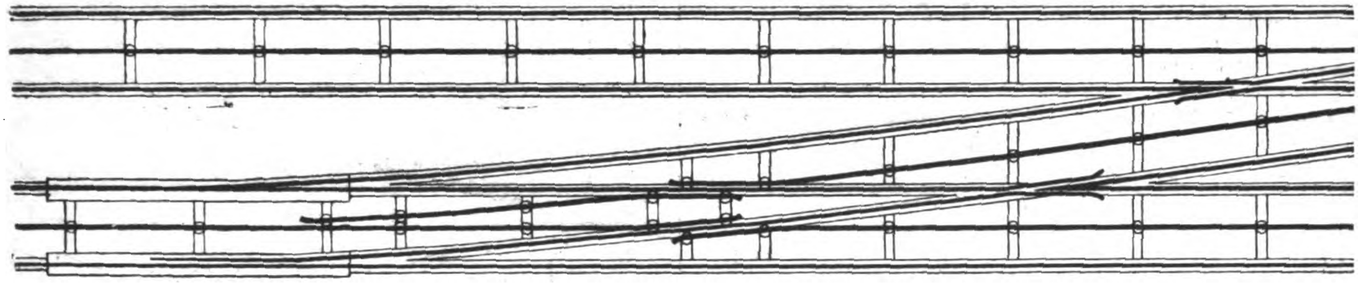

FIG. 2.—Plan of cross-over road showing method of bending the charged conductor (thick black line) to avoid passing the rail return.

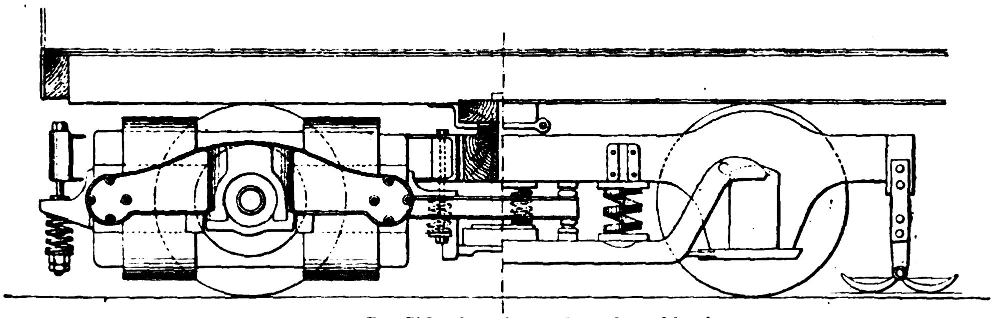

FIG. 3.—Side elevation and section of bogie.

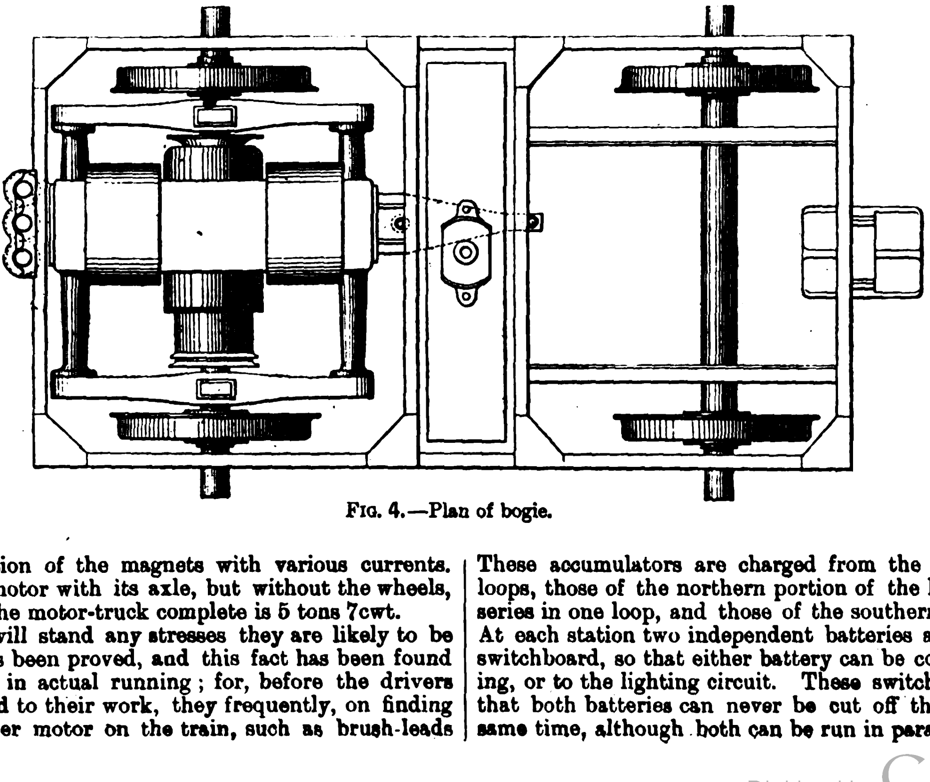

FIG. 4.—Plan of bogie.

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case the charging-main is short-circuited through the station so as not to interrupt the circuit for the batteries at the other stations. The batteries can never be on the charging circuit and on the station circuit simultaneously. These conditions were required by the Board of Trade.

Power at the Generating Station.—The efficiency of indicated horse-power to electrical horse-power on the line is very high, and results are given of special tests with carefully calibrated instruments. For this purpose No. 1 engine and dynamo were used. This engine had been running for some weeks, and was in thorough working order, the valves being carefully adjusted to give the best diagrams. The tests were taken after the engine had been running the traffic all day, when the load was transferred to a water-resistance tank. They lasted over three hours and a half, volts, amperes, and speed being kept constant, and readings and diagrams taken every half-hour. The details are given in the Appendix, and the diagrams of this and of each of the other engines in the

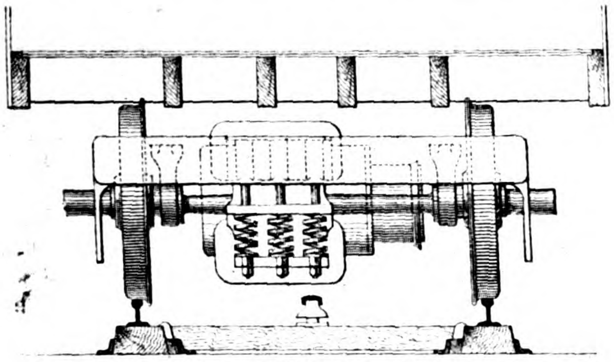

FIG. 5.—End elevation of bogie.

station running under ordinary conditions are given in the Paper. These diagrams were taken on both cylinders simultaneously by Tabor indicators. The electrical current was measured by a Kelvin hecto-ampere balance, and the pressure by a Kelvin electrostatic voltmeter. The results of the tests are :—

	Inches.
Diameter of high-pressure cylinder.....................	15½
,, ,, low-pressure ,, ...	31
Length of stroke	36

Mean efficiency (E.H.P. to I.H.P.), 88 per cent.
Coal consumed, 4,032lb.
Total E.H.P. hours, 1,195.
Coal per E.H.P. hour, 3·37lb.
Coal per I.H.P. hour (efficiency 88 per cent.), 2·96lb.

These results are eminently satisfactory, and are borne out by the low coal consumption in practice, of which mention will be made later.

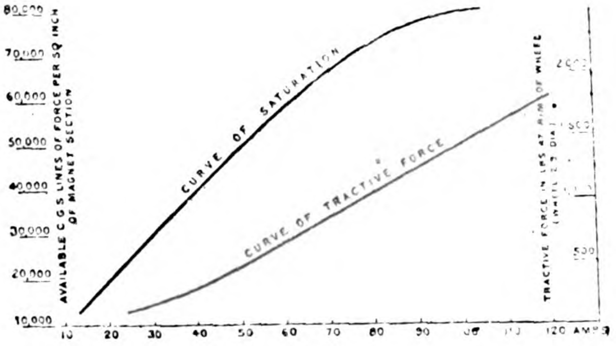

FIG. 6.

Curves are given (Fig. 7 being a sample) showing the power absorbed by a train during an experimental run covering the length of line at present open (5⅛ miles) in 24min. 57sec., with intervals of 25sec. stoppage at the stations, or an average running speed of 15·1 miles per hour. Also during one journey performed in 23min. 47sec., or at the rate of 16·1 miles per hour.

The particulars of these trials are :—

MARCH 5, 1893. FIRST JOURNEY.

Herculaneum to Alexandra (return). One train on line.

Loaded with 8 tons (iron weights).
Total time on journey, 24min. 57sec.
,, ,, current is on car, 17min. 7sec.
,, ,, train is standing, 4min. 35sec.
Total distance run, 9,030·4 yards = 5 miles 230 yards, say 5⅛ miles.
Average speed while running, 15 miles per hour.
,, ,, including stops, 12·3 miles per hour.
Average current per train while running, 82·7 amperes ; including stop, 67·3 amperes.
,, E.H.P. per train while running, 54·4 E.H.P., including stop, 44·4 E.H.P. = 33,300 watts approximately.
,, electromotive force, 485·2 volts on car.

MARCH 5, 1893. SECOND JOURNEY.

Herculaneum to Alexandra (return). One train on line.

Loaded with 8 tons (iron weights).
Total time on journey, 23min. 47sec.
,, ,, current is on car, 15min. 18sec.
,, ,, train is standing, 4min. 40sec.
,, distance run, 9,030·4 yards, say 5⅛ miles.
Average speed while running, 16·1 miles per hour.
,, ,, including stops, 13 miles per hour.
,, current per train while running, 90·8 amperes ; including stops, 73 amperes.
,, E.H.P. per train while running, 57·1 E.H.P., including stops, 46 E.H.P. = 34,500 watts approximately.
,, electromotive force on car, 484 volts.

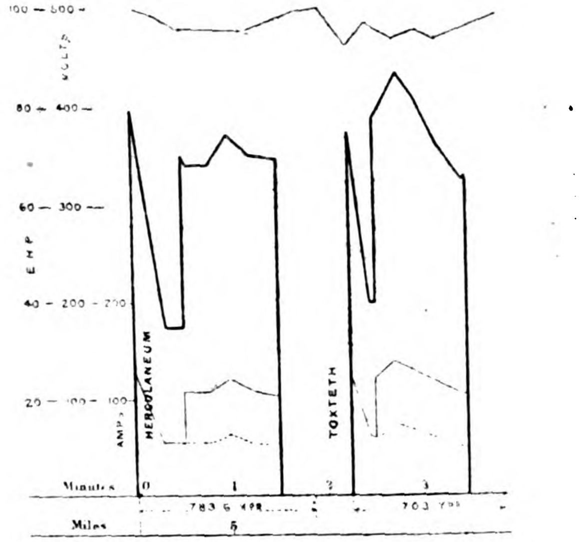

FIG. 7.

The weight of a car complete without passengers is 15½ tons. For the test each car was loaded with 4 tons, making the total weight of the train 39 tons. The average power absorbed was 44·4 E.H.P. at 15·1 miles per hour, and 46 E.H.P. at 16·1 miles per hour.

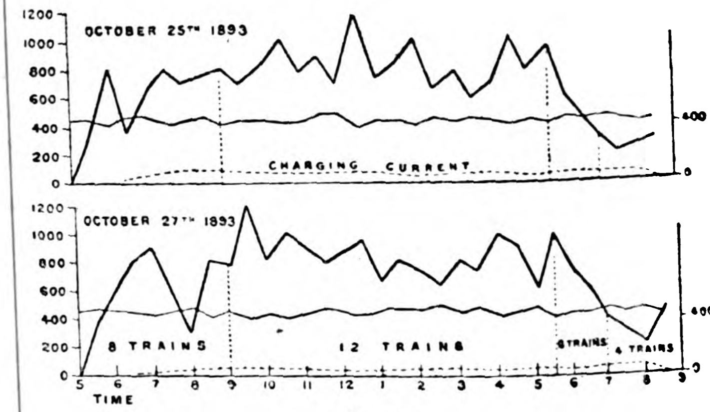

FIG. 8.

To compare this with the conditions of actual running, curves taken from the daily log-sheet are also given (Figs. 8 and 9) of the output from the generating station. Readings of volts and amperes were taken every half-hour. These readings include the current used for charging the station-batteries, and for a motor at the car-shed to drive air-compressors, &c. The battery charging current is also given. These curves show the current taken at different times of the day when the train-service varies ; and the advantage of a large number of trains in reducing the maximum current per train is at once apparent. When seven trains are in service, the maximum current attained is approximately 860 amperes, or, say, 123 amperes per train. This is twice the average current required by each train, whilst with twelve trains the maximum current from the generating station is 100 amperes per train, or only about one and a-half times the average current. Making the necessary deductions for battery charging and car-

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shed, the average demand for power continuously, with twelve trains running, is 37 E.H.P. per train. A plan of the line, with the distances between the stations, is given in Fig. 1, p. 493 ante.

A comparison of the consumption of coal when the number of trains is varied is interesting. During the month of April and part of May there were seven trains on the line, giving a ten-minutes' service from 5.10 a.m. to 6.40 p.m. During this period the coal burned was 22·55lb. per train mile. This includes coal for all purposes, no deductions being made for charging the station-batteries, &c.

From June to the beginning of October the train service has been as follows:—

5. 0 a.m. to 9. 0 a.m. eight trains in service.
9. 0 a.m. „ 5.30 p.m. twelve „ „
5.30 p.m. „ 7. 0 p.m. six „ „
7. 0 p.m. „ 8.30 p.m. four „ „
giving a five-minutes' service from 9.0 a.m. to 5.30 p.m.

The coal used for all purposes per train mile has been—

	Lb.
April	25·16
May	20·03
June	18·97
July	18·27
August	16·95
September	17·20

These figures show a continual steady decrease in fuel consumption. That for August is abnormally low, due to extra traffic during the holiday week, the car mileage on the 7th of that month being 21 per cent. greater than usual. On that day the trains carried 48,000 passengers, each train during the middle part of the

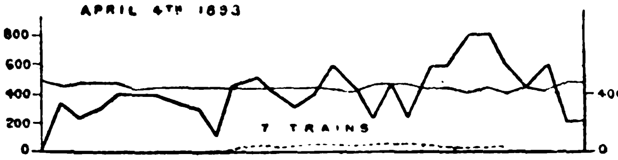

FIG. 9.

day being loaded with over three hundred people. The average weight of slack burned during the four months of June, July, August, and September, inclusive of all battery charging and power at the central station and car shed, was slightly less than 17·8lb., or, allowing for energy expended otherwise than on the trains, it may be taken at 17lb. per train mile.

TABLE SHOWING COAL CONSUMED PER KILOWATT-HOUR, &c.

—	Kilowatts generated.	Lbs. per kilo-watt-hour.	Lbs. per E.H.P.-hour.
April	69,954	8·40	6·32
May	86,627	6·90	5·17
June	97,789	7·10	5·30
July	109,909	6·70	5·00
August	117,843	5·95	4·44
September	119,328	5·81	4·34

During four days in June, owing to the dock from which condensing-water is drawn being emptied, the engines ran non-condensing, and an additional boiler was required.

The coal used is small Lancashire slack, having the following composition:—

	Per cent.
Fixed carbon	70·08
Volatile hydro-carbon	16·47
Sulphur	1·92
Moisture	3·01
Ash	8·51

Its calorific value is approximately 75 per cent. of that of best Welsh coal. The price of the slack which was used until the latter part of August was 5s. 10d. per ton; but since that date, owing to the strike in the coal trade, coal has been procured from various sources at prices ranging up to 17s. 6d. per ton.

Cost of Working.—Under their agreement, the contractors engaged to run the service of trains for the Liverpool Overhead Railway Company, and to supply all power, maintenance, drivers, superintendence, &c., if required, for a period of two years, for the sum of 3½d. per train-mile, which was estimated upon an average daily running of 2,400 miles. At the present time only 5¾ miles of line have been opened for traffic, and the contractors have received 4d. per train mile, as with a five-minutes' service, the total train mileage is necessarily decreased on the shorter line. For current to charge the station batteries 7d. per unit is received, which includes the maintenance of lighting and signal plant. In the Table on next page are given figures analysed from the actual working costs during the months of July, August, and September.

The increased cost of running during August and September is fully accounted for by the item of coal; and, taking into consideration the fact that the Overhead Railway Company has not employed so rapid a service as was at first anticipated, the average running per day being only about 1,350 train miles, the figures indicate most favourable results; as, even with this mileage, the trains were run at a fair profit for July and August, and it is evident that, with coal at a normal value, the line can be run at a cost within that guaranteed by the contractors.

In designing and executing the work described, the Author has received valuable assistance from Mr. J. H. Woodward, Assoc. M. Inst. C.E., and Mr. E. S. G. Rees, members of his staff, and from Mr. C. A. Rowlandson, M. Inst. C.E., who acted as the contractors' representative; and he further desires to acknowledge his indebtedness to Mr. S. B. Cottrell, Assoc. M. Inst. C.E., the Engineer and Manager of the Liverpool Overhead Railway Company.

Cost of Working, including the Lighting of Stations and the Signals.

—	Pence per train-mile.		
	July.	August.	September.
Supervision	0·416	0·416	0·416
Generating station, wages	0·618	0·590	0·628
Drivers' wages	1·076	1·043	1·058
Coal	0·589	0·718	1·230
Oil, waste, grease	0·140	0·139	0·129
Water	0·010	0·013	0·015
Stores and sundries	0·049	0·105	0·115
Cleaning and repairs, &c., at the car shed. Wages	0·545	0·521	0·539
Cleaning and repairs, &c., at the car shed. Material	0·284	0·430	0·221
Total	3·727	3·975	4·351
Allowance for signals and lighting	0·286	0·271	0·276
Cost of running	3·441	3·704	4·075
Train-mileage	39,250	41,430	40,640

The Paper is accompanied by numerous drawings and tracings, a selection of which has been made for the Proceedings.

APPENDIX.

EFFICIENCY TRIALS OF GENERATING PLANT, MARCH, 1893.

	Engine No. 1.						
Diagrams, Figs.	(*a*)	(*b*)	(*c*)				
Revolutions per min.	92	90	96	96	96	96	96
Steam, lbs.	116 0	116 0	116·0	118 0	119 0	114·0	116 0
Vacuum, inches	29 0	29·3	29·2	29·2	29·3	29·3	29·3
M.E.P. high pressure	57·5	56 9	58·1	54 6	56·5	54 1	57 1
„ low pressure	15·8	15·5	15·4	13·5	14·6	15 8	56 8
I.H.P. high pressure	181·1	175·6	191·0	179·6	185·7	178 0	187 7
„ low pressure	198·9	227·5	201·4	177 5	190·8	207 0	220·7
Total I.H.P.	380 0	403·1	392·4	357·1	376 5	385·0	408·4
Volts	508·7	517·5	517·5	512·5	520 0	527·5	510·0
Amperes	492 0	509·0	494·0	456·0	480·0	488·0	523·0
E.H.P.	335·0	353·1	342·7	313·3	334·6	345·0	357·5
Efficiency, per cent.	88·3	87·6	87·3	87·7	88·8	89·6	87·5

	Engine No. 2.			Engine No. 3.			Engine No. 4.		
Diagrams, Figs.	(*d*)	(*e*)	(*f*)	(*g*)	(*h*)	(*k*)	(*l*)	(*m*)	(*n*)
Revs. per min.	100	98	98	99	99	95	95	94	98
Steam, lbs.	117·5	118·0	114·0	115·0	114·0	119·0	125·0	119·0	117·0
Vacuum, inches.	27·3	27·5	27·2	27·3	27·1	27·2	27·1	27·2	27 3
M.E.P. high-pressure	42·8	50·9	66·8	44·5	54·0	62·8	44·2	55·4	63·5
M.E.P. low-pressure	5·92	8·36	17·0	7·02	9·25	14·5	6·88	9·72	18·5
I.H.P. high-pressure	146·7	171·0	224·0	151·0	183·3	204·6	144·0	178·6	213 4
I.H.P. low-pressure	81·1	112·0	227·2	95·2	125·4	188·6	89·5	125·1	203·1
Total I.H.P.	227·8	283·0	451·0	246·2	308·7	393·2	333·5	303·7	416·5
Volts	515·0	515·0	525·0	502·5	507·5	510·0	507·5	522·5	512·5
Amperes	259·0	332·0	540·0	287·0	380·0	492·0	267·0	306·0	522·5
E.H.P.	193·3	229·0	380·0	193·3	258·5	336·3	181·6	252·1	358·9
Efficiency %	...	...	...	78·5	83·7	85·5	77·7	83·0	86·2

The electrical data of Engine No. 2 are only approximate, readings relating to this test not having been taken on the standard instruments.

(To be continued.)

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TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

TENDERS INVITED.—The Corporation of South Shields invite tenders for a large quantity of plant, apparatus, and instruments, of which particulars are given in our advertisement columns. Copies of specifications, &c., can be obtained at the Borough Electrical Engineer's Office, South Shields, on and after the 17th inst.; and tenders must be sent in to Mr. J. Moore Hayton, Town Clerk, not later than October 31st.

——— The County of London and Brush Provincial Company require tenders for the supply and delivery of about 700 tons of 2in. and 2½in. cast-iron spigot and socket pipes. Further particulars can be obtained of Mr. A. J. Lawson, engineer and manager of the Company.

——— The Corporation of Cardiff invite tenders for wiring the Town Hall and market buildings, and supplying and fixing cables, casings, &c. Tenders must be sent in by the 12th inst.

——— The Corporation of Portsmouth invite tenders for the purchase of certain electrical plant at the Town Hall, Portsmouth, for which tenders have to be in not later than 6 p.m. on the 22nd inst.

TENDERS ACCEPTED.—The tender of Messrs. T. Scott and Co., of Birmingham, has been accepted by the Wolverhampton School Board for the installation of the electric light in the Walsall-street New School, for the sum of £233. 10s.

——— As stated in our issue for the 24th ult., the tender of Messrs. Crompton and Co. has been accepted by the Southampton Harbour Board for work in connection with the lighting of the Town Quay. Twenty-four tenders were received by the Harbour Board.

——— The Reading Electric Supply Company (Limited) have accepted the tender of Mr. E. Blackwell, of Reading, for basement, &c., works, at their central station, Western-road.

——— The tender of Messrs. Paterson and Cooper has been accepted by the Worcester Watch Committee for wiring the generating station at Powick for the sum of £206.

——— The tender of Mr. Grossmith, of Portsea, has been accepted for the electric light fittings for the new technical school.

CONTRACTS OPEN.—Our readers are reminded that the tenders for the supply of junction boxes, covers, and other castings for the Cheltenham Corporation, in connection with their electric lighting scheme, are due to-morrow, September 8th, as are also the tenders for the lighting of the outside of the Empire Palace of Varieties, Westgate, Barnsley. The tenders for the supply of arc lamp-posts (contract No. 18) have to be sent in to the Corporation of Edinburgh by the 17th inst. Particulars of the last-named contract may be obtained of Prof. A. B. W. Kennedy, 14, Old Queen-street, Westminster, S.W., or at the offices of the resident engineer, Dewar-place, Edinburgh.

APPOINTMENTS VACANT.—The Vestry of St. Mary, Islington, require a road foreman to take charge of a gang of men engaged in the laying of conduits and cables and other work in connection with the electric lighting of the parish. Applications have to be sent in to the electrical engineer, the Vestry Hall, Upper-street, Islington, N., not later than the 10th inst.

——— The Gas Committee of the County Borough of Salford require a properly qualified mechanical and electrical engineer to act as clerk of the works and superintend the erection of central station plant. Some further particulars are given elsewhere; and applications must be sent in before 5 p.m. on September 15th.

SALE OF ELECTRICAL ENGINEERING WORKS AND PLANT.—On Tuesday last the important electrical engineering works at Westminster, lately in the occupation of Messrs. Latimer Clark, Muirhead and Co., came under the hammer. Messrs. Fuller, Horsey, Sons and Cassell, of Billiter-square, conducted the auction. For the leasehold interest of the premises, which was held for a short time at a ground rent of £400 per annum, no bid was obtainable, and the sale of the plant and machinery, stock and stores, was immediately proceeded with, and the prices obtained, considering the present depressed condition of trade ruled exceptionally high. The small hand lathes from 3in. to 4½in. centres fetched up to £6 each, and the larger lathes in proportion. The 6in. screw-cutting lathe we noticed realised £40, Brown and Sharp's No. 1 size milling machine £91, and the Taylor and Hobson's engraving machine £28. The moulding and planing machines in the pattern-makers' shop, being old fashioned, went at proportionate prices. As regards steam power, the Galloway boiler, 6ft. diameter, 18ft. long, was knocked down at £136, and a 16in. centre screw-cutting lathe, with 15ft. bed, realised £150. The sale will be continued this day (Friday).

PLANT FOR SALE.—The sale is announced of the whole of the stock, at 88, Queen Victoria-street, and at Bradford, Glasgow, and Chiswick, of Woodhouse and Rawson United (Limited). Full particulars can be obtained of Mr. F. D. Leslie, receiver and manager, 74, Coleman-street, E.C.

LIQUIDATIONS.—A meeting was held at Birmingham last week of the creditors of Messrs. Woodall and Son, glass manufacturers, of the St. George's Glass Works, 10, Great Hampton-street, and Barr-street, Birmingham, at which a committee of creditors was formed to carry out the conditions of a deed of assignment by which the debtors have conveyed their estate to the trustee (Mr. W. N. Fisher, of 4, Waterloo-street, Birmingham, chartered accountant) upon trust to collect, sell, and realise same, and divide the net proceeds amongst the creditors. The trustee has the power to carry on the business in the meantime. Creditors in person or represented are requested to send their assent to the arrangement to the trustee at once.

——— From a summary of the Liquidator's accounts in the matter of Poole and White (Limited), just issued by the Liquidator, it would appear from the accounts from September 15, 1893, to March 31, 1894, that calls have been made by the liquidator to the amount of £200, and costs have been incurred to the amount of £123. 5s., leaving a balance of £76. 15s. Creditors and contributories are informed that any further information can be obtained on application to the Liquidator, Mr. E. Wilding, 2, Clement's-Inn, London, W.C.

——— A first and final dividend of 11s. 6d. in the £ is payable at the Official Receiver's office, 24, Railway-approach, London Bridge, S.E., in the matter of Moses Humm, of 8, West-bourne-road, Forest Hill, London, S.E.

——— The first meeting in the matter of P. H. Pitman, trading as P. Pitman and Co., hydraulic, electrical and general engineers, 3, Brook-road, Cheadle, Cheshire, takes place to-day at the Official Receiver's Office, Stockport, at one o'clock. The examination of the bankrupt takes place at the County Court, Stockport, on October 18th, at 11:30 o'clock.

LISTS OF CREDITORS.—The following is the list of the principal creditors in the failure of George Forrest and Son (Limited), of 2, Great New-street, E.C. :—

Bankers' Claims	£930	10	0	Highton and Co.	£34	19	6
S. C. Cupes	228	0	0	Lithanode and General Electric Company ..	22	5	0
C. S. Drighton	87	12	0	Russell, Innes and Son (Limited)	62	16	3
R Dyas	20	10	0	T. Smith and Co.	48	5	10
Edison Swan United Electric Light Co	36	14	11	W. Sugg & Co.(Limited)	21	17	2
Ellis&Sons, Birmingham	40	8	6	Smith and Sons	18	16	2
T. Glover and Co	21	12	6	H. Selim	93	5	0
General Electric Co. ...	18	10	11	Shaw Bros.	209	0	0
W. T. Glover and Co., Salford	17	10	6	J. Wilkinson and Sons..	21	0	6

(Remainder of London).

——— The following list of creditors in the winding-up of the Collier Audible Telephone Syndicate (Limited) is issued :—

A. R. Bennett, Manchester	£20	0	0	W. Heys, Manchester..	£87	0	0
A. T. Collier, St. Alban's	66	14	7	Leslie Antill & Arnold, London	67	6	10
Flocton & Co., Sheffield	20	19	8	H. Matthews, Manchester	14	12	8
General Electric Co. ...	23	14	3	David Moseley & Sons, Manchester	21	9	0
W. T. Glover and Co., Salford	10	13	0	Nicholson, Graham and Graham, London	99	4	0
W. B. Haigh and Co., Oldham	23	19	9	Shepherd and Sons, Cleckheaton	55	10	0
Haseltine, Lake and Co., London	19	17	0				

——— In the failure of Arthur Shippey, electrical engineer, of 13, King-street, Cheapside, London, E.C., the following is the list of principal creditors :—

Edison & Swan United Electric Light Co......	£130	0	0	Hepburn and Son	14	10	0
The Electrician Printing and Publishing Co....	12	10	0	*Industries*, Manchester.	30	0	0
Gartside, J., Ashton-under-Lyne	158	0	0	Johnson, Mathey and Co.	£33	0	0
General Electric Company	18	18	0	Nettlefold and Sons	157	0	0
Gulcher Electric Light and Power Company.	160	0	0	Pieper and Sons, Liege.	80	0	0
				M. Politzer	30	0	0
				Rooks and Co.	113	0	0
				Electrical Engineer	18	0	0
				Tongue and Birkbeck ..	33	0	0

Fully Secured Creditors.

Bolling and Lowe	85	0	0	P. Mason	200	0	0
Davis and Son	45	0	0	Mackey, Mackey & Co.	240	0	0
I. E. A. Gwynne	1,360	0	0	Reed and Son	30	0	0
Hepburn, Son & Cutliffe	179	0	0	R. Stuart	91	10	0
J. Garnham	100	0	0	L. A. Bailon	75	0	0
F. Hill	61	11	8	Bankers' claims	120	0	0
Lovering and Co.	55	0	0				

Partly Secured Creditors.

J. Bennett (exors. of) ...	50	0	0	Liabilities on bills	300	0	0

(Remainder of London).

DISSOLUTION OF PARTNERSHIP.—The partnership existing under the firm of John Sykes and Sons, machine makers, of Turnbridge, Huddersfield, has been dissolved. Debts will be paid by Mr. E. Sykes, who continues the business.

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DISSOLUTIONS OF PARTNERSHIP.—The partnership hitherto existing between Frederick Nettlefold, William Richardson, and Edward Nettlefold, trading as Richardson, Ellson and Co., electric light fittings manufacturers and mediæval metal workers, of Brownlow-street, High Holborn, London, W.C., has been dissolved.

——— The partnership between Samuel Barton M'Clellan and Walter Samuel Newbould, electrical engineers, of Ludgate-hill, London, E.C., has been dissolved.

——— The partnership existing between J. H. Cundall and Messrs. Cundall and Venner, Cannon-street, London, E.C., consulting civil and electrical engineers, has been dissolved.

MARTINY (LIMITED).—The hearing of the petition for the winding-up of this Company is to take place at the Royal Courts of Justice, Strand, W.C., on October 14th. The petition has been presented by Messrs. W. F. Malcolm and Co., of 36, Leadenhall-street, E.C.

TECHNICAL EDUCATION.—The London County Council Technical Education Board will in October proceed to award not more than 200 junior county scholarships in secondary education, of which 130 will be for boys, and 70 for girls. The object of these scholarships is to secure for promising pupils the necessary pecuniary assistance to enable them to continue their studies in technical and manual instruction. Further particulars can be obtained at the Council Offices, Spring-gardens, London, W.C.

THE NEW LINE INTO LONDON.—Tenders are now invited for the construction of the extension of the Manchester, Sheffield, and Lincolnshire Railway into London. The line will be 112 miles in length, and its total cost is estimated at £6,500,000. Sir Douglas Fox is engineer-in-chief of the line, the contracts for which are divided up into seven parts.

LEGAL.—BRAULIK v. SHARP AND KENT.—In the City of London Court, Mr. George Braulik, of Upper Thames-street, E.C., claimed the sum of £2. 2s. 6d. for electrical goods supplied to the defendants, Messrs. Sharp and Kent, electrical engineers, carrying on business at Victoria-street, Westminster, S.W. Mr. Money-Kent, one of the defendants, said that the goods were bought "on appro," and the plaintiff's traveller admitted taking the order on those terms, but said it was explained at the time that if the defendants desired to keep the goods for a fortnight or three weeks the plaintiff would be willing to allow this to be done. The defendants had, however, kept the goods for twelve months. Mr. Kent said he bought the goods "on appro," which meant, in the electrical trade, that if they were not sold they were to be returned. Mr. Commissioner Kerr, before whom the case was heard, said he did not know the meaning of the term "on appro" in the electrical trade, and decided to adjourn the case until Oct. 4th for trial before a jury.

MESSRS. JOHNSON AND PHILLIPS.—This firm report renewed activity in their cable department, particularly in the rubber shops in the manufacture of house-wiring cables and wires. It is noticeable that the majority of engineers now specify that only stranded conductors shall be employed.

CROMPTON'S POCKET COMPENDIUM.—A new edition of Messrs. Crompton and Co.'s pocket price list and useful formulæ has just been issued. The printed matter bears date July, 1894, although the lettering on the cover gives January. The price-list pages are *fac-simile* reductions of the large catalogue issued by the firm, and the work of reduction is very creditable. The little book contains explanatory notes on a variety of subjects, price lists of combined engine and dynamo plants, travelling cranes, hoists, instruments, apparatus, &c. As the reduction of the pages from 11in. by 8½in. to 4¼in. by 3⅜in. makes the reading difficult, a microscope is issued with each copy, for which a pocket is provided in the cover. Besides price list, telegraph code, &c., many useful notes and formulæ and a good wire table are given. We can vouch for the popularity of the previous edition of the pocket catalogue and formulæ, and hope similar success will attend the new venture.

COOKING BY ELECTRICITY.—Messrs. Crompton and Co. are showing electrical heating and cooking at the Food and Cookery Exhibition, Manchester, and their demonstrations are creating general interest. Several dinners have been cooked, and the new electric grill, recently brought out, is stated to cook to a nicety at a small expenditure of current.

ANOTHER WORLD'S FAIR.—An official movement is on foot to arrange for another great World's Fair, to be held in New York in 1898, to which the Municipal and State authorities have given their approval. The business houses of the city give the scheme only lukewarm support, as experience has proved that the few brief weeks of extra business is followed by a long period of depression.

AUCKLAND (NEW ZEALAND).—The City Council have been invited to a conference with the Harbour Board with a view of arranging for combined action in the matter of the electric lighting of the town and harbour.

BELFAST.—The Corporation have agreed to the proposal of the Electric Light Committee on the subject of rebates to be allowed to consumers of electric current, these rebates amounted to 2½ per cent. on quarterly accounts of £2. 10s. to £5 to 17½ per cent. on accounts of £70 and upwards. The Committee's report states that the works in connection with the central station and the laying of the mains are progressing satisfactorily, and that some of the engines have undergone preliminary tests.

BRISTOL.—The applications for the electric light from the Corporation mains is far in excess of expectations. During last week orders for no less than 1,000 lamps were received, although the dark evenings have not yet set in. It is intended to use about 500 incandescents to light the museum in the Queen's-road.

CEYLON.—It is stated that the introduction of the electric light into Ceylon is attracting much attention, and planters are making serious inquiries into the probable cost of the substitution of electric light for the kerosene lamps now used in their factories.

CHELMSFORD.—The Board of Trade have given the Town Council sanction for the erection of overhead electric lighting wires in certain new streets, &c., on condition that in the event of certain wires being placed underground, a portion of those overhead now sanctioned are also to be put underground. A number of up-to-date transformer pits are being provided for the underground work. The street lighting, by both arc and glow lamps, appears to give great satisfaction. Electric fire alarms have been erected throughout the town, and are reported to have proved successful.

CHURCH LIGHTING.—The Duke of Norfolk has recently presented the City of Norwich with a handsome Roman Catholic church, erected on the most commanding site in the city from the designs of Sir Gilbert Scott. The interior is 150ft. in length and 64ft. in width. The church is lighted thoroughout by electricity.——St. George's Church and the Roman Catholic chapel, Sansome-street, Worcester, are to be lighted electrically from the Corporation mains.——The vicar of Jesmond church, Newcastle-on-Tyne, has recommended that the electric light be introduced. For this, and other improvements to be made, a sum of £550 is estimated to be required.

DARLINGTON.—In 1890 the Corporation obtained powers for lighting the borough by electricity. No action has been taken since that time by the local authorities, who are, however, still anxious to retain the powers, and have by deputy interviewed the Board of Trade upon the subject. Mr. Hopwood has informed the Corporation that the powers will not be withdrawn, and as the Corporation desire to enlarge the proposed lighting area, all possible assistance will be given by the Board of Trade.

DOLGELLY.—The Local Board have received a communication from Messrs. Hall and Company with regard to the proposed purchase of the electric lighting plant. It was, however, decided that as arrangements were pending for the lighting of the town by gas the Board were not prepared to make any offer to Messrs. Hall and Co.

DOVER.—The local electricity supply company have issued a notification that they hope to be in a position to supply current for light and power by the end of the current month.

DUNDEE.—Messrs. Urquhart and Small have sent in their report to the Gas Committee on the addition which Mr. W. H. Brownlee, the electrical engineer, proposes should be made at the central station. The report points out that the amount of current applied for already amounts to nearly 3,500 amperes, of which 80 per cent. may be required at one time, so that the total plant at present available (with an actual capacity of about 3,000 amperes) would not prove sufficient in the event of a breakdown or a machine going out of repair. It is, therefore, recommended that additional plant should be put down, consisting of a 560-ampere dynamo and a 200-I.H.P. engine, with an additional boiler. This additional plant is estimated to cost about £2,500. The Gas Committee recommend the adoption of the report, but that the new boiler and portion of the engine power be dispensed with.

THE ELECTRIC LIGHT IN JAPAN.—The Foreign Office has recently issued an interesting report by Mr. Hensley, a representative of this country in the Mikado's country. The report states that there are now eleven electric light companies in full work, with an aggregate paid-up capital of $1,674,000 out of an authorised capital of $2,477,000.

ECCLES.—The Town Hall, Tramways, and Electric Lighting Committee have visited Whitehaven to inspect the electric lighting arrangements in that town, but report to the Town Council that they are not in a position at present to make any recommendation on the subject.

ELECTRIC TRACTION IN ROUMANIA.—The town of Jassy is about to be provided with a system of electric tramways, the municipal authorities having, it is stated, recently decided to grant a concession to private parties for the establishment and operation of such a system. Particulars of the proposed concession may be had from the Town Hall, Jassy.

ELECTRICITY.—"Electricity is in its Infancy."—*Financial News.*

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EMBEZZLEMENT.—Isaiah Parton, aged 29, was sentenced at Brighton last week to four months' imprisonment with hard labour for embezzling various sums, the moneys of the Brighton and Hove Electric Light Company (Limited), and also falsifying the books of the Company.

FOOTBALL BY THE ELECTRIC LIGHT.—The electric light is now frequently used in the north to enable football matches to be played at night. On Tuesday last a match between the Rochdale Hornets and Rochdale and District was played by the aid of the electric light before 3,000 spectators, and was concluded without hitch or accident.

GOOLE.—An extensive range of buildings for the new Market Hall is to be shortly erected from plans prepared by Mr. Tenant, of Pontefract, at an estimated cost of about £12,000. The buildings are to be fitted throughout for the electric light.

GLASGOW.—At a meeting of the Joint Committee appointed to consider the cost of lighting the public thoroughfares by electricity, the Electric Lighting Committee represented that as the cost of each of the public lamps is £30 per annum it would be impossible to continue the old charge of £20 per lamp per annum, and the Committee proposed that £26 should be the charge fixed in future. The Sub-Committee decided to report the matter to the Watching and Lighting Committee for consideration.——It is considered probable that the renewed applications for the extension of the electric lighting mains to the Park-terrace and Park-circus district, will be granted, and the Sub-Committee on electric lighting have recommended that the mains be extended, the estimated cost being £6,000.——The Gas Committee have decided to make no increase or decrease in the price of gas or electric light. The former remains at 2s. 6d. per 1,000, and the latter at 6d. per unit.——The Corporation Water Committee will shortly be prepared to supply hydraulic power for hoists and other purposes at a rate considerably below that charged by London companies.

HERTFORD.—In reference to the introduction of the electric light into this town a special meeting of the Town Council was called last week to decide upon the policy to be adopted. After some discussion, it was decided to call a public meeting to consider the matter.

ILKLEY.—A Local Government Board inquiry has been held here into an application for sanction to borrow £2,600 for improving and enlarging the gas works recently acquired by the Local Board at a cost of nearly £60,000. The application was opposed by Mr. Gaunt, who stated that the electric light was badly wanted at Ilkley, and it was more than likely the ratepayers would very soon insist upon having it. He considered, therefore, that the Local Board would have been well advised to have commenced by adopting the electric light, and if that had been done they would have purchased the gas works at a much lower sum than had now been paid for them.

INVERNESS.—The Town Council have received intimations from two companies of their intention to apply for Provisional Orders to supply the town with the electric light. It was decided to refuse the consent of the Council to both applications, and to remit the matter to the Law Committee with a view to considering the town's position in the matter.

ISLE OF MAN.—A Liverpool journal states that the success of the Douglas and Laxey electric tramway has led to a proposal to construct another electric line from Laxey, the terminus of the Douglas Company's line, to Snaefell, and that the construction of the roadway is to be commenced immediately.

LANCASTER.—It has been decided to add 10 Crompton arc lamps to the electric lighting of the town market.

LEICESTER.—Alderman Lennard, at the last meeting of the Corporation, in moving the adoption of the Gas Committee's report with reference to the electric lighting undertaking, referred to a circular issued by the gas department some three years ago, in which it was stated that consumers using electric current would have to pay between two and three times as much more for light as by using gas. That statement was made at a time when lamps were much dearer and less efficient than now, and such improvements and reduced prices had taken place that electricity might be looked upon as about equal in cost to gas, and he did not think that any shopkeeper would find his bills heavier at the end of the quarter if electricity were used in place of gas, and there were many important advantages outside the question of actual cost. They had a considerable demand for current up to the present time, although the undertaking was not nearly complete. Current equal to about 1,300 16-c.p. lamps had been applied for. Although they had decided to fix the price at 6d. per unit, there was no finality about this charge, and he hoped that the time would come when they would be able to propose an appreciable reduction in the price per unit.

LINCOLN.—The Town Council have decided to oppose the application of the Brush Provincial Company for a Provisional Order to light the district by electricity. The Council have expressed themselves prepared to undertake the work of lighting the district by electricity "as soon as they are satisfied that the true interests and advantage of the citizens demand such a mode of lighting."

MELBOURNE (AUSTRALIA).—In connection with the electric lighting of this city the City Council have accepted the offer of Messrs. G. and C. Hoskins, to machine dress 217 35ft. poles, and 1,127 30ft. poles, and to fit them with such arms as may be required at £1. 9s. 3d. and £1. 4s. 3d. respectively per pole, or a total cost of £1,683. 17s. A plan and specification has been approved for the supply and erection of iron columns, and the supply and laying of iron pipes in connection with the placing underground of the electric light wires in front of the Equitable Life Assurance Society's buildings at the corner of Collins and Elizabeth-streets, the cost of which will be defrayed by that society. It has been decided to invite tenders for carrying out the work according to the plans submitted. The tender of Messrs. Glover and Nixon for the sum of £58. 15s. has been accepted for the supply of 300 cast-iron pole irons required in connection with the electric lighting of the city.

MOTHERWELL.—On Tuesday last the Motherwell Commissioners had under consideration a notice from the Scottish House to House Electric Lighting Company intimating their intention to apply to the Board of Trade for a Provisional Order, and asking the consent of the Commission to the proposal. On the recommendation of a Special Committee, consent was not given, as the Commissioners were already in consultation with Mr. Mavor, of Glasgow, with a view to formulating a scheme for lighting the town by electricity.

NEW SWINDON.—A proposal to apply for an Electric Lighting Order has been referred to the Electric Lighting Committee of the Local Board.

PORTSMOUTH.—The report of the Electric Lighting Committee was dealt with at this week's meeting of the Town Council. The report states that, estimating the present rate of increase in the applications for electric current is maintained, the plant at present provided will be altogether insufficient to meet the demand, and that it will not be advisable to await this increased demand before taking steps to procure additional plant and apparatus. For these additions it is estimated that a further sum of £6,000 will be required, and it is therefore recommended that an application be made to the Local Government Board for sanction to borrow a further sum of £20,000, but only £6,000 of this sum to be at present obtained. A statement of the expenditure up to date accompanies the report. The Finance Committee comment upon the above report, and recommend that application be made for only £6,000, the amount immediately required. On Saturday of last week applications were made for no less than 886 16 c.p. lamps. The number already in use, and to which that 886 must be added, is 3,740. The rate of progress will be shown by the following fortnightly record:—June 5th, 2,094; June 20th, 2,508; July 4th, 2,863; July 18th, 3,087; August 1st, 3,517; August 15th, 3,674; August 28th, 3,740. Soon, too, the technical school and the public baths will have the system laid on, and they will raise the total number of 16-c.p. lights in use to about 5,000. That number will keep in full working the whole of the dynamos at the central station, leaving no machinery to fall back upon in case of contingencies.

ST. GEORGE'S (LONDON, W.).—On the ground that the Company have no powers to lay electric light mains in St. George's Parish, the Vestry have declined to give permission to the St. James and Pall Mall Company to lay an electric main in New Bond-street, W.

SUNDERLAND.—The exhibition which is shortly to be held here is to be lighted throughout by electricity.

THE BRAZILS.—It is stated that a number of Santos capitalists have offered to illuminate the city of Santos by electricity.

THEFT.—The Hungarian, Edward Morway, who was remanded last week, was sentenced at Glasgow on Tuesday last for swindling Sir William Arrol. The prisoner represented that he had a valuable electrical patent, and Sir William took him into his employment, fitted up premises for him at great expense, and purchased a quantity of expensive material, including £200 worth of platinum. It was only when the platinum began to disappear that the fraud was detected.

THE MIDDLE TEMPLE.—During the Long Vacation the library and the famous Elizabethan Hall of the Middle Temple has been fitted with the electric light. This hall is one of the few remaining historic buildings in London associated with the name of Shakespeare.

PRESTON.—The Markets and Town Hall Committee of the Town Council have appointed a sub-committee to consult with Dr. Hopkinson as to the lighting by electricity of the Town Hall and Public Hall.

TRAMWAY CAR LIGHTING.—The London Tramway Company have decided to use the electric light on the cars running over their Streatham Hill route. The lamps are now being fitted to the cars.

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ULVERSTON.—The Rural Sanitary Authority have decided to again take the matter of electric lighting into consideration.

UP-THAMES PLEASURE LAUNCH.—A new pleasure steamer, intended for service between Richmond and Hampton Court, was, we regret to learn, launched from the yard of the Thames Electric and Steam Launch Company, at Eel Pie Island, Twickenham, on Saturday last. The new boat is designed by Mr. W. S. Sargeant, and affords accommodation for 300 passengers. The vessel is propelled by a single screw, having three blades of Bull's metal supplied by the Phosphor Bronze Company, and is fitted throughout for the electric light. So large a vessel cannot fail to prove an intolerable nuisance on this part of the Thames.

WORCESTER.—The Watch Committee, at its meeting on Friday last, received a report from the sub-committee on electric lighting, which stated that a large number of applications had been received for the electric light, and those granted included several churches. It was stated also that the Dean was anxious to instal the light in the cathedral. The committee recommend the Corporation to vote a sum of £1,000 as working capital to pay the cost of such extensions as the committee decided were necessary.

WREXHAM.—The Board of Trade have intimated that they are prepared to defer the consideration of the question of revoking the Provisional Order of the Wrexham and District Electricity Supply Company (Limited) for twelve months.

COMPANIES' MEETINGS AND REPORTS.

Electric Construction Company (Limited).

The following report of the Directors of this Company, for the year ended June 30th last, is to be presented to the shareholders at the first annual general meeting, to be held on Thursday next, the 13th inst., at the Cannon-street Hotel, London, E.C., at 2:30 o'clock :—

During the year shares and debentures of other companies have been sold at a profit of £15,764. 10s. The profit and loss account shows a gross profit of £55,362. 2s. 9d., and, after deducting all general charges, interest on debentures and borrowed capital, and cost of maintaining buildings, plant, and patents, and allowing the sum of £3,000 for depreciation, there remains £18,467. 13s. 8d., which the Directors recommend should be appropriated as follows :—

£12,500	0	0	in reducing the amount at debit of "shares and debentures of other companies' account."
1,888	2	1	in writing off the reconstruction and preliminary expenses, and
1,819	6	0	in paying the dividend on the Preference shares at the rate of 7 per cent. per annum for the year, leaving
2,260	5	7	to be carried forward to next account.
£18,467	13	8	

The working expenses compare favourably with those of the old Company, and further economies will be carried out as opportunity offers. The liabilities of the Company have been reduced during the year by £48,236. The business has, to some extent, been interrupted by the reconstruction of the Company and the reorganisation at the Bushbury Works, and under the circumstances the results for the year may be considered satisfactory. The Directors have confidence in the ability and loyalty of the staff, and, with the excellent factories and capable artisans of the Company, improved results to the shareholders may reasonably be expected.

Several important electrical contracts have been carried out during the year. The working of the Liverpool Overhead Railway was handed over to that Company to their entire satisfaction on January 1st last. The electrical tramway of the South Staffordshire Tramways Company continues to be worked by this Company, and the cost of working for a period now exceeding eighteen months demonstrates the great superiority and economy of electricity as compared with other modes of traction. Numerous orders for electric lighting and other applications of electricity are being executed.

Sir Daniel Cooper, Bart., and the Right Hon. David Plunket are the retiring Directors. Sir Daniel Cooper offers himself for re-election, but Mr. Plunket, in consequence of other engagements, retires, and the Directors recommend that the vacancy be not at present filled up. Messrs. James Meston and Co., who were appointed to audit the accounts issued with this report, offer themselves for election as auditors for the ensuing year.

The Collier Audible Telephone Syndicate (Limited).

The statutory meetings of the creditors and shareholders of this Company were held last week at the offices of Mr. Winearls, Assistant Official Receiver, Carey-street, London, W.C.

The proofs having been dealt with, the Chairman said the usual statement of the Company's affairs had only recently been filed, and the Official Receiver's observations upon the case would have to be sent out to the creditors and shareholders at a later date. The syndicate was registered in April, 1891, to acquire and develop certain inventions of Mr. A. T. Collier for improved telephonic receivers and transmitters, and to carry on the business of a telephone and electrical manufacturing and supply company. The nominal capital of this syndicate was £9,000, the promoters being the London and Colonial Finance Corporation (Limited). When the Directors went to allotment about £2,400 had been subscribed, and immediately afterwards the syndicate commenced business, which appeared to have consisted exclusively of experimental work in connection with Mr. Collier's inventions. The working capital was put at £3,000, and, upon its being exhausted, loans were raised by means of debentures, and otherwise, to carry on the business. In 1892 the Collier-Marr Telephone and Electrical Manufacturing Company (Limited) was formed to take over the assets of the syndicate, the consideration being £50,000, payable in cash and shares. The syndicate in October, 1892, for the purpose of carrying out the sale to the Company, went in voluntary liquidation ; but eventually a compulsory winding-up order was made upon a petition lodged by a creditor. The unsecured claims, which in 1892 amounted to £1,525, had been reduced to £606 at the date of the winding-up order. It was alleged that some of the creditors had been paid in preference to the remainder, but this was a matter which would be dealt with by the liquidator later.

A section of the meeting urged the appointment of Mr. B. Davies, of Messrs. Isaac Coop, Davies and Co., chartered accountants, Coleman-street, E.C., for the post of liquidator, but the majority voted in favour of leaving the case in the hands of the Official Receiver to be wound up in the usual manner, and the Chairman finally intimated that the question would be referred to the Court for decision.

CITY NOTES.

AFRICAN GOLD RECOVERY COMPANY (LIMITED).—It is stated that the actions brought by this Company which have been for some time pending in the Transvaal Courts, in which the validity of its patents for treating mine tailings, &c., have been contested, resulted in a victory for the Company, who have received payment of royalty from the various defendants.

BABCOCK AND WILCOX (LIMITED).—The Directors of this Company recommend the payment of dividends for the half-year ended June 30th last at the rate of 15 per cent. on the Ordinary shares, and 6 per cent. on the Preference.

CITY AND SOUTH LONDON RAILWAY.—The traffic returns of this Company for the week ended September 2nd were £794, as against £747 in the corresponding period of 1893, being an increase of £47. The total receipts for the half-year amount to £7,736, as against £7,394 for the corresponding period of 1893, an increase of £342.

COMMERCIAL CABLE COMPANY.—This Company announce the payment of a quarterly dividend of 1¾ per cent. on the outstanding stock of the Company, payable on October 1st. The transfer books are closed from September 20th to the morning of October 2nd.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the month of August are £2,800, as compared with £2,851 in the corresponding month of last year.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—This Company's estimated traffic receipts for the month of August, 1894, amounted to £1,583, as against £1,670 in the corresponding period of last year.

EASTERN TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of August amounted to £60,279, as against £51,991 in the corresponding period last year, being an increase of £8,288.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of August amounted to £44,638, and to £41,791 in the corresponding period of 1893, being an increase of £2,847.

ELECTRIC CONSTRUCTION COMPANY.—It will be seen from the report of the Directors (which appears elsewhere) that the wise course has been taken of writing off out of the profits of the year from the debit of shares and debentures in other companies the considerable sum of £12,500. Notwithstanding this, the year's profits allow the full dividend on the Preference shares, of £3,000, being written off to depreciation, and of the carrying forward of £2,260.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic returns of this Company for the month of August, 1894, amount to £26,800, and from January 1st to August 31, 1894, £182,200. In the corresponding months of 1892 and 1893 the amounts were £175,600 and £180,000 respectively.

LEICESTER.—The Corporation invite tenders for £135,000 in Three per Cent. stock, to be redeemed at par in 1944, unless previously cancelled. The proceeds of this loan will be devoted to the construction of waterworks and electric lighting works, and is secured on the Borough fund and rates and revenues of the Corporation, including water, gas, and electric lighting revenues. The list closes to-morrow (Saturday).

MERSEY RAILWAY COMPANY.—At the half-yearly meeting of this Company, held last week, Mr. A. B. Kitching, who presided, stated that the Directors had caused inquiries to be made as to the practicability of working the railway by electricity, and so far as these inquiries had gone the information they had received was encouraging. They were awaiting further information and details before coming to a decision on the subject.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended August 31st (after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited), were £2,542.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The traffic receipts for this Company for the two weeks ending August 31st were £1,702, as compared with £1,737 for the corresponding period of last year.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share	Last Dividend.	Name.	Previous Week's Price, Aug. 29.		Price Wednesday, Sept. 5.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Sept. 5. Highest	Lowest
			TELEGRAPHS.					£ s. d.		Highest	Lowest
£1,012,880	Stock	10,0	Anglo-American	40	43	41	44	5 2 3	Jan., Apr., July, Oct.	42½	41½
£2,933,560	Stock	20 0	Do. Preferred	76	78	76	78	5 15 5	" "	78	77
£2,933,560	Stock	5/0	Do. Deferred	7	7½	7½	8	..	" "	8	7⅞
£181,500	100	4%	*African Direct Teleg. 4% Deb. (Reg. & Bearer)	101	104	102	105	3 16 9	January and July	103	102½
130,000	£10	3/0	Brazilian Submarine	12½	13	12½	13	5 0 0	Mar., June, Oct., Dec.	13	12⅞
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1906)	108	112	109	113	4 9 3	June and December	112	–
10,000,000	$100	$1½	Commercial Cable Capital Stock	139	143	139	143	4 17 11	Jan., Apr., July, Oct.	...	..
16,000	10	8/0	Cuba Submarine xd	12½	13½	12	13	6 3 1	February and August	..	–
6 0 0	10	10%	Do. Preference 10 per Cent. xd	19½	20½	19	20	5 0 0	" "	..	..
12,931	5	1/7½	Direct Spanish (£4 paid)	4½	5	4½	5	3 4 0	April and October	..	..
6,000	5	10%	Do. Preference 10 per Cent.	9½	10	9½	10	5 0 0	" "	..	–
£30,000	Stock	4½%	* Do. 4½% Debentures of £50 each	105%	108%	105%	108%	..	" "	..	..
60,710	20	2/0	Direct United States Cable, 1877	8½	9½	8½	9½	5 5 3	Jan., Apr., July, Oct.	9	..
400,000	10	5/6	Eastern	15⅝	15⅞	15⅞	16	4 1 3	" "	15⅞	16⅛
70,000	10	6%	Do. 6 per Cent. Preference	16½	17	16½	17	3 10 7	" "	16⅞	..
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	117	120	117	120	3 6 8	May and November	119½	114
£102,100	100	5%	* Do. 5 per Cent. Debentures, 1899	105	109	106	110	4 11 6	February & August	109	–
250,000	10	2/6	Eastern Extension	15⅞	16	15⅞	16	4 7 6	Jan., Apr., July, Oct.	16	15⅞
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	115	118	115	118	3 7 10	February & August	116½	–
£62,700	100	5%	* Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103	106	103	106	4 15 0	January and July	..	–
£95,100	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb., 1900	103	106	103	106	4 15 0	" "	..	..
£300,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.)	103	106	103	106	3 15 8	February & August	..	..
£200,000	£25	4%	* Do. 4% Mauritius Sub. Debs.	108%	111%	108%	111%	3 12 11	May and November	..	..
180,227	10	3 9	Globe Telegraph and Trust	8½	9	8½	9½	4 18 11	Jan., Apr., July, Oct.	9	8⅞
180,042	10	6%	Do. 6 per Cent. Preference	15½	16	15½	16	3 15 0	" "	16	15⅞
150,000	10	5 0	Great Northern	20½	21½	20½	21½	3 10 1	Jan., April, and July	20⅞	..
£190,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue xd	105	108	103	106	4 14 4	March & September	.	–
17,000	25	37/6	Indo-European	45	47	46	48	5 4 2	May and November	46½	46
37,548	10	5/0	London Platino-Brazilian	5	7	5	7	..	" "	.	..
£100,000	100	6%	Do. 6 per Cent. Debentures xd	109	112	106	109	5 10 1	March & September	..	..
£100,000	£100	4%	*Pacific European Tel. 4% Guar. Debs. "Red" 1942	103	106	104	107	3 16 9	..	104½	–
11,839	8	4/0	Reuter's	3	5	3	5	..	April and October	3⅞	..
3,381	£100 Cert.	25/0	*Submarine Cables Trust 6 per Cent.	107	112	107	112	5 8 1	" "	..	..
15,609	10	5/0	West African Telegraph	3	5	3	5	..	January and July	..	..
£249,900	100	5%	* Do. 5 per Cent. Debentures xd	102	105	100	103	4 17 1	March & September	..	..
30,000	10	2/0	West Coast of America	2	3	2	3	..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	100	105	100	105	7 11 3	June and December	103	..
88,321	10	9d.	West India and Panama	1	1½	1½	1½	..	..	1⅜	..
31,563	10	6%	Do. 6 per Cent. 1st Preference	10½	11	10½	11	5 9 1	May and November	.	..
4,669	10	6%	Do. 6 per Cent. 2nd Preference	9	10	9	10	6 0 0	" "	9⅞	..
£80,000	100	5%	* Do. 5 per Cent. Debentures, 1917	107	110	107	110	4 11 6	June and December	..	–
64,242	15	7/6	Western and Brazilian	7	7½	7½	7⅞	..	May and November	7⅝	..
33,129	7½	7/6	Do. 5 per Cent. Cumulative Preferred	6	6½	6	6½	..	..	..	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	2	2½	2	2½	..	..	..	..
£171,900	100	6%	* Do. 6 per Cent. Debs., Series "A" 1910	106	109	106	109	5 10 7	February & August	..	..
£214,800	100	6%	* Do. 6% Mort. Debs., Series "B" 1910	104	109	106	109	5 10 7	" "	..	..
$1,211,000	$1,000	7%	*Western Union 7% 1st Mort. (Building) Bonds	115	120	115	120	5 17 11	May and November	–	..
£166,900	£100	6%	* Do. 6 per Cent. Sterling Bonds xd	100	104	100	103	5 16 6	March & September	..	..
			TELEPHONES.								
44,000	5	10/0	Chili Telephone (fully paid)	1	2	1	2	..	..	..	..
224,850	10/0	2¾d.	Consolidated Telephone Const. & Maintenance	¼	½	¼	½	..	May and November	..	..
171,504	£1	6d.	Oriental Telephone and Electric (fully paid)	¼	⅜	¼	⅜	..	Yearly	..	..
484,597	5	3/4	National	4¾	5	4¾	5½	4 17 7	June and December	5⅛	4⅞
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	14	15	14	15	4 0 0	" "	14⅛	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	13½	14½	13½	14½	4 2 9	" "	..	..
119,234	5	3/4	Do. 5% Non-Cumulative 3rd Pref.	5½	5¾	5½	5¾	4 6 11	..	5⅝	..
1,000,000	Stock	4½%	* Do. Debenture Stock, 4½%	108	111	108	111	4 1 8	January and July	..	..
58,000	5	1/0	United River Plate	1	2	1½	2½	..	" "	..	..
£146,733	Stock	5%	Do. 5 per Cent. Debenture Stock	85	95	88	94	5 6 5	" "	..	–
			ELECTRICITY SUPPLY COMPANIES.								
40,000	£10	..	City of London Electric Lighting (fully paid)	12½	13½	12½	13½	..	..	13⅛	12⅞
40,000	10	6,0	Do. 6% Cumulative Pref. (fully paid)	14	14½	14½	14⅞	4 1 4	..	14⅜	14½
19,900	£5	..	Electricity Supply Co. for Spain	..					..	..	..
£30,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	4½	5½	4½	5½	3 12 7	..	..	..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	..		..		..	..	..	..
8,322	£5	..	House-to-House Electric	..		..		–	..	..	–
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	..		..		–	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..		..		–	January and July	..	–
45,000	£5	2/6	Liverpool Electric Supply (fully paid)	6½	6¾	6½	7	–	..	..	–
111,000	5	..	London Electric Supply	¼	⅜	¼	½		..		..
49,900	£10	5/0	Metropolitan Electric Supply (fully paid)	8½	8⅞	8½	9	2 15 7	..	9	8½
£150,000	Stock	4½%	* Do. 4½% Debs. (Bonds of £10, £20, and £10)	5	7 pm	6	7 pm	..	June and December	..	..
6,452	£10	..	Notting Hill Electric	4½	5½	4½	5½	.	..	..	..
18,950	£5	2/0	St. James and Pall Mall	7	7½	7	7½	.	..	..	..
20,000	£5	7%	Do. 7 per Cent. Preference	8½	8⅞	8½	8⅞	4 0 0	..	..	..
59,900	5	2/0	Westminster Electric Supply (fully paid)	6½	6¾	6½	6¾	3 6 8	–	6⅛	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
90,000	3	1/6	Brush Electrical Engineering	2⅞	3	2⅞	3⅛	5 16 6	..	3	2⅞
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	2½	2¾	2⅝	2¾	4 11 5		2½	2½
£125,000	Stock	4½%	* Do. 4½ per Cent. Debentures xd	110	113	109	112	4 0 4	March & September	111	..
20,000	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref.	1¾	2½	1¾	2½	–	January and July	..	..
12,139	5	..	Edison and Swan United	–		–		..	..	–	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	..		..		..	..	–	⅜
120,000	2	..	Electric Construction	⅜	⅜	⅜	⅜	–	–	⅜	–
12,845	2	..	Do. 7 per Cent. Cumulative Pref.	1½	2	1½	2	..	–	..	..
91,195	2	10/0	Elmore's Patent Copper Depositing	1	1½	1½	1⅜	..	..	–	..
20,000	5	..	Fowler-Waring Cables (fully paid)	½	1½	½	1½	.	..	..	23½
50,000	10	10/0	India Rubber, Gutta Percha, &c., Works	23	24	23½	24½	5 2 6	February & August	24	–
£200,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	103	105	104	105	4 6 2	March & September	–	..
15,995	£10	6/4	International Okonite Ordinary	..		..		–		..	–
16,000	£10	–	Do. 8 per Cent. Preference	–		–		–	December and June	–	..
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid)	–	½	–	½	–	..	–	..
78,949	5	3/6	Swan United (£3 10s. paid)	..		..		..	May and November	..	..
37,350	12	12/0	Telegraph Construction and Maintenance	40	42	40	42	5 14 3	March and July	..	..
£150,000	100	5%	Do. 5 per Cent. Bonds	102	105	102	105	4 13 6	January and July	..	–
37,514	£5	–	Woodhouse and Rawson Ordinary (£3 15s. paid)	..		..		..	..	–	–
41,098	£5		Do. Preference (fully paid)	.		.		..	.	–	..
£63,870	10	10/0	W. T. Henley's Telegraph Works Ordinary	7½	8	7½	8½	5 17 8	..	..	..
£30,000	10	..	Do. Preference	..		..		..	..	..	..
			RAILWAYS AND TRAMWAYS.								
£630,000	Stock	1%	City and South London Railway	36	38	36	38	1 16 2	May and November	37½	36½
7,000	10	5%	Do. 5% Perpetual Preference	12½	13½	12½	13½	3 14 1	May and November	..	..
£67,130	Stock	4%	Do. 4% Perpetual Debenture	121	123	121	123	3 5 1	..	..	..
37,500	£10	1%	Liverpool Overhead Railway	7⅛	7⅛	7½	7⅞	1 5 10	..	..	..
6,295	10	5%	Do. 5% Preference	12½	13	12½	13	3 16 11	..	..	..
£125,000	Stock	4%	Do. 4% Debenture	111	113	111	113	3 10 10	January and July	..	..

* In calculating the yield on this security, allowance has been made for accrued interest, but not for redemption.

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

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NOTES.

Compared with the ordinary run of accounts those published by electric lighting concerns under the auspices of the Board of Trade are models of clearness and explicitness, although no more than other human documents do they tell the truth, the whole truth, and nothing but the truth. However, taking them for what they are, these Board of Trade accounts tell something even to the uninitiated, and much to those who delight in analyses and "odorous comparisons." Clear and explicit as these accounts usually are, however, we do not remember to have seen any quite equal to the just-issued 1894 electric lighting accounts of the Glasgow Corporation, the main figures of which we gave some weeks ago.

The second year of the Glasgow municipal station shows, indeed, a deficit like the first; but it is a considerably diminished one (£607 as against £1,773), and likely, by the look of the accounts, to be converted next year into a profit; that is to say, if the lowering of the price of the Board of Trade unit from 7d. to 6d. brings about the anticipated growth in the consumption of current. Although the Glasgow station does not, more than any other municipal venture of the kind, as yet show any symptoms of the overwhelming superiority of municipal management regarded purely from the £ s. d. point of view, now almost out-of-date, it may be of interest to note that the generating expenses at Glasgow are a little over 2d., as against 2½d. with the Kensington and Knightsbridge Company, which is worked on the same system, and has a capital expenditure and output of the same order of magnitude. This is a good figure, but is, no doubt, quite accounted for by the difference in the price of fuel in Glasgow, and in Kensington, and by the fact that in Glasgow nearly 30 per cent. of the total units are sold in connection with the public lighting, with its steady load and long and definite hours. When we come to total cost per unit sold, including the sums set aside for depreciation, the Glasgow and Kensington figures are respectively 4⅜d. and 4¼d. We observe that the units unaccounted for still amount to 16 per cent. of the total number generated, the figure for the previous year having been no less than 26 per cent. This is, probably, as much a matter of meters as of mains.

We are glad to receive support, though in guarded language, from Dr. Fleming, in the sine curve controversy, and await with interest the result of his experiments. Meanwhile, it seems that the whole American nation has not risen up against us, but that, if left to themselves, the Americans will settle the matter for themselves without our assistance. Mr. Shand, whose name is well known in connection with the old Thomson-Houston Company, though he concludes the letter which we print this week with a verdict of not proven, amply confirms our views in the rest of his letter. To one short paragraph we would particularly draw attention, with the view of simplifying the debate: "Of course, in particular transmissions, when the use of alternators giving sine waves appears desirable, they will be met as special cases, and so treated."

We reprint in another column a brief description of the ingenious method adopted at Bangor (Me.) of working a small trolley line on the three-wire system. Mr. Carrol's experience at Bangor is of interest not only on account of the potentialities of the three-wire solution of the problem of the earth return, but because it shows that with a little care and thought the plan may be made quite workable even on a small scale. Necessity was the mother of invention in this instance, as in most others. A water power-house, situated 4½ miles from the nearest feeding point, the refusal of the "earth," even, with a river in obliging proximity, to act gratuitously as an electrical waste pipe, and the impossibility, in view of the relatively large capital outlay, of a copper return of the orthodox kind, all combined to make Bangor (Me.) famous as the first town, or ought we to say city, to adopt the three-wire system of electric traction.

Higher commendation of electric traction could hardly b given than is to be found in the remarks made by Sir William Forwood in the discussion at the Institution of Civil Engineers on the Liverpool Overhead Railway, and which we print in another column. This railway, of which he is Chairman, was commenced with the idea of using steam, but after he had visited America, and had seen what had been done there in electric traction, he felt sure that something better should be done and could be done in England; and not only had it been done, but in his opinion there was nothing in America comparable with the electric railway in Liverpool. Sir William Forwood is not known as an electrical expert, and it is not on such grounds that his opinion is valuable, but he is well known both in Liverpool and in Parliament as a shrewd and practical man. The control of the motors, the working of the signals, and the efficiency of the conductor are interesting to some minds; but Sir W. Forwood seizes the cost of locomotive expenses, the punctuality, and the reliability, as the points which are convincing to him of the success of the work.

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Sir Douglas Fox described several practical details of construction of the line, and alluded to the important consideration of the number of stations. The perfect ideal, as he put it, would be to have one station the whole length of the line. That, he said, could not be quite accomplished. But in this matter of stations lies one of the great differences between railways and tramways. Nearly all tramcars and omnibuses in this country will pull up on being hailed, or when a passenger wishes to alight, and a similar concession is frequently made on the light railways of the Continent. This is no doubt a convenience to individuals, and as a large proportion of the passengers take advantage of this privilege twice on every journey, it appears that the balance of convenience to each person and inconvenience to many is thus adjusted. But the practice of stopping at definite points has much to commend it, especially in the case of electric traction, where, as a rule, each start entails a heavy discharge of current, and perhaps a loss by the use of resistances.

A tramway, in the ordinary sense of the word, has no stations, and, by dispensing not only with the buildings but with the attendants, the expenses are, of course, much less than with a railway. Electric railways will probably create a new type of service, especially where motor cars are used, for trains of moderate length can be run at very short intervals. A three-minute service has hitherto been the ideal, and where it is necessary to keep time and to maintain the same interval throughout the day, it is, perhaps, as short as is practicable. But when the bulk of the traffic is concentrated in a few hours of the morning and evening, it seems possible to circulate the trains faster during that time. Under certain circumstances an express service might be run, the alternate trains stopping at alternate stations. This would greatly reduce the time from terminus to terminus, and it might be worth while to arrange an automatic block system as proposed by Profs. Ayrton and Perry, whereby the trains could not possibly approach each other.

Means for "turning down" electric light seems to have as great a fascination for inventors as the "distribution" problem of 16 years ago. The *Birmingham Gazette* discusses at great length the "important invention" and "discovery" of a Mr. T. B. Sharp, "a well-known inventor," who "has solved the mystery after devoting much serious thought to the subject, and making innumerable experiments." His attention was first called to this long-felt want by observing that a stocking had been tied round a lamp for the purpose of producing a dim night-light in a hotel bedroom. "His first idea was to place a make-and-break arrangement in the circuit in which the lamp is," and to this end he provides a commutator driven "by clock-work or any other means . . . . which cuts off the electricity instead of wasting it, and saves power very nearly in proportion to the time the current is broken, and the amount of light given is much in the same proportion." Mr. Sharp has, so far, only arrived at half the invention with which the Patent Office was deluged in 1878. In the months of October and November alone, no less than ten patents were granted for cutting the current off from one lamp, and sending it, during the interval, through another by means of revolving commutators.

It is interesting to compare the economy of this system with that of an ordinary resistance, and to consider the "worth whileness of the economy." Suppose a 16-c.p. lamp taking 0·64 ampere at 100 volts, that is, 4 watts per candle, is to be reduced to 1-c.p., the average current, whether continuous or intermittent, will be about 0·4 ampere. The resistance of the lamp will increase from 156 ohms to 170. If the current is reduced in the ordinary way, by inserting a resistance, 80 ohms will be required, and 12·8 watts will be lost in heating it, the lamp itself will take 27·2 watts. The consumption in the lamp will be 27·2 watts per candle, and the total consumption will be 40 watts per candle. Now, with the revolving commutator the average current will be as before, 0·4 ampere; but this is effected by cutting off the current for a certain time. The total consumption will be 40 watts per candle, as before, and the cost of the commutator would, we imagine, be more than that of a resistance. It is true that the cost per candle is tenfold greater, but the cost per lamp is reduced to about two-thirds. But, after all, a resistance would affect precisely the same saving, and would cost less.

Mr. Sharp saw some objections to the revolving wheel; it would of course consume far more energy than it would save, "so he turned his attention to the discovery of still another method," and not only by a powerful effort of thought has he imagined the principle of connecting lamps in series, but he has, possibly after "innumerable experiments," put his discovery into practice. He, in fact, takes advantage of the fact that a lamp is a cheap resistance, which will, indeed, under these circumstances, pay for itself—say, 1s. in 96 hours—taking as before the consumption per lamp and not per candle-power. The general result is that a 16-c.p. lamp tied up in a stocking, taking 64 watts at 6d. per unit, costs a trifle over 3d. for 8 hours, and if reduced to one candle by means of any of these brilliant inventions it will cost 2d. We have taken our data from tests of an average Edison-Swan lamp; with modern efficient lamps at 3 watts per candle the saving would be less. After all, we believe that excellent night-lights can be bought for 5d. per dozen. It is not so much about Mr. Sharp's inventions that we have gone so fully into these figures, but on account of the general fallacy of the economy of "turning down" lamps. The convenience of this practice is another matter, and between the use of a stocking and of complicated switches there is room for many inventions.

Protests are very properly being made in the daily Press about the practice of throwing advertisements by means of an electric lantern on the Nelson Column and the walls of the National Gallery. We have on several occasions, when in the neighbourhood of Trafalgar-square, seen a very disagreeable flicker, and some shadows resembling letters, but could not decipher any words. Business is business, but we feel sure that a large majority of our readers agree with us that this is not only a desecration of public monuments and buildings, but a prostitution of electric lighting.

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Correspondence.—We are obliged to hold over some of our correspondence until next week.

Cable Interruption: Date of Interruption.
Zanzibar-Mombasa .... September 4th.

Edison Bamboo Filament Patent.—The ordinary legal life of this patent comes to an end on the 16th inst.

Mountain Electric Railways.—It is proposed to convert the Arth-Rigi Mountain Railway into an electric line, on the Thomson-Houston system.

Electricity in Mining.—The authorities of the School of Mines at Ballarat, Victoria, are about to establish a class in electricity, as applied to mining.

Inter-urban Telephony in Chili.—Negotiations are in hand with reference to the establishment of a telephone line between Valparaiso and Santiago, a distance of some 30 or 40 miles.

University College, London.—In the department of applied science, lectures and practical work in engineering and chemical laboratories commence on October 2nd. Prospectuses can be obtained at the College, Gower-street, London, W.C.

The Indo-Chinese Land Line.—*The Times* correspondent at Tientsin states that Mr. N. R. O'Conor, C.B., the British Minister, and the Viceroy have signed the convention by which the Chinese telegraphs are to be connected with those of Burma and India.

Pacific Cable.—Advices received by the Ottawa Department of Trade and Commerce state that H.M. ship "Champion" left Honolulu on August 27th for Neckar Island, to make soundings in the vicinity and report upon the adaptability of the island as a cable station.

Inter-urban Telephonic Communication in Italy.—It is stated that the Italian Minister of Posts and Telegraphs has decided upon the establishment of telephonic communication between Rome, Genoa, and Turin; Rome and Naples; Rome, Florence, and Milan; Rome and Venice; Turin and Milan; Turin and Genoa; Genoa and Milan; and Milan and Venice.

Car Lighting.—One of the electric cars of the North Hudson County Railroad, of New Jersey, has been experimentally equipped with a small auxiliary storage battery, which is charged from the main line, and is automatically switched into connection with the car lamps whenever the main current is interrupted—as by detaching the trolley from the wire—but is disconnected from the lamps when the main current is restored.

Lightning.—A labourer of Norton, near Evesham, was putting a sheet over a rick last week when a thunderstorm suddenly broke over the district, and he was struck by lightning and instantly killed. Nearly all his clothing was stripped from his body, and his boots were also torn from his feet.——Two of a number of tourists who were on the summit of Mount Pilatus watching the sunrise, a day or two ago, were overtaken by a thunderstorm and killed.

Combined Electric Traction and Lighting in Germany.—It is stated that the *Allgemeine Electricitäts Gesellschaft*, of Berlin, has secured the contract for the construction of the electric tramway at Königsberg, between the Pillau railway station and the suburb of Sackheim. The overhead conductor system is to be adopted, the line being about four miles long. The necessary electrical energy will be furnished by the municipal central station, which, it will be remembered, is on the five-wire system.

An Electric Weed Killer.—The Illinois Central Railroad is said to be experimenting with an electrical apparatus for killing grass and weeds. A car carries a dynamo-plant and a sort of brush, consisting of a fringe of copper wires, depending from its front end, which is made long enough to cover the width of the track and extend to the end of the ties. A pressure of 10,000 volts, produced by a step-up converter, is found to be sufficient to do the work effectively. Steam and brine have both been tried for the purpose, but with less satisfactory results than those which have attended the use of electricity.

The Telegraph in India.—Western innovations thrown into the midst of Eastern antiquities have sometimes to undergo curious modifications. Thus, side by side with the announcement that during the past financial year 8,000 miles of wire were added to the Indian telegraph system comes the statement that at Delhi, during the Mohurrum procession, the *tazias* having been made of unusual height, the telegraph wires were pulled down, not by the people, but by the authorities, so that the lofty structures might have room to pass. It is to be hoped this obliging disposition will not spread home, or the alleged loss on the telegraph service will loom still larger.

Electric Heating by Induced Currents.—In a recent issue of the *Zeitschrift für Elektrotechnik und Electrochemie* the following method of heating by induced currents is described. A vessel of suitable heat-resisting, and preferably non-conducting, material is constructed with a deep indentation in the bottom. Into this indentation is inserted the single primary coil of a coreless transformer. Within the vessel is a ring of lead or of carbon, which becomes heated by the induced currents flowing in it, when a suitable current is passed through the primary coil. If the vessel be made of metal it will itself act as a secondary conductor, and no additional ring of lead or carbon will be needed.

The People's Palace.—We have received a copy of the calendar of evening classes for the session 1894-95, which is issued by the governors of the People's Palace. The subjects taught at these evening classes cover almost every variety of technological instruction. In the spring of the present year the Drapers' Company, who have from the first heartily supported the People's Palace education scheme, voted a sum of £5,000 for the erection and equipment of separate workshops for the engineering department, which have now been completed, and are available for use for the session 1894-5. The course for the B.Sc. degree of the London University is offered. The evening classes are under the management of Mr. J. L. Hatton, M.A. The session commences on Monday, the 24th inst.

Charterhouse Science and Art Schools and Literary Institute.—The winter session of this institution will commence on Saturday, 29th inst. During the late session upwards of 1,100 students, mostly elementary teachers, availed themselves of the privileges afforded by this institution, and of this number nearly 950 presented themselves for examination and were successful in obtaining a large number of certificates awarded by the Science and Art Department of South Kensington. Instruction of a practical character is given in most of the sciences at a very nominal fee. Artisans who do not desire to be prepared for the examinations will this year be received and taught in accordance with the scheme issued by the London County Council. Full particulars of the classes may be obtained from C. Smith, organising secretary.

An Interesting Electric Railway.—An electric railway, for both passenger and freight traffic, is, says the *Engineering Magazine*, now in successful operation between the towns of Wilmerding and McKeesport, in Western Pennsylvania. The line is about four miles in length, and passes over a mountain 1,200ft. high, encountering some grades as steep as 12 per cent., with many sharp curves. Each car is equipped with two 30-H.P. motors. A conveniently-situated coal mine made it possible to locate the power house and car barn midway on the line, on a plateau at the top of the mountain, and a picnic ground has also been established nearby, which is expected to become a place of pleasure resort for the citizens of both towns, and thereby add largely to the revenues of the road. The water used in the boilers is pumped from the foot of the mountain by an electric motor.

The Aim of Electro-Chemical Investigations.—Under this F. Oettel, in a recent number of the *Zeitschrift für Elektrotechnik und Electrochemie*, urges that a new era will commence for electro-chemistry when electro-chemical reactions are studied with the aid of the amperemeter and the balance, as a new epoch began for chemistry with the quantitative examination of chemical phenomena. In studying electro-chemical reactions the current should be measured, and from this the theoretical result of the operation should be calculated according to Faraday's law; if, then, by weighing or titration this result is reached, it may be concluded that no secondary reactions have occurred. But if there be a difference beyond the range of experimental error, and this difference is found to recur on repeating the experiment, a further examination must be made into the nature, conditions, and extent of the by-reaction.

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Electrical Resistance of Aqueous Solutions and Pressure.—In the *Wiener Berichte* for May will be found the results of researches by Bruno Piesch on the effect of pressure on the electrical resistance of solutions. The method of measurement was such that the resistance and the polarisation could be determined simultaneously. Pressures up to 600 atmospheres were produced by a Cailletet apparatus. The measurements gave the following results:—Change of pressure produces a change of resistance, which decreased in all cases with increase in the pressure. As the pressure increased the decreases of resistance were less. Polarisation also showed a change of value with higher pressure. These, however, are for the most part small. An increase of polarisation with the pressure was in general observed.

Electricity Applied to Mining.—A new colliery is being opened out on the Park Hall estate, near Eckington. About 1,000 acres of the High Hazle seam has been leased to an American gentleman by Mr. Chandos Pole, and operations are now proceeding under the management of Mr. Mylles Hardwick, mining engineer. The colliery is situated in the valley between Spinkhill and Barlbro'. A footrail is being driven into the hillside, and the seam of coal found is 4ft. in thickness. It is intended to work the colliery entirely by electricity. It is decided to put down high-pressure boilers, high-speed engines, and high-pressure dynamos. The under-cutting of the coal will be entirely done by "Jeffrey" electric coal-cutting machinery of the latest type. The colliery will be opened out on the pillar and stall system. The ventilating fan is to be driven by an electric motor. All the surface and underground workings will be lighted electrically.

Lighting Protection for Ships in Dry Dock.—Writing to Rear-Admiral J. A. Fisher, C.B., on the death by lightning of two men who had sought shelter under a vessel in the Norfolk, Va., dry dock during a thunderstorm, a disaster which was recorded some weeks ago in these columns, Lord Kelvin says:—"With reference to the recent report of a lightning discharge in Norfolk Dockyard, U.S.A., by which two men were killed, it is proved by that accident that to secure against danger to men working under a ship in dry dock there ought to be a thorough metallic connection, by wire rope or otherwise, between several points of the ship's iron, such as bollards, ring-bolts, &c., and iron pipes leading to the water outside the dry docks. Similar precautions ought to be taken in respect to the frames of ships on the stocks in the course of building, although we have, so far as I know, never heard of an accident from lightning happening to men at work in the building of ships. An iron ship simply resting on wooden blocks, and without any connection by metal with the water of docks, or river, or sea in the neighbourhood, is certainly dangerous to persons standing on the ground and touching any part of the iron hull during a thunderstorm."

Lightning in the United States.—According to a "Circular of Information," published by the United States Weather Bureau, 209 persons lost their lives in the United States by lightning during 1893, the total for the four years 1890-93 being 784, or an average of 196 per annum. All this loss of life took place practically in the five months April-September, the maximum death rate occurring in June and July. In the eight years ending 1892, for the most part west of the Rocky Mountains, there occurred in the United States 3,516 fires, doing damage to the amount of 2½ millions sterling. One interesting point which appears to be shown by statistical studies of lightning stroke is the decreased liability to accident in thickly-settled communities. It may be said in general that the risk in the country is five times greater than in the city. For ordinary dwelling houses, not unduly exposed in city blocks, lightning rods are hardly necessary, a very considerable protection being afforded by the tin roofing, numerous cornices, gutters, &c. The geological, as well as the topographical, conditions may have some influence upon the frequency of lightning stroke. With regard to trees, the oak is more frequently, and the beech less frequently, struck.

Graphics.—Mr. Henry Harrison Suplee, who is in charge of the mechanical engineering section of the *Engineering Magazine*, continues his campaign in praise of graphic methods. It is not uncommon, says Mr. Suplee, in the current issue of the magazine, "to hear men say that graphical diagrams will do very well for approximate results; but that the superior accuracy of calculations gives them marked superiority. It is doubtless true that results can be obtained by analytical methods to a far greater degree of refinement than is possible by the use of scale and dividers; but the sense of accuracy which is pleased with results carried out to the sixth decimal place is sometimes marred by the discovery that some important element in the calculation has been omitted, or, as is often the case, that it is impossible to use the results thus laboriously obtained to a greater degree of precision than, say, the second decimal place, and that the work which has been expended is unavailable. As a matter of fact the graphical processes will give results which are nearly always as precise as any of the subsequent uses which are to be made of the values thus obtained, and it is of little use, for instance, to determine dimensions which, when obtained, are to be laid out on a drawing, to a closer value than can be read from a scale or marked with a pencil, so that for such purposes the same system is equally reliable for the one or for the other. At the same time, it is possible to use graphical methods to investigate subjects which are only solvable analytically by most tedious labour and that, too, by those who have kept themselves expert in this branch of work by close study and constant practice. The true end of mechanical engineering is the production of the completed and operative machine, and this itself is a drawing, executed in steel and iron, and the symbols which are but as a means to this end need never be more precise than their final outcome in any case."

Velvo-Carbon.—The mania for new primary batteries has almost died out. A year or two ago there were a number of attempts at making "dry cells," a misleading name for a rather untrustworthy battery. The old idea of a primary battery consisted of three features. A secret depolariser, generally some form of chromic acid, a promise of a utilisable zinc salt from the spent solution, and a carbon plate. The two first requisites gave wide opportunity for ingenuity and lies, but nobody troubled about the carbon plates. There is no mystery about the last new battery, it appears to be a straightforward invention, and the new feature is the carbon. It consists of Lacombe arc light carbon rods 9 mm. diameter, one foot long, with velveteen cemented upon them, afterwards carbonised at a high temperature. For some purposes a deep-pile corduroy is used. The idea is to give a very large surface. A new method of electrically connecting carbon electrodes consists in the use of a silver wire, or strip wedged into a recess in the carbon. As at present applied to carbons for use entirely under the surface of simple dilute sulphuric acid, the carbons are of arc light rods as made for coring, but uncored. In the core hole at the end is wedged a length of 2in. of 28 gauge silver wire, by means of a celluloid wire wedge. If the connected portion of the carbon is to be above the level of the liquid the joint is protected by ozokerit wax. For use in depolarising solutions a platinum wire is used in place of the silver. The makers have chosen a rather severe kind of work for showing the capabilities of such a battery, and have fitted an electric launch 35ft. in length, 6ft. 6in. beam, 1ft. 4in. draught, with a Newton motor, weight 6cwt. This motor, when tested with 20 volts 60 amperes, ran at 500 revolutions per minute. A battery of 48 cells, of a total weight when charged of 14cwt., was arranged in two sets of 24 cells each. The water, or spent solution, is dealt with by an ebonite pump fixed permanently in the motor chamber, which communicates with the cells by lead pipes, and flexible rubber pipes. A charge of dilute sulphuric acid is said to run the launch "all day at full speed." The acid is tapped into the cells from a flexible lead tube, one end of which is inserted in the carboy on the bank. The whole of the cells may be charged or discharged in ten minutes. Half-an-hour is said to be sufficient time to replace a set of zinc plates. The amount of zinc used is said to be 6½lb. per supply unit, with 12lb. of acid. The former cost 5d. per pound, the latter ½d. per pound. Another experiment gave 5lb. of zinc, and 18lb. of acid per unit, making the costs of materials about 3s. per unit. It is claimed that for lighting purposes the solution is so weak that local action is negligible.

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THE COST OF GLOW LAMP LIGHTING.*

It may not be inappropriate at this moment to call the attention of users of incandescent lamps to the fact that price is not the only factor to be considered in connection with the choice of a glow lamp. Consideration should also be given to the rate at which the candle-power decays when constant pressure is kept on the terminals of the lamp, as well as to the initial efficiency, and the *useful* life of the lamp. The useful life of the lamp, so far as most consumers are concerned, must be considered to be limited to that period of the total lamp life in which its candle-power is not diminished by more than 30 to 40 per cent. of its original candle-power, although this is not by any means a definite limit to the utility of the lamp. The user has to determine what is the total cost to him, during that useful life, of the energy supplied to the lamp, and what is the total candle-power hours given by the lamp. Suppose, for example, that the lamp is a 100-volt 16-c.p. lamp, and that it takes originally 50 watts to bring it to this candle-power, when on a 100-volt circuit. Then let us suppose, in the course of 600 hours' burning, that it is reduced to 8 c.p., and that it then takes 40 watts at the same pressure. If the rate of decay is tolerably uniform, the total energy taken by the lamp in watt-hours is the product of $45 = \frac{1}{2}\ (50 + 40)$, and 600, or 27,000 watt-hours; which is 27 British Board of Trade units (frequently written B.T.U.). The average candle-power hours given by the lamp is $\frac{1}{2}\ (16 + 8) = 12$, which multiplied by 600 gives 7,200 candle-power hours. If the Board of Trade unit of electric energy costs 6d., then the total cost of the energy taken up is 13s. 6d., for which the consumer gets 7,200 candle-hours of light at a mean candle-power of 12. If the lamp originally cost 1s. 6d., the total cost of the 7,200 candle-hours, including lamp, is 15s., or the consumer gets 40 candle-hours for a penny, given at a mean candle-power of 12. In other words, he is paying 0·3 of a penny per hour for his lamp and light. A penny includes, therefore, the cost of lamp and power for about $3\frac{1}{3}$ hours. Suppose, however, the user is offered a lamp at the price of 1s., but that extended experience shows that a 16-c.p. lamp of this kind falls to 8 candle-power in 300 hours' use. It is clear that this last lamp, if it takes the same power at each candle-power as the other, will transform in this time $45 \times 300 = 13{,}500$ watt-hours, or $13\frac{1}{2}$ Board of Trade units, and the total cost of lamp at 1s. and power at 6d. per unit to the user will be 7s. 9d. For this he gets $12 \times 300 = 3{,}600$ candle-hours, or 39 candle-hours for a penny. Hence, the cheaper lamp has not really much benefited him.

Therefore, the question which is so commonly asked, viz., Is electric light cheaper or dearer than gas? cannot be answered by a simple "Yes" or "No." The factors which decide the relative cost, so far as the electric glow lamp is concerned, are as follows:—1st. The price paid per Board of Trade unit of electric energy. 2nd. The price of the lamp. 3rd. The average useful life of the lamp. This last will depend not only upon the lamp itself, but also upon the constancy of the electric pressure of the supply. 4th. The manner in which the "wiring" of the house or building has been done; a factor which greatly determines the degree to which the consumer can effect economy by not using more lamps than is actually necessary. 5th. The intelligence shown in placing the lamps so as to make each do the utmost illuminating duty, and the care with which the control is effected by switching off lamps not actually needed. We may add also a 6th. The employment of a by-no-means negligible precaution in securing the best results—the keeping of the outside of the lamps clean and free from dust and dirt by having them well washed at intervals. A dusty lamp gives much less light than a clean one.

To assist the reader in making certain essential comparisons, a table is given below which shows the total cost in power and lamp renewals for working for 200 hours a 16-c.p. 100-volt glow lamp taking on an average 50 watts. The costs are given for various prices of the Board of Trade unit from 3d. to 8d., and for lamps costing 1s. and 1s. 6d., and for useful lives of from 200 to 1,000 hours. Let it be borne in mind that the "useful life" of a lamp is not a sharply marked period, but is the approximate average time during which its candle-power has not deteriorated by more than say 40 per cent. of its original value.

Table *showing the cost of 200 hours' use of a 100-volt 16-c.p. Glow Lamp, including the proportionate cost of Lamp Renewals and cost of Power. The Lamp is assumed to take on an average 50 watts, and to cost either 1s. or 1s. 6d.*

Cost of Energy. Board of Trade Unit.	3d.		4d.		5d.		6d.		7d.		8d.	
Price of Lamp.	1/-	1/6	1/-	1/6	1/-	1/6	1/-	1/6	1/-	1/6	1/-	1/6
Useful Life of Lamp in hours.	Cost of 200 hours' use of Lamp.											
200 hours.	3/6	4/-	4/4	4/10	5/2	5/8	6/-	6/6	6/10	7/4	7/8	8/2
400 "	3/-	3/3	3/10	4/1	4/8	4/11	5/6	5/9	6/4	6/7	7/2	7/5
600 "	2/10	3/-	3/8	3/10	4/6	4/8	5/4	5/6	6/2	6/4	7/-	7/4
800 "	2/9	2/10	3/7	3/8	4/5	4/6	5/3	5/4	6/1	6/2	6/11	7/-
1,000 "	2/8	2/9	3/6	3/7	4/4	4/5	5/2	5/3	6/-	6/1	6/10	6/11

The foregoing table must be read as follows:—Suppose the user gets current at 6d. per unit, and buys lamps at 1s. 6d., and let the lamp he buys be assumed to have an average useful life of 800 hours. On looking along the column in line with 800 and under the heading 6d. and 1s. 6d., will be seen 5s. 4d. This is the cost of the 16-c.p. lamp for 200 hours of burning, including proportion of lamp cost and power. Hence, in this case the 800 hours' burning cost 21s. 4d. on the whole, and for this the user gets an average candle-power of about 13 candles for 800 hours, or $13 \times 800 = 10{,}400$ candle-hours. It is obvious that no hard and fast comparison with the cost of equivalent candle-hours given by gas light is possible, unless a careful statement is made of the manner in which the two lights are used.

One great advantage which electric illumination possesses, from a domestic and economical point of view, is the ease with which it can be turned off and on. A switch placed near the door enables a person leaving a room to turn out all the electric lights without calling for the smallest trouble in relighting them, which cannot be done in the case of gas. In effecting a comparison of cost, we have to take into consideration the time of wastage and non-useful combustion in the consumption of gas; and this, apart altogether from the immense superiority of the illuminant which fouls no air and destroys no decorations. Actual extended experience shows* that, with care and good management, electric energy at 8d. per unit can be made to give as much illumination by means of incandescent lamps as gas at 3s. 2d. per thousand cubic feet used with ordinary gas burners. At this rate, one Board of Trade unit of electric energy can be made to do the work of about 200 cubic feet of gas.

A very important factor which enters into the question of the cost of incandescent lighting is the care with which the arrangements of the electric light "wiring" have been carried out. The "wiring" may be done in such a way that the user can only turn on and off large groups of lamps at once. As far as possible each lamp should be on a separate switch, and be capable of being used and put out of use alone. Such independent wiring costs more per light than group lighting, but it enables the user to create the necessary illumination with a minimum of expenditure of electric energy.

The actual average annual consumption of electric energy by incandescent lamps placed in buildings of various classes differs very greatly. Taking the case of supply by meter, it is found that for a large class of private houses the average number of Board of Trade units taken per annum by an 8-c.p. lamp will

* From a forthcoming work on "Electric Lamps and Electric Lighting," by Dr. J. A. Fleming, to be published by *The Electrician* Printing and Publishing Company. All rights reserved.

* See *The Electrician*, March 16, 1894, p. 561.

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not exceed 12 to 20. Indeed 20 is generally an outside limit. Lamps in clubs, hotels and restaurants show a very much larger average than 20, and may reach 30 to 40 B.T.U. per 8-c.p. lamp per annum, or occasionally even more. It may be mentioned that a 16-c.p. lamp would, under the same conditions, take twice, and a 32-c.p. three times the above amount. Since a 35-watt 8-c.p. lamp takes one B.T.U. of electric energy in 30 hours of continuous use, it follows that from 360 to 600 hours is the average total time during which a lamp in a private house is in use in the year. That is, from one hour to one hour and a half is the average daily time during which each lamp is alight in residential buildings. During the other 23 or 22½ hours of the day, however, the electric supply station has to keep in readiness, machinery or other apparatus capable of giving current for that lamp should the user require it. The *load factor* of a supply station is the ratio of the actual amount of Board of Trade units sold to the amount which could be sold if the demand were constant and equal to the maximum demand. It will be seen from the above figures that the load factor of an electric supply station, supplying a purely residential district, does not exceed 8 or 10 per cent. The load factors of various classes of buildings are very different. The load factor of private houses is seen from the above figures to be even below 8 per cent. The most profitable consumers, therefore, from the point of view of the suppliers of electric current, are not those who have most lamps, but those who use the lamps they have for the longest number of hours.

THE RISE OF CURRENT IN INDUCTIVE CIRCUITS.

BY ALEXANDER RUSSELL.

The following extension of some theorems connected with the rise of current in an inductive circuit to the rise of current in branched circuits is simple, and leads to some very interesting results. For example, on closing a main circuit which branches off into various inductive paths, we may get a reversal of current in some of the branched circuits, and on breaking the main circuit we may get a reversal of current in other of the branched circuits. For simplicity, the case of two circuits only has been considered in this Paper, as the extension of the algebraical laws given to any number of branches is obvious. The curves, showing the rise of current, were drawn from somewhat complicated mathematical equations, which have been omitted as unnecessary, seeing that a study of the graphical numerical examples will give a very good idea of what happens in the general case.

For convenience, the coil, which has a resistance of R ohms and a self-inductance of L henrys, is denoted by the coil (R, L). It is well-known that when a difference of potential, V, is established between the terminals of a resistance coil, the current in the coil, owing to the back E.M.F. of self-induction, does not instantaneously assume its value, but takes a certain finite time to rise to its steady value. If the coil be (R, L), the rate at which the current grows at the start is $\frac{V}{L}$ and then the rate at which it rises rapidly diminishes until it becomes zero and the current attains its steady value $\frac{V}{R}$. If it had attained this value instantaneously, more electricity would have circulated in the coil. Hence the effect of induction is to block out a certain number coulombs (Q) from the coil. There is also a certain number of joules ($\frac{1}{2}$ Q V) stored up in the coil in the form of electro-kinetic energy, which energy will manifest itself by a spark if the circuit be broken, or will cause a quantity, Q, of electricity to circulate in the coil if it be short-circuited. In the latter case the current subsides, rapidly at first and very slowly afterwards, to zero.

It can be shown that if A_1 be the steady value of the current n the coil (R, L) then

$$Q = A_1 \frac{L}{R};$$

$\frac{L}{R}$ is often called the time constant of the coil.

We shall now consider how the rise of current in a coil is affected by the presence of neighbouring closed circuits. Take the case of a coil (R, L) with a closed coil (S, N) near it (Fig. 1). Let M be the mutual inductance between the coils, and let V be the potential difference instantaneously established at the terminals of (R, L). The rise of current in (R,L) induces a current in (S, N) which attains a maximum value, and then dies away, becoming zero when the current in (R, L) attains its steady value. It is obvious that the rise of current in (R, L) will not be the same as when there was no closed circuit near it, as the induced current in (S, N) reacts on the current in (R, L); helping its rise when the current in (S, N) is increasing, and opposing its rise when the current in (S, N) is diminishing.

Hence the current in the coil (R, L) rises more rapidly at first and less rapidly later on than if mutual induction were absent (Fig. 2).

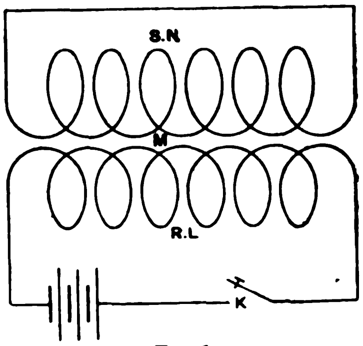

FIG. 1.

Figs. 2 and 3 show the rise of current in the two coils, when the values of the constants are R = S = 1 ohm, L = 0·5, N = 1, M = 0·6 henry, V = 3 volts.

The quantity of electricity that circulates in the coil (S, N) is equal to $A_1 \frac{M}{S}$ where A_1 equals $\frac{V}{R}$. In the case shown it equals 1·8 coulombs. Since the quantity induced in a coil depends upon the *final value* of the inducing current, it follows that the total quantity of electricity that circulates in the coil (R, L) due to the E.M.F. of mutual induction caused by the current in (S, N) is zero.

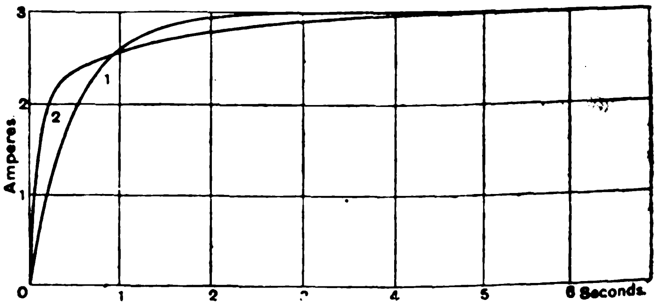

FIG. 2.—(1) Rise of Current, no Eddy Currents produced. (2) Rise of Current, affected by Eddy Currents.

Hence the amount of electricity blocked out of the coil (R, L) by induction is the same, whether the coil (S, N) be near it or away from it. The work done in raising the current to its steady value is the same in the two cases, and the electro-kinetic energy stored in the coil ($\frac{1}{2}$ Q V) is also the same. Therefore the heating effect on the coil (R, L) is less when there is a closed circuit near it. Again, suppose the coil (R, L) to be short circuited; the energy stored in the coil gives rise to currents in the two coils. Let H_1 and H_2 be the respective heating effects produced, then

$$\tfrac{1}{2} Q V = H_1 + H_2.$$

Thus H_1 is greatest when H_2 is zero; that is, when there is no mutual induction.

To get the curve showing the falling away of the current when the coil (R, L) is short circuited, we look at the curve (Fig. 2) upside down; the new line along which time, and above which amperes are measured, being the line 3T. The curve

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(Fig. 3) being the same as before, the currents being merely in the reverse direction.

The case of the rise of current in two neighbouring inductive coils connected in parallel is important. Let (Fig. 4) (R, L) and (S, N) be the two coils, and suppose that when there is a difference of potential, V, between B and C, the steady current in the (R, L) branch is A_1 amperes, and the steady current in the (S, N) branch is A_2 amperes. Then, by what has gone before, the quantity of electricity blocked out of the (R, L) branch by self-induction is $A_1\frac{L}{R}$, and in addition to this there is a quantity $A_2\frac{M}{R}$ blocked out by mutual induction.

Hence if Q_1, Q_2 be the total quantities blocked out of the two branches by induction, then

$$Q_1 = A_1\frac{L}{R} + A_2\frac{M}{R} = A_1\left(\frac{L}{R} + \frac{M}{S}\right), \quad . \quad . \quad . \quad . \quad (1)$$

$$Q_2 = A_2\frac{N}{S} + A_1\frac{M}{S} = A_2\left(\frac{N}{S} + \frac{M}{R}\right). \quad . \quad . \quad . \quad . \quad (2)$$

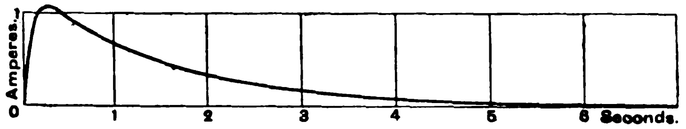

FIG. 3.—Rise of Current in a Closed Coil near an Inductive Circuit.

Now in the formulæ (1) and (2) M may be either positive or negative, depending on how the two coils are connected in parallel. When M is negative, it will sometimes happen that either Q_1 or Q_2 is negative. Of course, they cannot both be negative. Suppose Q_1 is negative, then, in this case, more electricity flows through the coil (R, L) than if there were no self and mutual induction. Hence the current in this branch must at first attain a value greater than its steady value. Again, since $\frac{M}{S}$ may be very large compared to $\frac{L}{R}$, the quantity blocked out of the (R, L) branch may be very large, so large, in fact, as to necessitate the current flowing in the reverse direction at the start in order that the requisite quantity be blocked out before the current attains its steady value.

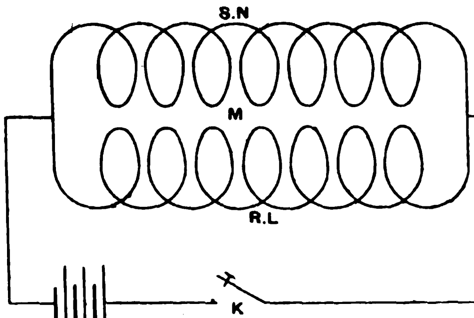

FIG. 4

The curves, Figs. 5 and 6, show the rise of current in the two arms when

$$R = S = 1 \text{ ohm}; \; L = 0{\cdot}5, \; N = 1 \text{ henry}; \; V = 3 \text{ volts}.$$

The curves (1) show the rise when M = 0. The curves (2) show the rise when M = +0·6 henry; and the curves (3) show the rise when M = −0·6 henry. The curve (2), Fig. 5, shows the rise of current in the coil when M = 0·6. The current at first rises more rapidly than if mutual induction were absent, and then less rapidly. The quantity of electricity blocked out, which is represented graphically by the area contained between the curve (2) and the lines 03T is, however, greater than if there were no mutual induction, the difference between the areas of the two loops formed by (1) and (2) being $A_1\frac{M}{S}$. The curve (3) (Fig. 5) shows the rise of current in this arm when M = −0·6.

In this case the current rises very rapidly, attaining a maximum value of nearly 3·3 amperes when the time is 0·5 seconds, and then gradually subsiding to its steady value of 3 amperes. The area included between (1) and (3) is as before $A_1\frac{M}{S}$.

Similar remarks apply to the curves shown in Fig. 6. The curve (2) in this figure is interesting, showing a reversal of current in the branch (1, 1) when M = +0·6, the current attaining its maximum negative value when the time is nearly 0·07 second.

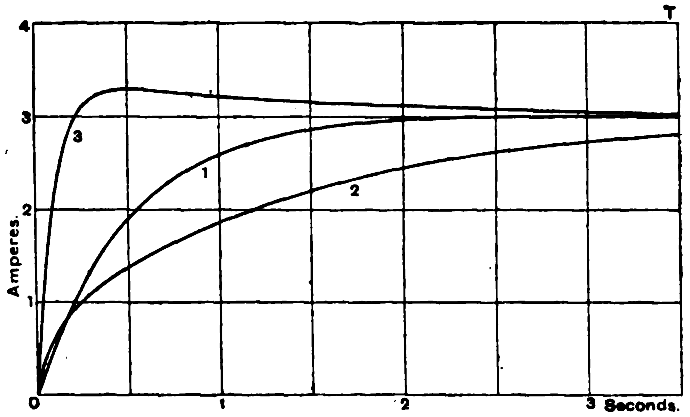

FIG. 5.—Rise of Current in One Arm of a Branched Circuit. (1) No Mutual Induction; (2), Mutual Induction helping Self-Induction; (3), Mutual Induction opposing Self-Induction.

Fig. 7 shows the rise of the resultant current in the two branches. At any moment the ordinate of the curve in Fig. 7 equals the sum of the ordinates of the corresponding curves in Figs. 5 and 6. The total quantity of electricity blocked out of the two coils in parallel is $Q_1 + Q_2$, which is equal to the area between 03T and the curve in Fig. 7, and the electro-kinetic energy stored in the two coils is $\frac{1}{2}(Q_1 + Q_2)$ V.

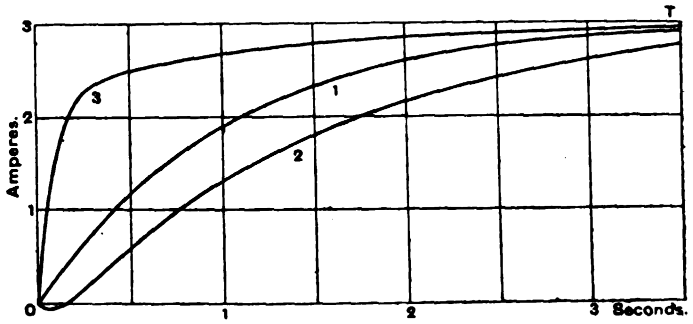

FIG. 6.—Rise of Current in other Arm. (Looked at upside down, and taking the line 3 T as the line along which time is measured, and above which Current is measured, these Curves show the fall of Current when the two Branches are Short Circuited.)

Substituting the values of Q_1 and Q_2 from (1) in this expression, we find that the electro-kinetic energy is equal to

$$\tfrac{1}{2} L A_1^2 + \tfrac{1}{2} N A_2^2 + M A_1 A_2,$$

and this may vary between wide limits depending on the value of M. M must lie in value between

$+\sqrt{LN}$ and $-\sqrt{LN}$. If M equals $-\sqrt{LN}$ and $\frac{R}{S}$ is equal to $\sqrt{\frac{L}{N}}$, the electro-kinetic energy would be zero, no electricity would be blocked out, and there would be an instantaneous rise and fall of current.

These effects are very well illustrated by connecting the two coils of an ordinary transformer in parallel, and then sending a direct current through them. With a small Lowrie Hall transformer, a tangent galvanometer was put in series with its high-tension circuit, then, on making the circuit, the needle swung 6 deg. to the left, and then took up a steady deflection of 15 deg. to the right. Hence in this case we had a reversal of current in the high tension arm. On breaking the circuit the needle swung 5 deg. farther to the right, and then settled down to zero. Again, when the connections of one of the parallel arms were reversed, on closing the circuit there was a

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large deflection to the right, and on opening the circuit a still larger deflection to the left, showing that there was again a reversal of current in the high tension arm. A small compass needle with a few turns of wire round it can be used instead of a tangent galvanometer.

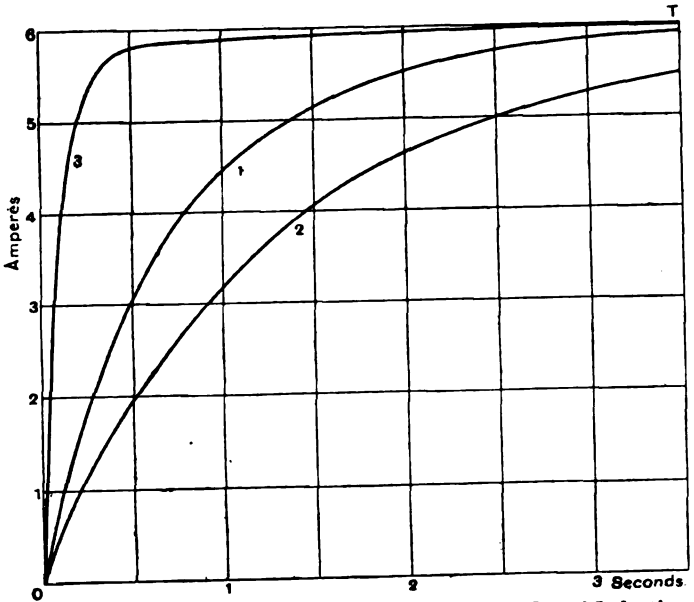

Fig. 7.—Rise of Current in Main Branch. (1), No Mutual Induction ; (2), Mutual Induction helping Self-Induction ; (3), Mutual Induction opposing Self-Induction.

It is easy to devise some very striking lecture-room experiments, showing how by increasing the resistance of one branch we can make the reversal of current vanish in that branch and take place in the other.

THE ILLUMINATING POWER OF PROJECTORS.*

BY F. NERZ.

The great projector exhibited by the Electricitäts-Actiengesellschaft (formerly Schuckert and Co.) at the Chicago Exhibition has been the source of many lucubrations in the technical press, some of which are not calculated to conduce to the better understanding of this subject. Prof. Silvanus Thompson, in *The Electrician* for September 29, 1893, gives vent to a criticism of the statement that this projector illuminates distant objects with an intensity of 190 million standard candle-power; and he comes to the conclusion that for this result a crater-surface of 17·6 sq. metres would be required, since it is known that an arc giving only a million candle-power requires about 0·093 sq. metre surface of crater. Prof. Thompson does not give us any information as to the conditions under which this is true. If the value is intended to mean the zone of greatest intensity, then Prof. Thompson takes the surface much too high. His figure works out at 11 c.p. per 1mm. square of crater surface; while for the 8-ampere lamp of commerce a mean spherical intensity (not maximum) of about 320 c.p. is attained, being about 20 c.p. per 1 sq. mm. A lamp for 60 amperes has a crater about 12mm. in diameter, and according to Thompson's figure should have 1,255 c.p. The actual maximum intensity measured by the author is more than ten times as great.

The glass parabolic mirrors now made by the Elektricitäts-Actiengesellschaft, receive the light of a horizontal lamp under an angle of incidence of about 120 deg., and therefore include the most powerful rays emitted by the crater of the positive carbon. The average intensity of the light falling on the mirror is about 80 per cent. of the maximum intensity of the arc. One must assume that Prof. Thompson in giving figures in support of his statements has taken this latter fact into consideration, and has not given the mean spherical intensity; but even for the latter case his figures are too small. One must also assume that he was talking only of lamps for large currents such as are used with projectors, and that his figures refer to these. Prof. Thompson's criticism rests on an erroneous idea as to the data for the determination of the illuminating power of projectors. It is obvious that he is considering the illuminating power of the intensity of the rays of the lamp falling on the reflector, whereas it is the illuminating power of the collected bundle of rays which must be dealt with. However, Mr. C. P. Steinmetz corrected this mistake in an article in *The Electrician* of October 27, 1893, and his conclusions are in agreement with those come to by the author in his Paper on the "Construction and Uses of Projectors,"* and there were little to add to this, had not the matter spread further and been discussed by Mr. C. Hering in the *Electrical World*, and M. E. Hospitalier in *L'Industrie Electrique*. Mr. Hering attempts to show that the general law of emission of light cannot be applied to projectors, because the light cannot be considered as starting from the projector, but rather from a theoretical source of light in a point, P, behind the mirror. To a question put of the largest manufacturers of projectors as to how the results of photometrical measurements on such apparatus are obtained, Mr. Hering has probably received no satisfactory answers. The answer of Messrs. Schuckert and Co. was as follows :—That they used a Weber photometer for their measurements of lamp and projector, the latter being not less than one kilometre distant. "The mean intensity of illumination of the rays falling on the mirror multiplied by the ratio of the squares of the diameter of mirror and crater must then give the intensity of illumination of the beam measured by the photometer, naturally allowing for atmospheric absorption." They refer him for further particulars to the author's pamphlet on projectors already published in *The Electrician*.

Thus the photometer is at least a kilometre from the projector. Now, Mr. Steinmetz gives the angle of the great Chicago projector at about 2deg., which would give an emission point 43 metres behind, thus giving 1,043 instead of 1,000 metres as the distance to the photometer. One may surely neglect this error, seeing that the photometer readings are not determinable to such limits of accuracy. The further remarks of Mr. Hering are quite unintelligible, in which he seeks to prove that the light coming from the projector does not follow the ordinary laws of light emission, and the author recommends Mr. Hering to read M. Blondel's articles in *L'Industrie Electrique* on the "Théorie Photométrique des Projecteurs," in which he shows that the measurements at Chicago are correct if the mirror be sufficiently nearly parabolic. This condition is quite justified, and the utmost efforts of the manufacturer should be directed to the production of a very close approximation to theoretical form. Tests of the Schuckert mirrors against the Mangin reflectors of Messrs. Sautter, Harlé and Co., have shown that the former glass mirrors are always superior in shape. There are several methods of testing the accuracy of the parabolic mirrors. The first, suitable only for comparisons, is that indicated above ; the two projectors are set up at the same distance of over a kilometre from the photometer, and provided with obscuring apparatus. The atmospheric conditions are then identical in the two cases. Tests so made by the military authorities in Austria of the Schuckert and the Sautter Harlé apparatus, showed, after a large number of observations, an advantage of 25 per cent. and upwards (averaging 36 per cent.) in favour of the former type.

A second method is the determination of the ratio of the spreading actually found to the theoretical amount. If d be the diameter of the crater, δ the angle at the apex of the shadow cone which is formed in the case of a horizontal lamp by the negative carbon, and ρ the radius of curvature of the parabolic reflector with the angle of incidence $\frac{\delta}{2}$, then the angle of spreading should theoretically be given by the equation

$$\tan\frac{\alpha}{2}=\frac{d\cos\frac{\delta}{2}}{2\rho}\,;$$

or, substituting for ρ its value $2f\left(1+\cos\frac{\delta}{2}\right)$, where f is the focal distance of the mirror,

$$\tan\frac{\alpha}{2}=\frac{d\left(\cos\frac{\delta}{2}+\cos^2\frac{\delta}{2}\right)}{4f}.$$

Having thus determined the theoretical spreading, one determines the actual amount by measuring the angle of the beam, and the ratio gives an idea of the correctness of form of the reflector. This ratio is for the present Schuckert mirror 1:1·08, the deviation from parabolic form being thus extremely small. Of course, this method is not susceptible of very great accuracy, owing to the difficulty of determing the diameter of the crater and the angle of illumination of the beam, these being indefinite owing to the gradual manner in which the carbon passes from white heat to blackness in passing from the crater to the outside. Another method for determination of defects of shape in the reflector is to observe the shadow cast by a ruler or other straight-edged object. The smallest fault in the mirror, quite undiscoverable by measuring instruments, gives irregularities in the shadow. More exact results are obtained by the third method, that of Tschikoleff. The glass mirror in its

* Abstract from the *Elektrotechnische Zeitschrift*, No. 27, 1894, p. 365.

* *The Electrician*, 1893, April 21st and 28th.

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Projector Table.

Diam. of reflector D; mm.	Current Amperes.	Volts.	Watts.	Standard c.p. per watt.	Intensity of light rays falling on mirror in c.p. — Max.	Intensity of light rays falling on mirror in c.p. — Mean.	Mean intensity of reflected rays, in standard c.p.	Diam. of crater, *d*.	Gathering power of mirror, D^2/d^2.	Intensity of beam issuing from projector at a great distance; neglecting atmospheric absorption.	Focal length of mirror *f* in mm.	Angle of spreading.	Diam. of illuminated field at 1 km. distance. metres.	Brightness in metre-candles for an absorption of 10·4 per cent. per kilometre. — At 1,000m.	Brightness in metre-candles for an absorption of 10·4 per cent. per kilometre. — At 2,000m.
400	20	43·5	870	4·0	3,480	2,780	2,500	9·3	1,854	4,625,000	180	2° 58′	51	4·57	0·93
	25	44·0	1,100	4·6	5,000	4,000	3,600	9·4	1,811	6,490,000	180	2° 59′	52	5·8	1·3
	30	44·0	1,320	4·8	6,300	5,000	4,500	9·5	1,773	8,000,000	200	2° 43′	47	7·17	1·6
450	20	43·5	870	4·0	3,480	2,780	2,500	9·3	2,341	5,850,000	200	2° 40′	46	5·24	1·18
	30	44·0	1.320	4·8	6,300	5.000	4.500	9·5	2,244	10,600,000	200	2° 43′	48	9·5	2·125
	40	45·0	1,800	5·14	9,250	7,400	6,660	10·0	2,025	13,500,000	200	2° 52′	50	12·5	2·7
600	40	45·0	1,800	5·14	9,250	7,400	6,660	10·0	3,600	24,900,000	250	2° 18′	40	22·4	5·0
	50	46·0	2,300	5·35	12,300	9.800	8,820	10 9	3,030	26,700,000	250	2° 30′	44	23·9	5·35
	60	47·0	2,820	5·55	15,500	12,400	11,160	12·1	2,459	27,200,000	250	2° 47′	48	24·3	5·45
750	60	47·0	2,820	5·55	15,500	12,400	11,150	12·1	3,840	42,300,000	310	2° 16′	39	37·8	8·5
	75	49·0	3,675	5·8	21,200	17,000	15,300	14·3	2,744	42.300,000	310	2° 38′	46	37·8	8·5
	90	51·5	4,680	6·0	28,100	22,500	20,300	16·7	2,020	42,300,000	310	3° 6′	54	37·8	8·5
900	60	47·0	2,820	5·55	15,500	12,400	11,150	12·1	5,532	61,000,000	310	2° 16′	39	54·7	12·25
	75	49·0	3,675	5·8	21,300	17,000	15,400	14·3	3,950	61,000,000	380	2° 8′	38	54·7	12·25
	90	51·5	4,680	6·0	28,100	22,500	20,300	16·7	2,900	61,000,000	380	2° 32′	44	54·7	12·25
900	100	53·0	5,300	6·05	32,000	25,700	23,130	17·5	2,640	61,000,000	380	2° 43′	47	54·7	12·25
	125	55·5	6,660	6·23	41,500	33,200	29,880	20·0	2,030	61.000,000	420	2° 44′	48	54·7	12·25
	150	59·0	8,900	6·45	57,000	45,600	41,040	23·0	1,530	61,000,000	420	3° 8′	55	54·7	12·25
1,100	150	60·0	9,000	6·5	58,000	46,400	41,750	23·0	2,287	96,000,000	520	2° 32′	44	86·0	19·25
1,500	150	60·0	9,000	6·5	58,000	46,400	41,750	23·0	4,300	180,000,000	650	2° 2′	36	161·0	32·25

holder is placed in front of a screen roughly divided, with the axis of the reflector perpendicular to the screen. The latter has, arranged centrally, an opening in which is fixed a photographic lens. The screen is painted black and divided by white lines 5 mm. wide into compartments, or squares of 50 cm. per side. If the screen be illuminated by arc lamps placed alongside, there appears on the ground glass of the camera attached to the lens above mentioned, a picture of these lines when the screen is at a certain distance from the mirror, and this picture can be photographically enlarged. The images of the lines must be regular continuous curves, and the smallest defect shows itself in an irregularity. The limits of allowable irregularity are not easily defined; and a mirror should be kept as a standard which has passed the first test mentioned, and all worse than this should be rejected. This method of Tschikoleff does not give any information as to the approximation of the mirror to parabolic form; it merely tests for regularity of shape. Tschikoleff recommends that an accurate template be made, and the final determination performed thus: The mirror is set up in a suitable frame with a lamp in its focus and the reflected light is caught on a screen set up a few metres away—the field of light on this must be as even as possible, and rings of light in the spot show inaccuracy of form.* Here again only experience can determine how far irregularities may be permitted.

The above tests are only necessary to convince minds which are prejudiced against glass parabolic mirrors; and when once anyone is convinced of its advantages the second method, of measuring the angle of the beam, will be quite sufficient. The table herewith gives an idea of the performance of the Schuckert mirrors. If we take in this table the value of the illumination for a mirror of 60cm. diameter with a 40-ampere arc, we find the value 24,900,000 standard candles. In the experiments of the Austrian military authorities, 20,000,000 standard candles was the value measured at 2,050 metres distance. This makes the value of atmospheric absorption at 10·4 per cent. per kilometre, a value well within the bounds of probability. Above 60 amperes there are no reliable observations and only approximate values are given, resting on the observation that above certain values raising the current does not increase the illuminating power of a projector.

So long, therefore, as the author's statements as to the illuminating power of projectors are supported by evidence, while no proofs are brought to the contrary, we may be permitted to accept the figures given by Messrs. Schuckert as correct.

It might appear open to question whether the old statements as to projectors should not suffice us, without introducing the new standard of the illuminating power of the beam. We may, therefore, consider a little more nearly the older statements. Up to a few years ago the French firm of Sautter, Lemonnier and Co. were the only authorities on the construction of projectors, and we find in all their publications that they took the intensity of the radiation from the source to the mirror as the standard of reference. In some cases they specified the "pouvoir condensateur," but generally the description was projectors of 600, 2,000, or 4,000 carcels. As a rule the distance at which objects could be discerned was also given, under the understanding of a clear night, bright colours on the illuminated object, and often a certain size therefor, besides a practised observer in a good position. These conditions are naturally extremely indefinite, and for purposes of comparison are quite valueless. So that against the statement that the Spanish Government sent to Melilla a Mangin projector 80cm. in diameter which made objects 5 kilometres away easily discernible, and which was far superior to the Schuckert instrument, may be set the counter-statement that in the Gulf of Ismid, with a 60cm. Schuckert projector, objects 9·8 kilometres away were clearly seen. Both statements are valueless, except for the purpose of throwing dust in the eyes of the uninitiated. The atmospheric absorption, varying from 2 to far over 50 per cent., entirely vitiates such observations. It may be shown mathematically* that the seeing distance is proportional to the fourth root of the illuminating power of the projector. If, therefore, we take a projector better by 36 per cent. than a second, we find that if the latter has a sight distance of 1,250 metres, the former has only 1,350 metres. To raise the sight distance from 3,000 metres to 3,300 metres, or 10 per cent., would require a mirror better by 50 per cent.

It is then abundantly clear that photometrical observations at the place illuminated are the only possible means of comparison, and they avoid all errors due to fatigue or dazzling of the sight. The author thinks that the attempt of Messrs. Schuckert to break with precedent, and to put the question of projector measurements on a sounder scientific basis, should meet with support from experts, and does not deserve to be decried as it hitherto has been by those who should only have a scientific interest in the questions at stake.

Electric Traction in Italy.—A contract has just been secured by the French Thomson Houston Company for the construction of an electric tramway between Varese and Santa Maria de Montana. The line will commence at the Varese railway station and pass through the town, and through the village of Saint Ambrose, terminating at Santa Maria de Montana. The line will be a single one with a gauge of 3·6ft. It is said that only about 10 per cent. of the whole line will be on the level. The rolling stock will comprise four motor cars, each fitted with two 25-H.P. motors, and capable of accommodating 50 passengers each. There will also be four ordinary cars to act as "trailers."

* The mathematics are given in the original article.—ED.

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HERMANN VON HELMHOLTZ.

A prince and a great man has fallen in the ranks of science, a rich and matured judgment is lost to the world. The century which has witnessed such a blaze of scientific genius is becoming rapidly impoverished of its great men in almost all departments, and to all appearance it seems unlikely to carry many of its typical heroes over into the twentieth century. There are not wanting prophets who foresee a critical period for science in the near future, writers who suggest that, unless scientific men band themselves together, the hostile powers of dogmatic theology on the one hand, and of aggressive ignorance on the other, will close in and temporarily destroy it. That part of science which leads direct to practical applications is no doubt safe in the hands of the coming democracy, but into the higher regions and upper air of pure science itself the outlook is not so clear. A period of neglect is not an impossibility; perhaps it may even be held that such a period would in some ways be useful by giving time for the mass of already acquired knowledge to be assimilated; time for it to soak into the minds of the people. The progress made during the lifetime, and largely by the aid, of such a man as VON HELMHOLTZ is something enormous. Our ideas on a number of fundamental subjects have been revolutionised within the last fifty years, and glimpses have been caught into regions of which the average man is not yet even dimly conscious. Continual progress at this rate seems well-nigh impossible, and were it possible it might be useless; for what the average man cannot even begin to assimilate remains undigested, and must in the course of time be either extruded or ignored. The advance of science into regions too hopelessly beyond ordinary capacities and intelligences must need for its permanence either the continuance of a race of giants, such as we have been and still are familiar with, or else the raising of the average level of knowledge and intelligence to an unprecedented and probably impossible extent. When the general feeling about any branch of science is that it is in the air, and too lofty for sublunary consumption, then, however admirable and coherent it may really be, for all practical purposes in the air it is; and when its holders and supporters die, it may be expected to float away beyond the ken of those who remain, until a new race of geniuses arrive, and mankind in general has advanced to a higher plateau of thought.

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These thoughts apply less directly, perhaps, to the work of von Helmholtz than to the work of some other men of similar magnitude. The extraordinary combination of power which he possessed, the many-sidedness of his character and knowledge, his power of expressing himself with fair simplicity in ordinary language, have enabled him to tether permanently for the use of mankind much elevated floating material which otherwise would have been out of range. And in this he has been fortunate in not being alone. He has been one of a race of giants, and he has had the advantage of a great school of disciples and co-workers, eager and well-instructed men, who have, with industry and ability, seized and secured and developed one discovery after another as they emerged from the mint of his genius.

His work in acoustics and optics in connection with the ear and the eye is well known, and has given a great stimulus to workers, especially to workers in the subject of physiology, sometimes stimulating them to agreement, sometimes to divergence of view, but always leading to activity and discussion and progress. His work on the application of the principle of the "Conservation of Energy to Physics," in 1847, has now become almost a commonplace of science. No one doubts now that Leyden jar discharges are oscillatory, or that the mechanical power of electric motors depends on the back volts generated in their armatures, In more recondite regions he first showed how to apply mathematics to the more difficult problems of hydrodynamics, and thus rendered possible that treatment of vortex motion which appears destined to play so enormous a part in the semi-ultimate explanation of the physical universe. On this must be based in all probability the theory of matter, the theory of ether, the theories of gravitation and of cohesion. To have been at the origin of such a wide-embracing theory as this transcendental hydrodynamics may not improbably in the future seem to posterity to constitute Helmholtz's greatest title to fame.

We of the present think more of the ophthalmoscope, or of his work in connection with practical units of electrical measurement; and we even go so far as to permit one great man to be sent on a bootless errand to Chicago, there to discuss trivial questions about practical electrical units, and to help decide the momentous question whether a unit of self-induction shall be called by the name "Henry" or by some other euphonious appellation. Whatever the merits of this trip to Chicago, it has not been accomplished without cost to the world. The age of 73 is in some senses and for some lives a ripe age, but a man like Helmholtz should have lived longer. That the peaceful, placid existence represented in his own most beautiful autobiographical sketch should have been terminated in such a senseless manner; whether the journey was undertaken at the beck of a headstrong and self-sufficient young man on whom the Germans have chosen to confer unwieldy power, or whether it was undertaken for some better reason, cannot but be regarded as a terrible pity. It may be true that at 73 a man's most active work is done, his main lines of thought matured; but how valuable may not such a ripe power and matured judgment be to the world! Has the world many such men, that it can afford to throw them away so lightly?

This same autobiographical sketch of Helmholtz must become better known. As a pamphlet for private circulation it was translated a year or two back by Dr. Atkinson; but, though brief, it ranks with the life of Darwin in the insight it gives into the calm, clear-sighted, modest, vigorous, and patient thoughtfulness which characterised both these great men: it is a lesson to this fevered age concerning the atmosphere in which discovery is possible, of the mode of working of a true genius, of the manner of man to whom inspiration is almost a daily experience.

Helmholtz is usually thought of as a physicist, a physiologist, and a mathematician; but even this wide range did not exhaust his sympathies and interests. The new science now struggling to the birth—that of experimental psychology—welcomed him among its most powerful, though silent, sympathisers. He attended the last congress in London before going to the Edinburgh meeting of the British Association, and the hardly-discovered facts, now being at last rescued from superstition and placed upon a scientific basis, found in him no cold disdain nor surly opposition, but a friendly countenance and helpful criticism.

Well, he has gone, and we are the poorer for his loss. The services of such a man are not to be limited by national boundaries, nor acknowledged with constricted gratitude; he belongs to the world and to nothing less. The possession of great genius is a great responsibility; not every nation is worthy of it. Fortunate were the German people in receiving in their midst so indomitable and persevering a worker, so single-hearted and estimable a man; and they have proved themselves worthy of the trust. All his later life they have held him in highest honour, and they provided him with material resources such as no other civilised nation at the same epoch was likely to bestow. Honourable his life has been, both to man and nation, and the world, though blind to many things of high and noble import, has in this case no cause to regret that the man came before his time, or that he spoke to a faithless and perverse generation.

SOME NOTES ON THE GOVERNING OF STEAM ENGINES, PARTICULARLY WHEN COUPLED TO DYNAMOS.

BY G. L. ADDENBROOKE.

This is a subject which has always been in my mind in connection with central-station electric lighting; and the fact that it has been brought into prominence by Mr. Swinburne, in his simple but lucid Paper before the British Association, shows that the question is now beginning to attract the attention which it deserves.

Mr. Swinburne says that the governing of engines, particularly small ones, is generally better attended to on the Continent than in England; the reason, I think, is that although our neighbours may be less particular and less thorough in some points than we are, yet they are more accustomed to treat matters as a whole, and to take into account conditions which the ordinarily trained executive engineer in this country considers as subjects for discussion by theorists at the societies; but which he, in his capacity of having to make things go, need not concern himself with.

That is one way of looking at the question. The next is that for most industrial applications the governing of the engines for many years has been amply good for all practical purposes, so that there has been no need to devote special attention to it. An exception must here be made as regards marine engines, the difficulties in governing which in a rough sea, when the screw comes frequently out of water, have never yet been satisfactorily overcome, although a great amount of time and care has been devoted to perfecting different forms of governors for this purpose.

In order to understand the exact position of matters at present, as regards the governing of the engines used for other than marine purposes, it is advisable to look back a little at the history of the steam-engine governor, and the purposes to which it has been chiefly applied up to the present date, premising the fact that so far electrical engineers have not paid any very great amount of attention to the problem, as they

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have been occupied by other considerations of more immediate importance, and have been generally content in this particular to accept the practice of industrial engineers, and to rely on their judgment as having the greater experience.

Steam-engine governors were, I believe, first used on pumping engines, and their main object was to prevent the engine running away when the pump rods or any other important moving part broke, and the engine would, unless controlled, have run away and probably wrecked itself. For doing this a very rough style of governor was sufficient.

The use of winding engines in mines did not advance matters much, because, although a more sensitive governor is desirable, yet the driver generally controls the valve motion largely himself, as this is more convenient—the engine being used for short periods and being frequently reversed.

Engines were next applied to driving forging and rolling plants in ironworks; and here a governor is essential, as the strains vary so quickly when the material is being passed through the rolls. A comparatively rough governor is, however, sufficient, as the moving masses are usually very heavy, and exact equality of speed is not absolutely essential.

What really caused careful attention to be paid to the construction of governors and valve-gear was the application of steam engines to driving spinning machinery, the rise of mechanical weaving and spinning, and of the best modern types of steam engines, being almost contemporaneous. For a loom to work properly, regular speed is essential, or the shuttles will not throw properly, and uneven strains are produced in the material. Not only, therefore, has the best steam practice been usually devoted to the construction of engines for driving textile factories for the sake of economical working, but at the same time the utmost pains have been taken to design valve and governing gear which would admit of the engine's doing its work at a constant speed whatever the load. The latter condition was essential, because only one engine was usually employed for driving at a time, though the load would constantly vary as different machines were thrown in and out; and at times a part of the factory might be altogether closed if work in one of the departments was slack.

The engineers who devote themselves chiefly to the construction of mill engines have for many years been able to meet these conditions, and to supply plant which would readily retain a speed within 2 per cent. or 3 per cent. of the normal, whatever might be the load. It is true that large fly-wheels and comparatively slow speeds have hitherto been chiefly in vogue for this class of plant, but this is a somewhat minor point.

Such being the state of affairs when electric lighting first became practical, electrical engineers naturally turned to the constructors of mill engines for advice and help; the result was the application of the mill engine, with rope driving, to turning dynamos, a system which has worked well wherever it has been properly applied, while for freedom from breakdowns and exactness of working this method has probably not yet been surpassed. Such plants, however, occupy a great deal of space, are rather expensive, and there is a certain loss of power in rope driving. Consequently the high-speed engine has been developed to get over these difficulties, so far, chiefly of the single-acting type; but now that the conditions of running of such engines is better understood, and confidence in high-speeds is increasing, there are indications that similar engines, but double-acting, will gradually come to be preferred.

Our cursory glance at the history of the application of governors to engines has now made it manifest that the best practice hitherto has been in the construction of governors to produce perfectly even motion, whatever the load. Further, it must be noted that such engines have usually been engaged in supplying energy direct in the form of motion to lines of shafting and to machinery which it is required to run at a constant speed.

Let us now turn to the driving of dynamos by means of steam engines. The proper methods of governing such engines will naturally depend on the purposes to which the current produced is to be applied. If for the transmission of power or the running of arc lights in series, very little alteration of existing methods is required; but if the engine is used for lighting incandescent lamps direct, whether for a private installation or in a public supply station—which latter is, of course, the most important case, and the one to which it is proposed to devote most attention—then it is desirable to clearly define the limiting conditions of the problem; so that, knowing exactly what is required, we may be in a position to judge how far existing appliances meet the conditions, and where they are defective, and thus arrive at a definite idea of the directions in which alterations and improvements are required.

Now in a central station, the ultimate object is the incandescing to a certain point of carbon filaments, to procure from which the standard amount of light—16 candles from a 16 c.p. lamp—the pressure or voltage must be steady and exact, within one per cent. on either side of the normal, any further variation either way making a great difference in the light. It is true the Board of Trade permits a wider variation than this, viz., 4 per cent.; but this is extreme, and greater than ought to be permitted in any well-regulated station, since 4 per cent. variation in the pressure of the supply means 25 per cent. variation in the light given by the lamp, besides a change in colour if the voltage is reduced, or premature destruction of the filament if it is increased.

The obtaining of an even pressure over a district is a question of the system of supply and the design of the mains, and one we are not dealing with here. All we need gather for our present purpose is that the supply, and consequently the running, of the engines must be regular under all conditions, whether lamps are turned on and off, and, secondly, some predetermined voltage also must be maintained at the station terminals, differing at different times of the day to allow for varying losses in the mains as the load alters.

Perhaps, in order that we may present to ourselves a clear idea of the conditions, an entirely mechanical analogue may be useful. Let us suppose that the engine-room in a central station is the engine-room of a large mill which is worked by several steam engines, driving by means of pulleys and friction clutches on to a line of counter-shafting. Imagine that these clutches are not very well designed, and that there is always a certain amount of slip in them, not more than six or seven per cent. at light loads, but increasing considerably at heavy loads. It is, of course, required to keep the mill machinery running evenly within two or three per cent. If the load is a light one not only will the engine or engines be lightly loaded but there will be very little slip in the clutches; on the other hand, as the work done in the mill increases and becomes heavy, not only will the load on the engines increase, but, having to keep the mill machinery revolving at a constant speed, the speed of the engines will also have to be increased to make up for the extra motion lost in the clutches, the friction of which will absorb energy, which will be dissipated as heat as the losses in dynamos are. Under these circumstances it is clear that it will not be sufficient if we have a governor which keeps the engines running always at the same rate: we must over-govern to some extent, that is, we must not only have the speed of the engine always under control. but we must also have an arrangement by which the engine shall go a certain percentage faster at heavy loads than at light. We may diminish the difference of slip at different loads by improving the efficiency of our friction clutches, but the fact remains that it exists to some extent and that it must be compensated for.

In an electric lighting central station the dynamos may be regarded as the friction clutches in the above simile. Besides a certain loss of power greater at heavy loads than at light, and which may be likened to the loss in friction in the clutches, there is also a loss of motion. increasing with the load, due to self-induction and the back action of the armature current on the fields, which weakens them and necessitates the speed being increased to obtain the same voltage; this is like the slip in the friction clutch. If not corrected by outside influences it may amount to from 10 to 20 per cent.

In the central station there is the further point that at the hours of heavy load it is necessary to run at a higher speed altogether than at light loads in order to keep up a higher general pressure in the mains to allow for increased loss in them.

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Consequently, in driving dynamos in central stations for lighting, we have not only to secure regular running or absence of sudden variations of speed at all loads, but we have got to provide, taking the light load as a basis, that as the load increases the driving speed shall be increased in order :—

1. To increase the pressure on the mains.

2. To overcome the increased armature resistance and provide increased excitation of the field magnets.

3. To make up for the slip or loss in pressure caused by the increased back action of the armature on the magnets and increased self-induction, which necessitates a higher rate of driving, though it does not directly mean loss of energy.

It is true that it is not absolutely necessary to increase the speed of the engines, it may be kept constant at all loads as in mill engines, and the requisite variations may be produced by the use of resistances or by varying the excitation of the dynamos, by means of resistances or the use of a separate exciting engine.

SWINBURNE DYNAMOTORS AND MOTOR GENERATORS.

The machine illustrated in Fig. 1, which was made for University College, Bristol, to the order of Prof. A. P. Chattock, by Messrs. Swinburne and Co., is a small direct-current motor or generator

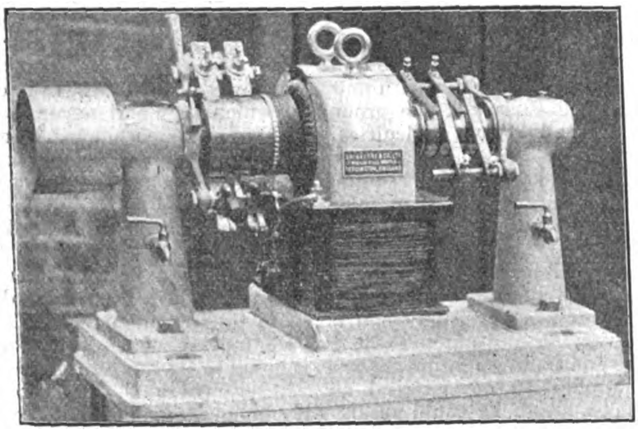

FIG. 1.

fitted with four slip rings. Driven by a belt, it either gives a direct current, or excites itself and gives an ordinary alternating cur-

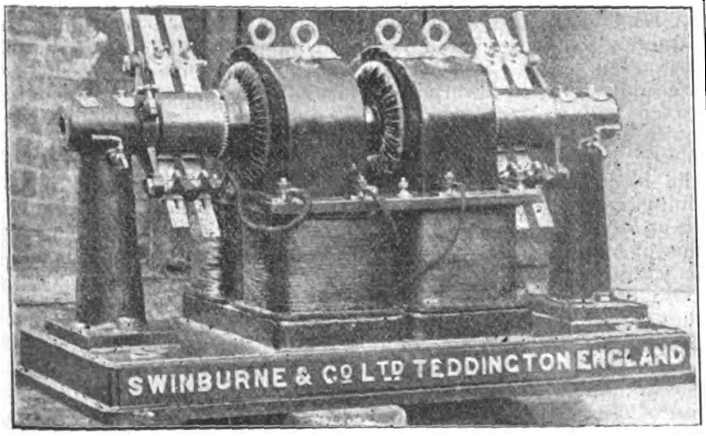

FIG. 2.

rent of low frequency from two of the slip rings. If three of the slip rings are used, a triple alternating current is obtained. The machine may be fed with a direct current, and will then give a much larger alternating current output; for as there is only one armature winding, the wires have to carry comparatively small currents for most of each revolution. This machine is intended for use in laboratories, technical colleges, experimental shops, &c., in place of Messrs. Swinburne and Co.'s ordinary B type motor alternator, where cost is a principal consideration, and the comparatively low frequency does not matter.

The dynamotor shown in Fig. 2 is for charging cells in central stations. In many cases it is a serious expense to arrange for dynamos to give the full charging pressure, it is much more convenient to use a dynamotor for giving the odd 25 or 50 per cent. extra pressure needed for charging. A dynamotor of this sort can also be used for charging and discharging all the cells uniformly on the mains, so that one cell is not worked more than another. This is of great importance in battery stations, as it increases the life of the cells, and saves the complications of charging and discharging switches.

A small machine has been made by Messrs. Swinburne and Co. for working a telephone exchange off the town mains, without trouble from want of insulation. The armature is wound with two circuits which are very highly insulated from each other, so that the telephone system can have earth returns without any complications due to the network of electric mains getting power from the same sources. The insulation between the windings is practically infinity.

THE THREE-WIRE TROLLEY SYSTEM AT BANGOR, ME.*

BY J. G. CARROL.

Having noticed an article in one of the electrical journals suggesting the feasibility of operating an electric railway by the three-wire system, I became much interested, particularly as the road I am connected with has been using that method for some three years. The article stated that such method was possible or practicable only on double-track road. I will endeavour to make clear how it is possible to operate a single-track road by such methods. In the first place, our power plant being situated 4½ miles from the nearest point of the road, it was necessary that some means be devised to avoid the enormous expense that would be incurred in getting the copper wire necessary to have a metallic circuit. We tried in the first place to get a ground return by putting copper ground plates in the river at different points along our route and at the power station; but to no purpose. A portion of our line, 2½ miles long, situated in the city of Brewer, is connected at each hydrant with the rail, and as we operate the water system of that city, and the pumping station is in the same building as the railway power plant, this gives us a good return when needed. But, operating as we do now by the three-wire system, this is unnecessary when in balance. We have 7·74 miles of single track with seven turnouts. The rail is 35lb., one-half tram and the balance T. The system consists of two distinct roads, one in the city of Brewer, about 2½ miles long, and the other in Bangor, 5¼ miles. By reference to the map it will be seen that there is no connection between the two. The rails are bonded at the joints with No. 4 copper bonds, and connected at each joint with a supplementary No. 4 copper wire.

Our power plant consists of four Thomson-Houston generators, driven by four Holmes turbine wheels of 120 H.P. each. Our equipment consists of two F-30 motors under each car. We operate in regular service nine motor cars, and nearly every week-day run three additional motor cars, drawing three trail cars. We connect our generators as in Fig. 1, each two machines being connected in multiple. For convenience we will call two machines on one side A and the other two B. The positive side of group A is connected to earth, and the negative of B to earth; the positive of B to line, and the negative of A to line. From B is run a main composed of five No. O wires, and from A is run a main of four No. O wires. The mains terminate at a point near the centre of the city, and three feeders are run from B to different points along the positive trolley wire, while two feeders are run from A to the two sections of negative trolley wire indicated by the map (Fig. 2). It will be seen that there are two trolley wires from X to Y. From one of these a branch runs to Z. The wires from X to Y are of different polarity, and of course carefully insulated from each other. The use of two wires does away with

* From the *Street Railway Review*.

the use of overhead frogs at turnouts, and serves another important purpose in the balancing of the system, which will be explained later.

In order to operate successfully the load on each side must be equal, or nearly so. This we accomplish in the following manner : Our time table and turnouts are so arranged as to admit of a 15 minute schedule. Every 15 minutes four cars are at X, and at the same time three are at the ends of the routes 1, 2, and 3. This applies to the Bangor divisions. At the same time two cars are at the ends of the line on the Brewer division. In operation one car

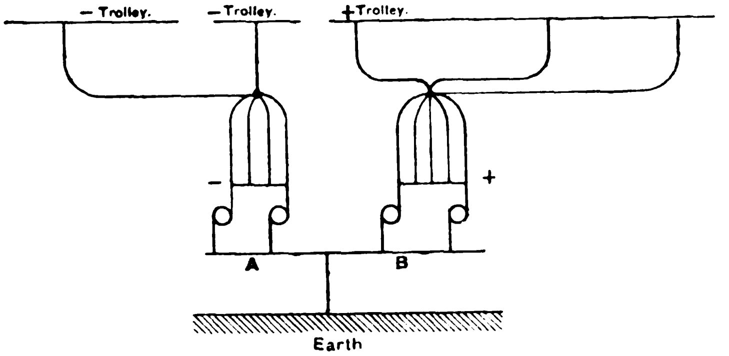

Fig. 1.

bound from X to Z takes the negative wire. One car bound from X to Y takes the positive wire. One car is bound from X to F and one from X to R on the positive side. This arrangement gives us five cars on the positive side and four on the negative. As long as this balance is maintained, everything runs smoothly. In putting on extra cars we have occasion to run them only from Y, which is a point opposite the fair grounds, to X, which is the business centre of the city. By making these extra cars use alternate wires this balance is still maintained. We have a number of heavy grades and short curves. In fact, there is scarcely a level

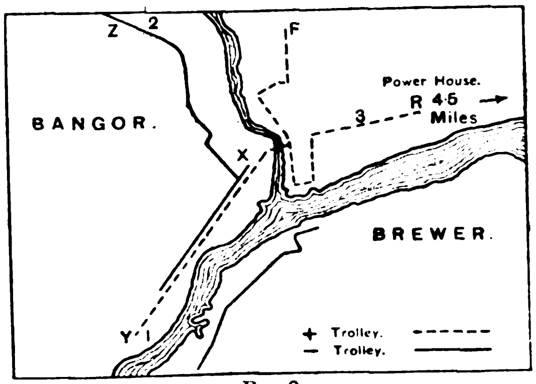

Fig. 2.

piece of track in Bangor. For instance, on the Pearl-street line, we have a grade of 6 per cent. for 200ft. ; on Main-street one of 8 per cent. for 100ft. ; on Olive-street one of 7 per cent. and two of 5 per cent. ; on Center-street one of 8 per cent. for 200ft. ; and in Brewer four of 6 per cent., one of which is 500ft. long.

The one bad feature of this system is that in case of a generator getting disabled we are out of balance by having two machines on one side and one on the other. This we intend to remedy by having a spare generator ready to put in on either side, as may be necessary.

THE ELECTRICAL EQUIPMENT OF THE LIVERPOOL OVERHEAD RAILWAY.

BY THOMAS PARKER, M. INST. C.E.

(*Continued from page 555.*)

DISCUSSION.

Mr. Alfred Giles, President, said that if there was any truth in the old adage that in the multitude of counsellers there was wisdom, the Papers before the meeting should prove it. He was sure, in considering the advantages offered by the Overhead Railway at Liverpool as compared with the pattern which it followed, the Elevated Railway in New York, the Institution was very much indebted to the authors for the investigations they had made, and he called upon the members to accord to those gentlemen their most cordial thanks.

Mr. J. H. Greathead wished to add one or two words by way of explanation. The first Paper gave two tables, one or two points of which he wished to emphasise. The first had reference to the weight of electric motors compared with steam locomotives. On the Liverpool Overhead Railway the electric motors weighed 20 per cent. of the total weight of the train exclusive of the motors, whereas on the Metropolitan Railway in London the locomotive weighed just double, say 40 per cent. of the weight of the train. On the other hand, the tractive effort of which the electric motors were capable was, in the case of the Liverpool Overhead Railway, 120lb. per ton of train, compared with 71lb. per ton of train of which the steam-locomotives were capable. That seemed to be a very important point. There was also another feature, that not only could a much greater tractive effort be obtained by electricity ; but, by adopting motor carriages, a correspondingly greater adhesion was secured. Table B illustrated that point, because on the Liverpool Railway the adhesion was 115lb. per ton of train, whereas on the District Railway, calculated in the same way, it was only 61lb. per ton of train. And, finally, the maximum tractive force per ton of motor or locomotive was very striking. On the Liverpool Railway electricity gave 730lb. tractive effort per ton of motor as a maximum at starting, while on the District Railway the tractive force was only 234lb. per ton of locomotive, or less than one-third of that obtained at Liverpool in starting the train.

Sir William Forwood said he felt it a great honour and privilege to be permitted to be present to listen to the two able and instructive Papers which had been read. During the past four or five years he had been pretty well saturated with all that appertained to overhead railways, but he had still learned a great deal that was new and interesting from the Papers. He was the chairman who had survived the construction of the Overhead Railway, and as such was entitled to some congratulation ; for though it had bristled with a great many problems which had been a source of vast interest to the engineers of the line, it had also been full of difficulties which had caused the Chairman and Directors of the undertaking many headaches. They had published a prospectus undertaking to construct the line at a certain cost, and naturally they had been asked to live up to that prospectus ; and when they were faced day by day with new developments, with drains underneath the surface of the ground of which they had never heard, and with all sorts of difficulties which meant a considerable extra cost to the shareholders, it naturally was a matter of some anxiety to the Directors. He was glad to be able to say that after ten months' working, the shareholders had been paid not only a preference dividend, but also 1 per cent. upon ordinary capital. This was entirely due to the employment of electric traction for the railway. Naturally, as a layman, he could not pretend to enter into many of the scientific problems which had been treated in the Papers, but perhaps some of those present might say, "This is a very interesting railway, but what practical use is it going to be ? is it an experiment, or is it going to be the forerunner of the application of electrical traction elsewhere ?" That was a point on which he could speak. He believed, from all he could see, that it was going to be the forerunner of the application of electrical traction on a very considerable scale ; for when the construction of the line had been nearly completed, which was a great improvement upon any elevated railway in America, the means to be adopted for traction had to be considered. The line was commenced with the idea of using steam, which was used upon the overhead railway in America ; but after visiting America, and seeing what had been done in electrical traction, he felt that in England, if possible, something better than had been done in America should be attempted, and he was proud to say it had succeeded. There was nothing in America comparable with the electric railway in Liverpool. Naturally the Directors were face to face with two problems. In the first place, they wanted to be quite sure that the railway would be economical if worked by electricity, otherwise they would soon have found themselves in the bankruptcy court ; in the second place, they wanted to be quite sure that it would be a reliable railway, otherwise it would be utterly useless to adopt electricity as the motive power to convey men of business hurrying to and fro in their daily vocation. It was only after very deliberate consideration that they were able to decide upon the adoption of electricity. They had the advantage of the experience gained on the City and South London Railway, and also of what had been done in America, and they had made up their minds—not without considerable misgivings—to go in for electricity. The cost of steam plant would have been £37,000 ; the cost of electrical equipment was £67,000 to £70,000 ; therefore, the first outlay was very considerable ; but, having made up their minds to employ electricity, they were determined—acting under the advice of their engineers—to have the very best electrical equipment that could be obtained, and their success was due largely to the accomplishment of that resolve. It was agreed that the manufacturers who supplied the electrical plant should be compelled by contract to run the line for the first two years at a given price

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per train mile. He did not know that it had had a great effect upon the contractors, because he believed that they would have done their work thoroughly well in any case; but, at the same time, it was a prudent course for the Directors to adopt. He was glad to say that the result had been very highly satisfactory. In the first place, with regard to cost, the Electrical Construction Corporation had been paid 4d. per mile for traction during the first ten months of working. Their outlay was carefully watched, and finding that the trains were running with perfect regularity and without break-downs, and finding also that the contractors were making money out of the contract, at the end of that period, though the contract ran for two years, the Company stepped in and said—"Gentlemen, we put an end to your contract." And since the first of January last the Company had been running the railway on its own account. He was glad to be able to state that this had resulted in a saving in January of £150; in other words, 5½ miles of railway were run at a cost of 3½d. for locomotive expenses. He thought that was very satisfactory. The engineers had stated—and he fully agreed with them—that when the line was opened to the length of seven miles, a further reduction would be made on the 3½d. Then came the question as to reliability, because if the railway was subject to break-downs it would soon lose the passenger traffic. He might state that there was an enterprising line of penny omnibuses running the whole length of the railway, and had there been many break-downs on the line, the traffic would soon have been transferred to the omnibuses below. But since the opening of the railway ten months ago, although a five minutes' service of trains had, with the exception of the first two months, been maintained, nearly 96 per cent. of the trains had been punctual, and during the last week but one, 99 per cent. of the trains were punctual. That was a record which he did not think was equalled in the railway world, but the experience of those present was no doubt much greater than his own on that point. The railway had given much satisfaction to the commercial community of Liverpool; not only was it regular, but there was an absence of noise and dirt, and it was a perfect treat to ride upon the Overhead Railway. There were ladies who made frequent journeys in the day for pleasure. That statement might provoke a laugh; but he could assure the members present that, on visiting Liverpool, they would not be satisfied with one journey upon the Overhead Railway. It disclosed one of the finest prospects in the country. It passed along the whole line of the docks, and afforded passengers a view of some of the most magnificent ships in the world. Beyond the docks was the estuary of the Mersey, which of itself was a sight which had few equals in England. He would say to all the members and associates of the Institution, that the Directors would be delighted whenever they came to Liverpool if they would call at the office, and ask for an order to see the railway and the generating station. He gave that invitation in the sincere hope that it might be availed of. He wished to acknowledge the sense of the great services that the Directors had received from their engineers, Sir Douglas Fox and Mr. Greathead, and also from Mr. Parker, who had been in charge of the electrical equipment of the line. Of course it was a novel thing. He knew that the Directors had felt timid on many points; they were thankful for the courage their engineers had given them on hose points, and he hoped within the next few years the railway would be completed for the whole distance originally contemplated; he also believed, before any great length of time elapsed, the Company would be able to pay a 5 per cent. dividend to the shareholders. That was a point to which he attached great importance, for although engineers might think only of constructive success, the question was, after all, one of dividends; and he was sure that all would be pleased that this, the first real electrical railway in England, had not only given satisfaction to the travelling public, but was also earning substantial dividends for the shareholders.

Sir Douglas Fox had desired not to speak until he had heard some criticisms upon the Papers, but responded to a call from the President. He might say, as Sir W. Forwood had so very well put it, that the problem, which had been to some extent solved at Liverpool, was one that had caused a great deal of anxious thought to all connected with it. The engineers owed a great deal of their success to the fact that they had practical men at the head of affairs in connection with the Company. The Directors were, without exception, Liverpool men; they knew what was required to accommodate the traffic, and, with the plain common sense which was found in that city, they told their engineers exactly what they wanted, and so made the duty of providing it much simpler. Not only so; but he wished to say that his colleague Mr. Greathead and he had felt that they were exceptionally fortunate in several circumstances surrounding the arrangements in connection with this work. Not only had they had a Board of Directors who showed full confidence in them from beginning to end, and such excellent representatives in Liverpool as Mr. Francis Fox and Mr. Cottrell; but they had in their contractor, Mr. Willans, a mechanical engineer of considerable talent, who, with his able assistant, Mr. Hudleston, had done everything in his power to assist in the work. Mr. Hudleston's assistance had been especially valuable. The railway, as shown on the plan, might look very simple; but he could assure the members that, in his experience, he had never known a case in which there was so much intricate adjustment necessary, before it was possible to lay out the line in its present perfect state. It had to be literally threaded through the midst of a very complicated system of cross-over roads, dock-lines, warehouses and existing railways, and the engineers were tied on every side by the authorities, headed by their kind friends (for they had shown every desire to assist the Company) Mr. Lyster, the Dock Engineer, on the one side, and Mr. Boulnois, the City Engineer of Liverpool, on the other. The fact that Mr. Hudleston had been formerly an officer of the Dock Board, and, therefore, thoroughly understood their requirements, had enabled him to give great assistance to the engineers in carrying out their arrangements. Not only was that so, but a great deal of ingenuity was exercised in connection with this work by those holding somewhat subordinate positions. The clever and novel way in which the erection of the structure was carried out had been described. It was found desirable, for economical reasons, to deliver all the ironwork at the north end. There was a convenient yard connected with an existing goods station, and the whole of the material was there delivered. It was decided by the contractor to commence at one end and work over-hand, and that had been done for nearly six miles. Although at first sight that might seem to be a slow process, it worked out exceedingly well, and a good deal of the detail was well executed by the sub-contractors. There was also considerable difficulty at first in connection with the manufacture of the steel plates for the platform of the viaduct; and here, again, in connection with the Phœnix Foundry Company, a Member of the Institution, Mr. Goodwin, had rendered valuable assistance. What was desired with reference to this railway was, first of all (and there came in the influence of the Directors), to have an economical, and at the same time a thoroughly durable, structure, which could be cheaply maintained, and which would be, as far as possible, fire-proof, because the line ran through a very inflammable neighbourhood. Ever since the opening of the railway it had been proved how important that was, and how utterly fatal it would have been to have adopted a timber structure. A large timber-yard had been on fire, the flames passing right across the railway, but doing it little or no damage. Of course they were tied, as engineers unfortunately almost always were, for headway, and, consequently, were obliged to introduce the bracing necessary to resist wind pressure in a very cautious manner, and just get it in where it was possible. One of the important things necessary was to decide upon the most economical span for the normal structure. That was a matter which his colleagues and he had discussed very fully; and, rightly or wrongly, they had come to the conclusion, that, with piers of that height, the most economical span was 50ft. They called it the normal structure; but it was rather a case where the exception proved the rule, for only one-third of the length was normal, and two-thirds of it were composed of abnormal spans. That was, of course, due to the inter-threading that he had spoken of. They commenced with the idea that for a considerable length they would be able to escape this inconvenience by deviating the lines underneath; but, in spite of a large expenditure upon such works, they had been obliged to introduce abnormal spans to the extent above mentioned. In connection with that he wished to mention that over £80,000 out of the total cost was represented by the slewing and repaving of the dock lines underneath the structure, and the accommodation works. When they had resolved upon the 50-foot span, the next most important point was, what sort of floor were they to have? They wanted as noiseless a floor as possible, which would be easily accessible for painting, which would be very stiff vertically, which would tend to help them in the cross-bracing of the structure, which could be cheaply and rapidly manufactured and be easily made water-tight. After a good many designs were considered, they at last fixed upon the "Hobson" system, it being the first time, he believed, that it had been used, and that certainly had given great satisfaction. He would not weary the members with lists of figures, but he should like to direct attention to the results of the testing of the flooring as given in the Paper. A very important point was, as usual in the case of passing through towns, to make the structure drop-dry. Those who had any experience of that requirement would appreciate the sorrows of engineers; but they had done their best in that direction, and, he thought, had been fairly successful, thanks to that particular flooring. They had found from experience—learning always more by mistakes than by successes—that, among small matters of detail, it was important, where that or any similar flooring was used, not to attempt to mix sand with the asphalt, but to put in pure asphalt in spite of the additional cost, for that saved trouble afterwards. The platform had given wonderful stiffness to the structure, and it had proved even quieter than had been anticipated. He had been rather afraid there might have been a severe drumming noise, but there was not. It was less noisy than most plat-

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forms which trains ran over, and that, combined with strength, was a great adxantage. It allowed perfect ventilation of the permanent-way timbers, the attachment of the rails by means of fangbolts without impairing the insulation of the electric conductor and a proper system of drainage. The question of foundations was a matter requiring some consideration, when it was remembered that there were at least 1,200 separate piers; and, if anything in the way of a luxurious foundation had been attempted, it would very soon have been heard of in the cost. As a matter of fact, nothing could be simpler than the system adopted—a block of concrete, bolts built into it, and a wrought-iron column fixed by those bolts direct on to it, and then the column protected by a very effective cast-iron boss, which entirely prevented any waggon or other passing load from striking against the column. The traffic had been running for nearly a year, and Mr. Cottrell, the Company's engineer and manager, had told him only yesterday that there had not been any sign of settlement, as far as he was aware, throughout the whole length. The great point was in such a case to permit of only very moderate pressure upon the foundations. He wished to say a word about the parapet. He did not know that it was very beautiful, but it had proved efficient. It was necessary that the parapet should be so arranged as to enable people to get out and walk to a station without danger if the train should stop outside; for otherwise the Board of Trade would probably have required special provisions. There was a parapet which practically gave a station platform along the whole length of the line, and at each span there was an ample refuge for the platelayers. The parapet was very cheap and free from rattle. It fulfilled an unexpected use, as had been mentioned; namely, that for a considerable length it had been used for the purposes of carrying compressed air. Another very important point in all railways of that kind was to have sufficient stations; in fact, the perfect ideal would be to have a station of the whole length of the line. That could not be quite accomplished. The complaint the people made in Liverpool—he did not know whether they were any worse than the people in London—was, that they did not like to go by the railway, because when they alighted, they had to walk 100 yards to their destinations, and that was their reason for travelling by omnibuses! To minimise that objection as far as possible, 13 stations had been already constructed, and it was intended, in the six miles, to have no less than 17 stations. He would like to say one other thing: It was not necessary, because there were a number of stations, to spend a great deal of money upon them. He thought that some success had been obtained in giving a fairly æsthetic appearance to the stations, and that at a very moderate cost. The outlay per station, including staircases, roofing, two platforms, turnstiles and everything complete, had averaged about £2,000, which could not be called excessive. There were no complicated or difficult engineering works on the line; it was more a matter of great detail, involving, he might mention, over 1,000 detail drawings, apart from the working plans. There were two or three matters in which he must specially admit the indebtedness of the engineers to Mr. Hudleston, One was the Stanley swing bridge, which was really a clever design for that particular position. It was not a large swing bridge, but it was a peculiar one. It had two levels, and had to be arranged in a very restricted space, so that it could be fixed with a minimum interference with the existing traffic. The bridge was so arranged that it not only could swing as a whole but was also a bascule bridge so far as the lower or dock lines portion is concerned. The lower half could be raised to allow barges with masts to pass underneath without interfering with the traffic on the overhead railway.

Mr. Alfred Giles (President) asked if any way-leave was paid for the line.

Sir Douglas Fox replied that there was a rental paid to the Dock Board under agreement. He wished to point out that the superstructure of the railway was strongly braced longitudinally by the introduction of cluster piers at intervals, and that the curvature of the line was overcome by the introduction of triangular piers, so that all the spans, even on the curves, were rectangular. One point with reference to the tilting bridges, of which there were two or three, was that they were so designed as to have all the appearance of ordinary spans; and, being in connection with the hydraulic power available on the dock estate, they were moved in the simplest possible way. The permanent way had proved highly efficient, although it was light and economical. One great advantage was its being kept strictly to gauge without difficulty by means of chubs, which were solidly riveted on the platform. The Timmis automatic electrical signals were working satisfactorily, after certain improvements in detail had been introduced to prevent residual magnetism, short circuiting, and certain mechanical defects. The principal magnets, which worked the signals, give a pull of 34lb. at a distance of $1\frac{3}{4}$in., with 10 amperes. The Board of Trade inspection of the railway occupied four days, there being over 500 spans on the open portion, each of which, of course, had to receive careful examination. Those four days of testing gave a very interesting result incidentally, in reference to the handiness of electricity for the quick stopping and starting of trains. It had been found that the trains were thoroughly under control, and the work of testing could be carried on far more rapidly than he had ever known with ordinary locomotives. The test-load for the ordinary structure was four loaded trains, each weighted so as to be equal to a train with a full complement of passengers, and with the motor-bogies placed together in each train, instead of at the ends as in ordinary working. With this load, which amounted to about 13cwt. per foot of each line of way on a 50ft. span, the deflections were very small. On a 40ft. span they were $\frac{1}{8}$in., and on a 75ft. span they were $\frac{1}{2}$in. On the Stanley Bridge, which from its depth would be expected to be very stiff, the load was far more severe. There, four of the heaviest Lancashire and Yorkshire tank-engines, weighing about 30cwt. per foot run, were placed on each low-level line of way, in addition to the loading of the overhead line with 13cwt. per foot run, making altogether about 4 tons per foot run of bridge, and the deflection was about $\frac{3}{8}$in. at the nose of the bridge. It might be interesting to state what considerations had chiefly guided the engineers in deciding the question of motive-power for the railway. If locomotives were to be used, certainly the cost of the superstructure must have been increased. They could not have had anything like the same moderate rolling-load or such efficient starting and stopping as with the electrical arrangement. Locomotives would also have required much more expensive coal, which, with the water, would have greatly added to the weight of the trains. A more fatal objection, however, was this—that the Dock Board would not even allow smoking on its estate, and they were not likely to tolerate locomotive engines emitting sparks, which were much more dangerous to adjoining property than those connected with the electrical motors. For that reason alone it was decided that locomotives could not be used. They had carefully considered the question of the introduction of the cable system; but, of course, this was not a case in which that motive power would work out with any great advantage, because there were no steep gradients, except one little dip of 1 in 40 down and up again. With that exception, the line was practically level. When it was considered that the cable must be kept constantly running, involving a much greater loss of power than arose from the leakage of electric current, and that, in addition, they could not get anything like the speed between the stations that was obtained by means of electricity, they arrived rapidly at a decision to give the preference to the latter medium. He had found from recent careful investigations in the United States, that it did not prove economical to run a cable at a higher speed than 12 miles per hour, which would not give an average, including stoppages at stations, of more than six miles per hour, or about one-half the speed attained on this railway. The incessant noise caused by the cable was also a serious objection. He wished to confirm distinctly what had been said by Sir W. Forwood, the Chairman of the Company, that they were more than satisfied with the result. There was great punctuality of the train service, and he was glad to know that Mr. Cottrell was present, and no doubt would give the latest figures with regard to the cost of haulage on the line. One thing was certain—that it had been possible, by the introduction of electricity and of short trains, to give a most efficient local service. One great point in a line of that kind was to be able to run trains of a moderate length at very short intervals, rather than heavy and long trains at much longer intervals; and he could not help thinking that some of the metropolitan railways would obtain greater success if they were to adopt that plan. Even waiting three or four minutes at a station seemed a long time; whereas if very short trains were run that interval might be considerably shortened. He agreed with Mr. Greathead as to the advantage in this case of adopting motor cars, although under other circumstances, and especially where long and heavy main-line trains had to be dealt with, separate motors might be necessary. An advantage of having two motor-cars, each having one motor, in the train, was that, like twin screws in a steamer, in case of injury to one the other is available to drive the train, although, of course, at reduced speed. The total cost of the works, stations, and equipment was £90,100 per mile. The general works, comprising the whole of the foundations, superstructure and permanent way cost £59,000 per mile. The stations had cost £4,600 per mile. The electric plant, including the conductor and the generating station, cost about £7,700 per mile. The rolling stock, including carriages and motors, cost £5,000 per mile. The accommodation works, which were quite outside the general question of a railway of that kind, and represented chiefly the cost of altering the dock lines and roads underneath, cost £13,800 per mile. In addition to these costs, there was the outlay of £4,400 per mile for the Act of Parliament, administration and other matters, making a total expenditure of £94,500 per mile. He thought that the Liverpool Overhead Railway was a successful solution of the problem Mr. Greathead and he had been asked to solve—viz., to provide for running short trains at rapid intervals, and at a low rate of cost. He hoped that this railway, which he thought bid

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fair to prove not only a mechanical and electrical, but also a financial success, might be the forerunner of greater things; and that the time might shortly come when not only trains of 40 tons weight would be dealt with, but also on main lines—especially tunnel lines—trains weighing 200 tons would be worked by electricity. He had no doubt that this, to secure which active effort was now being made, would come to pass in the near future; and that the considerable step in advance which had been secured at Liverpool would tend at any rate towards that important result.

Mr. Killingworth Hedges considered the assertion that electrical railways were suitable for level ground, or districts with comparatively low gradients, and were not suitable for steep gradients, was not altogether correct. He might refer to Canadian practice, where there were already nearly 300 miles of electrical railway. The Niagara Falls Electrical Railway, a line about 11½ miles in length, from Chippewa, above the falls, to Queenstown on the Niagara River, afforded an illustration of his statement—and many of those who had heard Prof. G. Forbes' Paper on the scheme for utilising the Niagara Falls on the American side, would be pleased to know that, whilst the Americans had been talking about what they were going to do with that immense power, the Canadians had on a very small scale actually handled the power, and since July, 1893, had utilised it for this railway. It ran along the road for part of the distance and was carried on an embankment like an ordinary railway until it reached a steep descent to the Niagara river, where the gradient was 1 in 21, and in some places, he had been informed, 1 in 19. Having had facilities to inspect the line, he had found there was not the slightest difficulty in working this electric railway up those gradients. The ordinary 30-foot American cars were used, with two motors, and as very often there was great stress of traffic, because the Niagara Falls and the surrounding country was essentially a holiday place, a trailing car was put on. One interesting point about the railway was that the whole of it was Canadian, even the rails having been rolled in Canada. The power was taken from the rapids above the Falls, a flume ran for a short distance into the power-house, where two turbines were fixed 60ft. down in the solid rock. From the outlet, water was taken by a tunnel which opened under the Falls, so that the water mingled with that of the Falls, and was no detriment to the beauty of the scenery. With regard to cost, having travelled through the United States, and having seen a great many figures with regard to different electric railways and tramways, he must say, in compliment to the authors, that he could not find any case where the working expenses were as low as those given in the Paper. He had received a communication from Mr. Robert Gillham—a well-known American expert in cable tramways—giving the working expenses of an elevated electrical road in Kansas City. It much resembled the Liverpool Overhead Railway, except that it was rather longer—20 miles, including the surface lines. The cost per train-mile for ten months ending January, 1894, came out, according to Mr. Gillham, at 12·9 cents, say 6½d., per train-mile. Coal cost $1. 75c. per ton of 2,000lb., or 7s. The working cost of the Denver City cable line for the last quarter was 14 cents, or 7d. per train-mile, the mileage being about the same. The train on the cable-line consisted of a dummy car with a gripper and a trailing car; in the other case it was only one car. The number of passengers carried was approximately the same. He would ask the authors if they could give any comparative cost of installation of cable lines and electric railways. There appeared to be a great desire to employ cable lines throughout England, arising partly, he believed, through want of confidence in electric railways, and partly because of the overhead system. If gentlemen who had to do with municipal affairs would take a trip to America they would see the latter railways working well under every condition; and, with regard to unsightliness, he thought the superior advantages of electricity would be found to amply compensate for any drawback of that nature.

Mr. A. P. Trotter said that it had been observed that in the Liverpool line the head-room was restricted; but the electric features were not so restricted, and it was on account of the head-room that the engineers had been enabled to put the conductors above the level of the rails, instead of being obliged to place them below that level, as in the City and South London line, where their arrangement had led to great complication in the crossings. Three-quarters of an inch only, he understood, was sufficient to clear the conductor above the level of the rails. A feature of the Liverpool line, which surely would be of very great importance when electric traction became more common, particularly in light railways, was placing the motors upon the carriages and doing away with the locomotive. Head-room, again, was, he understood, the reason why locomotives were used on the City and South London, and why motors on the carriages were considered to be impracticable. A still more important reason for having motors on the carriages was that a number of motors could be used. In this case there were only two carriages; but with a greater number the multiplication of motors was easy, and brought with it very great economy. It was not generally known that Dr. John Hopkinson had a patent for the combination of electric motors in series or parallel. That patent had not been maintained, but it was interesting to know that the period would expire in July, 1895. It was strange that on the City and South London Railway that system had not been adopted, but it was employed on the Liverpool railway. The placing of motors in series and in parallel was a very great improvement in the economy of current in starting. The starting of a motor might be compared very accurately with the starting of an inward-flow turbine. When an inward-flow turbine was started, the whole head was unnecessary for the work of starting the turbine. The requisite momentum of the water could be obtained by much less head; but when the turbine got up speed, the centrifugal force checked the water, and finally the turbine worked at full load. Similarly with the electric motor, when

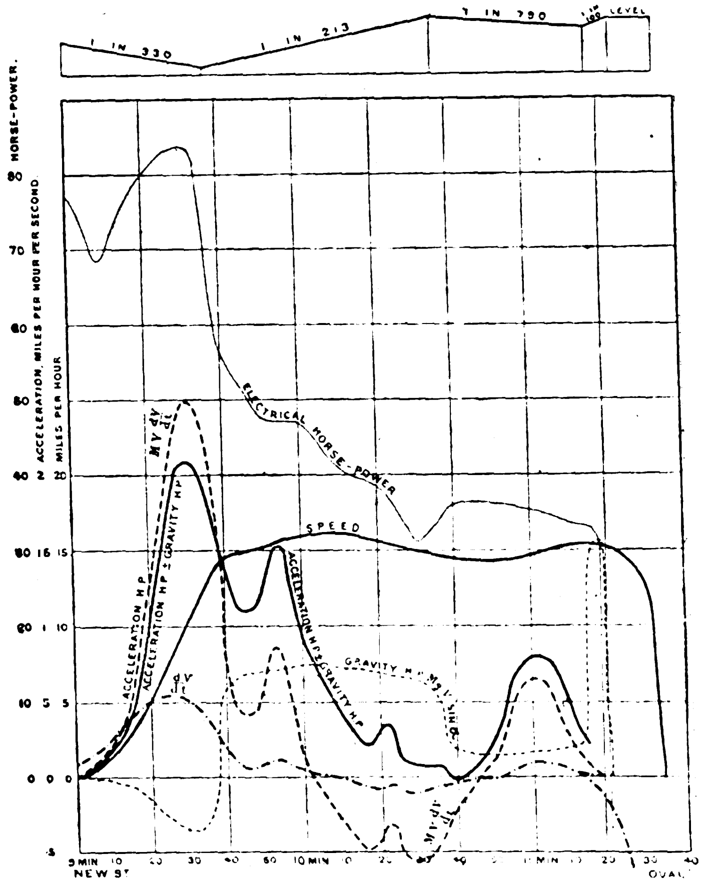

Fig. 1.—Analysis of part of Fig. 3, Minutes of Proceedings Inst. C.E., Vol. CXII., p. 246.

The full lines, marked Electrical Horse-power and Speed, are reproductions of curves in Fig. 3, Minutes of Proceedings Inst. C.E., Vol. CXII., p. 246.

The chain-dotted line marked $\frac{dV}{dt}$ is the slope or differential coefficient of the speed curve, and gives the positive or negative acceleration.

The strong dotted line is the continued product of the acceleration of the speed at any instant, and of the mass (35 tons); and gives the acceleration horse-power, *i.e.*, the horse-power required to set in motion at the given speed, on a level line, a frictionless train of 35 tons.

The fine dotted line gives the gravity horse-power; that is, the power expended in lifting, without friction, a mass of 35 tons, or the power developed by the falling of this mass, and is the product of the weight into the speed into the sine of the gradient. The transition from one gradient to the next being unknown, and the length of the train being neglected, the corners have been so rounded as to give a smooth resultant in the line of total calculated horse-power.

The full line marked Acceleration H.P. ± Gravity H P. is the resultant total calculated mechanical horse-power, exclusive of friction. It is not carried to the end of the run, as the instant at which the brake was put on is not known.

The gradients are shown on a time scale, corresponding with the scale at the foot of the diagram.

the speed was low the current simply ran away to waste, and at last was checked when the motor got up speed by the back-pressure generated in the motor, not unlike the centrifugal force in the turbine. He directed attention to some diagrams, Figs. 1 and 2, in which he had analysed carefully the theoretical power required for a specimen case on the City and South London line, the diagram of which had been furnished by Mr. Greathead, with a view of discovering the portion of power expended in starting, in climbing gradients, in pure traction and in friction. Before the train had

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attained a speed of 10 miles an hour, a very serious amount of energy, amounting to about 18 per cent., had been lost by current running to waste through the motors.

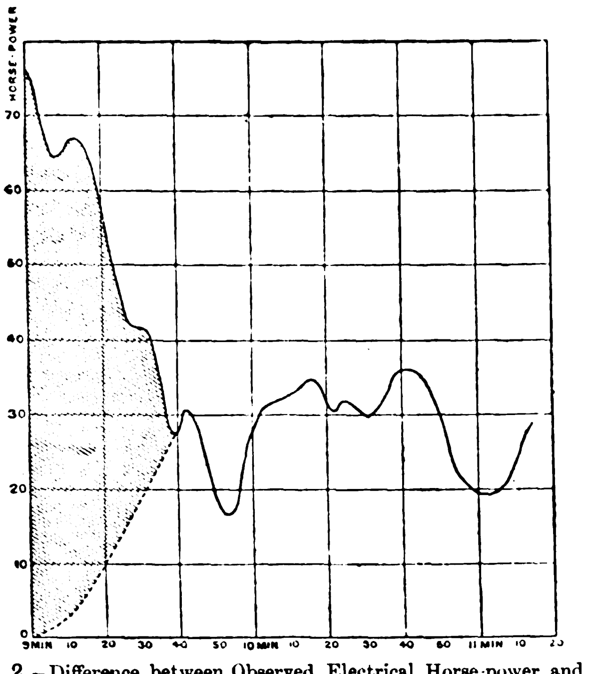

FIG. 2.—Difference between Observed Electrical Horse-power and Calculated Mechanical Horse-power, which equals the power expended in Traction and in General Friction.

The dotted line shows assumed power, proportional to speed, and therefore in excess of actual power.

The shaded area represents the energy wasted in starting the train, which is, to a large extent, avoidable.

Mr. W. H. PREECE had, like many other members of the Institution, spent his holidays last year in the United States during the months of August and September, devoting special attention to the working of the telegraphs and telephones of America, and also looking carefully into the questions of electric lighting, transmission of power, and other practical applications of electricity. Nine years had elapsed between his two visits to the States. In the year 1884 there was only one electrical railway there, and that in its experimental stage, viz., in the city of Cleveland. Last year he had found in the city of Cleveland a greater mileage of electric railway than there was in the whole of the United Kingdom. Throughout the States there were no less than 6,000 miles of railway worked by electricity. There were 6,900 motor cars, and 4,000 trolley-cars working in conjunction with the motor-cars. At the Chicago Exhibition there was a track laid down for the special purpose of testing and examining all the exhibits which were shown, and he had had the pleasure of spending some hours with the electrical jury testing and examining a locomotive that weighed 30 tons. This locomotive was said to exert a pull of 6,000lb. on the draw-bar, not a very marked result, but still sufficient to draw a train of 500 tons weight along a level English railway. More than that, in the city of Baltimore there was an electric locomotive weighing no less than 80 tons, intended to draw trains weighing 1,200 tons through that city. The peculiar feature of the electric railways of the States was that up to the present time they had rather replaced horse-tramways than really introduced what were known as railways in this country ; and, owing to the difficulty of climate, the cost of horse-flesh, and the short duration of its life, electric tramways had proved economical and very successful. They had proved a great financial success, for, owing to the smoothness with which the trains ran, they had greatly increased the comfort of travelling, although they ran between the same points and on the same rails. This comfort of travelling by the electric trains had increased the traffic 30 per cent., so that, for no other reason whatever than the introduction of electricity, they had introduced what the Americans called, in their practical way, a "factor of public satisfaction." The practical feature in which members would be perhaps more interested, was that the trains were almost all worked by wires overhead, on what was called the trolley system. That system, on a small scale, had been introduced in Leeds, and also in the Staffordshire district, in the neighbourhood of Walsall ; but its development in England was small compared with that in the United States. There it was seen not only in all the suburbs of the cities, but also in the great cities themselves ; and anything more horrible had never been seen in this world than those wires extending through a beautiful city like Boston, simply covering the principal thoroughfare with a cobweb of a diameter of about $\frac{1}{8}$in. to $\frac{1}{4}$in. The great problem now being solved in the States was how to work those railways by an underground system, and how to get rid of the disturbances arising through the use of the earth. That problem had been solved at Washington and Chicago, and probably in a year or two someone would come forward to give the results of those experiments. The only railway in the States which would compare with the magnificent railway described by the authors was one that extended through the midst of the World's Fair at Chicago, called the Intramural Railway ; and to give an idea of the extent and size of the Exhibition, that railway, which had been constructed simply to carry visitors round and about the various buildings, was $3\frac{1}{4}$ miles in extent. It worked extremely well. It was very like the Liverpool Overhead Railway ; it had a third rail, not in the centre, but by its side, and the rails were used for the return. Twelve trains were constantly running without accident or trouble, and it was a comfort to be thus able to move about from place to place in the Great Fair by that charming railway. Another feature worth noting in the United States was that experience had shown that they had commenced with too light rails in the early days, rails of about 30lb. to 35lb. weight per yard having been thought satisfactory. These had been gradually increased The Intramural Railway had been constructed with rails weighing 60lb. per yard ; several lines had been constructed with 72lb. rails, and he was told there were one or two railways where they had even gone to the extent of using rails weighing 90lb. per yard ; finding that, by using those heavy rails, the cars ran more smoothly, and there were none of those jars and jolts and discomforts that interfered so much with the working of motors and electrical appliances. Again, the Americans were fast following the English example of direct-driving in their power-houses. He found one single fault, and only one, and that perhaps a personal one, in the system adopted in connection with the Liverpool Railway, viz., that the general practice in this country of using direct-driven machinery had been abandoned for the use of rope-driven apparatus, which he thought was a slight survival of the past. In the States many power-houses were found where rope-driven machinery was the rule ; but, on the other hand, in all modern stations and all new work, the system which had been found so much better in England, of using direct-driven machinery, was being adopted. He thought, on the whole, after a most careful examination of what had been done in the States, that the authors had unquestionably taken a great step in advance at Liverpool. That was nothing in the States that was superior to, and he did not know anything that was as good as, the working of the railway described. One feature referred to in the first Paper deserved to be brought strongly under notice, viz., in Table B, it was shown from experience that the tractive-force in pounds per ton of motor or locomotive was, for the electrical system in the Liverpool Overhead Railway, 730lb. per ton, and on the City and South London Railway, 367lb. per ton ; so that, in the short period between the construction of the two lines, the same engineer, by the advance which had been made in electricity, had been able to increase the tractive force nearly 100 per cent. Going to the Metropolitan District Railway, it was found that the tractive force per ton of the locomotives was only 234lb. ; so that the difference between the traction per ton on the District Railway and that on the Liverpool Overhead Railway was the difference between 234lb. and 730lb. That was an advance of which English engineers might be very proud. The most important feature brought out in the Paper was the economy of electrical traction. He had more than once pointed out in that room that the economy of electric traction and the production of electrical energy was entirely dependent on the ability to maintain a full and constant load. Whenever a revolutionary doctrine was enunciated, even though it might be the truth, it was always received with ridicule by those whose interests were effected ; and when he asserted, as he had done in that hall, that, if he had the means of producing electrical energy constantly and continuously at a full load for 24 hours, electric light could be produced at a price equivalent to gas at 2d. per 1,000 cubic feet, he had been laughed to scorn. The engineers of the Overhead Railway had shown that, although they had not a load continuous for 24 hours, they had one continuous for nearly 12 hours, and the diagram showed that the mean load throughout the day was fairly constant. The author of the second Paper had shown that the cost of working that line was 4d. per train mile, and hence the cost of production of electrical energy to maintain the traffic on the railway was equivalent to $\frac{5}{10}$d. per mile, and $\frac{5}{10}$d. per mile was not far short of gas at 5d. per 1,000 cubic feet ; that was, if the energy used for working the trains were used for generating light. The results of the experiments on the Overhead Railway showed that the figures he had given were approximately true, and also that the secret of working electrical appliances, whether for light, for traction, or any other purpose, was to maintain continuously as long as possible a full load, and to maintain the machinery at its maximum working. The fact had been mentioned that the leakage on

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the railway at Liverpool was a mere 2 or 3 amperes, and that such an unnecessary refinement as using oil to reduce this was absurd. There was a marked amount of selfishness about that. It might be perfectly true that the Liverpool Railway could afford to lose 2 amperes or 3 amperes; but there were persons in Liverpool, and interested persons, who could not admit that the absorption by the earth of 2 or 3 amperes was a refinement. The Postmaster-General did not like to find, as was found, that every single circuit in Liverpool was disturbed by the elevated railway. It was perfectly true that he was very good-natured, and they had not applied to the Court of Queen's Bench to obtain an injunction to stop this railway; but if its managers allowed the 2 or 3 amperes to become 20 or 30 amperes, it might be they would find some day an application by the Postmaster-General to the Lord Chief Justice to stop the traffic on that railway. But it was not alone the Postmaster-General who had an interest in stopping the leakage, for how about the gas people?—how about the water people? One of the most striking features brought to his notice in the States was the terrible havoc committed amongst gas-pipes, which were riddled and pitted all over, and water-pipes which were corroded and destroyed, whilst the lead coverings of the telephones cables were absolutely a decayed mass through this refinement, or absence of refinement—not a leakage of 2 or 3 amperes, as at Liverpool, but a leakage amounting to 200 or 300 amperes. If those gentlemen did not look after the pennies, they might depend upon it the pounds would bring them into very serious difficulties. There were several problems that were unsolved. It might be taken as a fact that where there was great diversity in practice, perfection had not been attained, and there was great diversity of practice in electrical railways. It was not yet determined which was the best mode to work electric railways, whether by alternating currents at low frequency, or by the continuous current as at Liverpool and in the City and South London and Chicago railways. Again, practical men who had to look to pounds, shillings, and pence, were not satisfied with the means at present developed in starting trains. With a steam locomotive a train was started without loss of energy, but on an electric railway, the train was started with a considerable loss of energy, and the great waste of energy occurred at the moment the train was starting. Someone would have to produce a remedy, and he was sure that if Mr. Thomas Parker devoted his attention to it he would introduce some means by which to start the electric train without any useless loss of energy. The Americans, he was proud to say, paid great heed to what was being done in this country. They thought, no doubt, we were a grandmotherly lot, and were very slow; but they all admitted that we had adopted a thoroughness and a refinement in our methods that it was necessary for them to follow. Doubtless the Paper now brought forward would be read and studied in America with great interest. Sir Douglas Fox had stated that the Dock Board were so particular about fires that they would not allow a man to smoke. Quite right; a bad practice! But they would not also allow locomotives, because they emitted sparks, and therefore electric traction was introduced. Mr. Preece did not know whether Sir Douglas Fox laboured under the illusion that electrical machinery could always be worked without producing sparks. One of his amusements in the States was to watch the electrical railway at night, for a more beautiful display of fireworks he had rarely seen. If Sir Douglas Fox was satisfied with the absence of sparks on the Liverpool Railway, then something or other must have been done on that railway which had not been described in the Paper. He hoped that when Mr. Parker replied he would give some explanation as to how sparks were stopped in Liverpool. The authors had said that the Americans in New York studied very carefully the application of electricity to elevated railways, and had given facts and figures showing that the cost of applying machinery to the Elevated Railway was estimated at £771,000. The authors had, however, shown that the cost of the plant on the Liverpool Railway of the same length and character was only £45,000, or only 5 per cent. of the estimated cost of the Elevated Railway in New York. Again, the engineers at New York made out the cost of working the Elevated Railway to be 3s. per train-mile, but now the fact was on paper that not only was tractive power greater than that produced by steam obtained, but a magnificent railway was worked in first-rate style, giving satisfaction to everybody, at the small rate of 4d. per train-mile.

(To be continued.)

The Field Telegraph.—The field telegraph, says *The Times* keenly critical correspondent who has been exposing the various shortcomings of Aldershot in 1894, has been occasionally used to maintain connection between bodies of troops operating in combination but at some distance apart, and has proved a complete success.

"UNIQUE" SWITCHES.

The latest improvements in these switches are shown in the accompanying illustrations. They are now made in four sizes, up to 20-ampere capacity. Mr. Lundberg, the manufacturer, informs us that the helical bronze springs used are now uniformly tempered. In the smallest size of switch the key is of special construction, and persons, whether wilfully or ignorantly turning the key against the springs, can do no mischief through buckling them, the key undoing but not detaching a rubber ring, taking all strain against the roof of the cover. The brass work of the key is fixed to it by an improved method which has superseded the use of tapped porcelain, the latter method, though perfect in theory, having proved very unsatisfactory in practice, the screws invariably shaking loose.

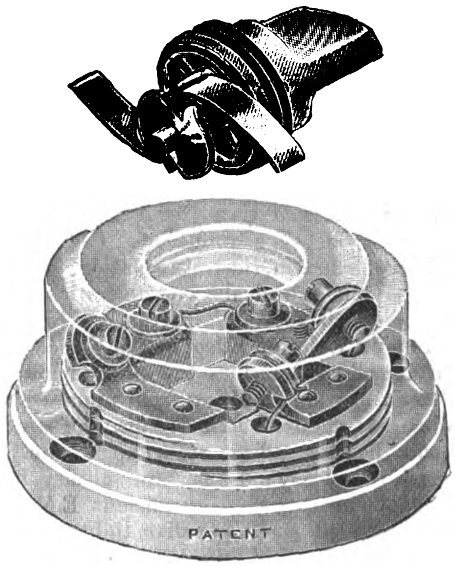

Fig. 1.—Improved "Unique" Switch.

The brass cradle piece, to which the springs are attached, is now made out of stampings only, the spring being clamped between lugs attached to the two parts forming the complete cradle, in this manner the split pins previously used for this purpose are done away with.

The bases of all sizes are still arranged for use as single-way switches with or without fuse, or as two-way switches for corridor or bedroom lighting, for operation at either end, with or without fuse as desired.

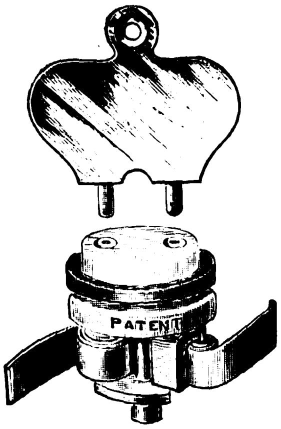

Fig. 2.—Porcelain centre with key.

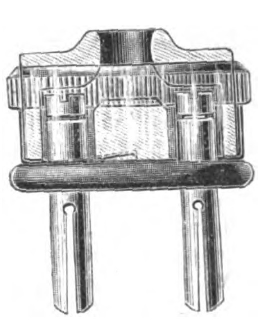

Fig. 3.—Ratchet plug.

Improved terminals are also used in all sizes, the method adopted in the smallest size being shown in Fig. 1, the leading wires being drawn into the slot of the lug on the contact plate, and clamped under the screw, the slot preventing it slipping out and allowing the wire practically a full turn under the screw.

In the larger sizes use is made of a screw-eye terminal, the leading wires passing through the screw eye, and being clamped against the upright lug of the contact plate through which the screw-eye passes, by means of a hollow nut. The 3-ampere and 6-ampere sizes can be fitted, if desired, with porcelain centres for use with removable keys (*see* Fig. 2) at the same price as ordinary keys.

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A 3-ampere damp and dust-proof pattern with brass cover is now on the market, and is intended for use in exposed positions. Fig. 3 shows an improved 2-pin ratchet plug for use in the "Unique" combination switch and wall-socket, which prevents any possibility of the springs being damaged if turned backwards, the spring tongue of the ratchet only engaging when turning to the right.

The illustration (Fig. 3) fully shows the construction and operation of the plug, which is supplied at a slightly increased cost over the ordinary fixed pattern.

We have had a number of Unique switches in daily use for nearly three years, and have found them to work and wear well. One or two springs have broken, either from imperfect tempering or from attempts to turn the handle the wrong way. We have had two Unique wall plugs in use for the same period, but find it necessary to pull out the plug and to untwist the cord at intervals to take out the kinks. The ratchet plug described above does not seem to get over this difficulty, but Mr. Lundberg's ingenuity ought to be able to surmount it.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *August* 25, 1894.

The American Association for the Advancement of Science.—Among the very numerous Papers read at the recent meeting of the American Association for the Advancement of Science but few dealt with electrical subjects, and none of these were of special importance. In the Paper by Prof. Sheldon on "A Calorific Effect of the Velocity of Vibration of Hydrogen Ions," he describes the phenomena of the "pail forge," or electric heating resulting from plunging a metal in a liquid forming part of an electric circuit, and stated that the theory of this heating effect rests upon the inability of hydrogen ions to travel beyond a certain velocity, which results in the heating of the cathode, if sufficient E.M.F. is applied. Prof. M'Adie described some peculiar lightning flashes, and stated that, in order to obtain accurate knowledge about lightning discharges, it is necessary to have two or more photographs taken from different points of view; for this purpose Prof. M'Adie has three cameras pointed at the summit of the Washington monument in the city of Washington, one at the Capitol, 1·4 miles distant; a second at Fort Myer, four miles distant; and a third at the Weather Bureau, 1·3 miles distant. Mr. C. J. Roffelson described a method of producing the alternating current curve by the aid of the phonograph, for which two operations are necessary; first a record on the wax cylinder of the phonagraph, and, second, magnifying this record by means of a multiplying arrangement. It is stated that this method is especially adapted for the study of harmonics. Prof. Brakett described some magnetic characteristics of iridium. It was found that a bar of this metal is more readily magnetised transversely than longitudinally; that the magnetic intensity, compared to that of steel, is as 1 to 12; that position or movement in the magnetic field is not sufficient to magnetise it, jarring being also necessary. Low permeability and great coercive force are the characteristics of this material. Mr. N. D. C. Hodges presented a Paper on "Lightning as a Case of the Dissipation of Energy," in which he stated that, while he does not know how much energy it takes to deflagrate a pound of copper, he does know that no lightning discharge has ever manifested enough energy to deflagrate more than two or three pounds, and he thought, therefore, that there might be a foot pound of energy in a cubic foot of electrified air. The empirical nature of Mr. Hodge's statements was severely criticised by Prof. Alex. Macfarlane. A mathematical Paper by Mr. L. A. Bauer was read, the title being "The Extension of the Gaussian Potential Theory of Terrestrial Magnetism," in which it was shown that it is theoretically possible to calculate the potential of terrestrial magnetic force at the earth's surface, thus enabling a secular variation term to be introduced into the Gaussian potential expression, and an expression therefore obtained which would permit the drawing of approximate magnetic charts for any time during the interval for which the formula had been established. By this means the orbit described by the magnetic pole in the course of centuries could be determined, but the statement is made that the practicability of this determination is doubtful at present on account of the lack of data. Prof. B. W. Snow, in a Paper on "The Directed Velocity of the Particles in the Electric Arc," described the details of a spectral method of investigating this subject, the result of which showed that the direct velocity of the particles in the arc is less than one mile per second, and, therefore, that the temperature of the arc cannot be calculated from the directed velocity of the particles.

Engineering Education.—During the meeting of the Association, the Society for the Promotion of Engineering Education held its meetings, and a large number of Papers were read and presented. Owing to the small amount of time available, but few of the papers were read in full, and these but little discussed, In the discussion on the subject of graduate and post-graduate degrees, a consensus of opinion was developed to the effect that the old academic degrees are not of much use to the engineer, who seems to prefer to replace them with the abbreviaton of his professional society. The Society for the Promotion of Engineering Education was organised at the World's Fair, where the first meeting was participated in by the professors in attendance on the various scientific congresses there being held. Much interest is being taken in the Society by the various professors of engineering in the United States, and it promises to take high rank among professional societies. Its main object is to produce some order out of the chaos of opinions now held in this country in regard to the policies and methods of engineering education.

CORRESPONDENCE.

THE SINE-CURVE CONTROVERSY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I only lately became repossessed of my weekly copy of *The Electrician*, and read the letters and editorials on the above subject. Broadly speaking, all the evidence I have before me, deduced from a very extensive series of tests on transformers, which have been made on different types of alternators grouped in various ways, leads to a conclusion which is identical with the position taken up by Mr. Steinmetz. If one and the same transformer is tested at the same mean-square primary pressure of an alternator of different types, the iron loss in the transformer at no load is found to vary. Taking, for instance, a particular type of transformer, I found that when tested for iron loss on an alternator having a drum armature, with iron core of the type of Westinghouse or Thomson-Houston, the iron loss is less by some 10 per cent. than when tested on an alternator having a copper strip iron-less armature of the type of the Mordey or Ferranti armatures.

It must, however, be borne in mind that the form of the electromotive force curve of an alternator, when determined by an electrostatic voltmeter and contact breaker—the alternator being taken alone and on open circuit—is not necessarily or always identical with the form of the curve of potential difference between the primary terminals of a transformer worked off that alternator. It is, of course, the form of this last curve which it is important to know. I find, also, that the power factor of a transformer at no load is less when the transformer is tested at the same mean-square primary pressure off an iron-clad or iron-cored armature of the drum type, than when tested off a strip iron-less armature; but that the apparent power taken up in both cases is about the same. Coming, then, to one question at issue, viz., the form of electro-motive force curve, which the alternator should possess in order that the iron losses of transformers worked off it should be a minimum. This is a question which can only be settled by an experimental comparison of the no-load losses of transformers tested off alternators of which the E.M.F. curve is at the same time ascertained. In order to do this when the alternator is at a distant place, some means must be obtained of driving a revolving contact breaker at a definite speed relatively to the alternator. This, I find can be done by putting the contact breaker on the shaft of a small synchronising alternate current motor, which runs in step with the distant alternator, and enables the instantaneous curve of potential difference between the primary mains to be ascertained. By the employment of this device I expect to be

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able to place against one another the results of a series of tests in which the iron losses of the transformer are compared with the form of the curves of the primary potential difference applied to its terminals. Until these experiments are complete it is impossible to state positively that the E.M.F. sine curve is the best or the worst form for minimising the iron core losses of transformers. Up to the present it has certainly not been shown that it is the best.—Yours, &c., J. A. Fleming.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Your remarks regarding the efforts of some American manufacturers to produce alternators giving true sine waves are quite apposite and to the point at the present time, and the views to which you give expression probably accord quite as well with the real views of American manufacturers generally, as do those you venture to criticise. Manufacturers generally in America are, I believe, very little concerned regarding the form of wave given by the alternators they make, and very much indeed with the development and construction of alternators of high efficiency that are mechanically strong in which the ratio output-weight is great, the expense of construction moderate, and that are capable of operating circuited apparatus with the highest attainable efficiency. On being able to make and to use machines meeting these requirements depends in a great measure the financial success of the manufacturer, and of those engaged in the business of alternating current supply.

It is found in practice that alternators having armatures of the so called "iron-clad" or overhanging projection type, meet requirements so satisfactorily that they have almost entirely superseded those having armatures of the old smooth-core type, and thus in a great measure effected the retirement of sine waves. These "iron-clad" armatures are vastly better from a mechanical standpoint than the old smooth-core armatures. The wires are well protected in the slots and efficiently driven. The possible output also is 60 to 75 per cent. greater, but, generally speaking, they do not give anything resembling sine waves; nevertheless, their substitution for the old type has not resulted in any decrease in the efficiency (*i.e.*, increased core losses, &c.) shown by apparatus operated upon the circuits which they supply; indeed, so far as I have been able to find, facts point the other way, and indicate the possibility of securing higher efficiencies (*i.e.*, decreased core losses, &c.) by the use of alternators giving waves of comparatively irregular form. Some of the earliest constructed of these "iron-clad" alternators reduced the core losses of apparatus circuited with them 12 to 15 per cent. below the value found when the same apparatus was circuited with smooth-core machines giving practically sine waves. This is a matter of record, and probably two years old.

Of course, in particular transmissions, when the use of alternators giving sine waves appears desirable, they will be met as special cases and so treated.

A possible explanation of the advertisements regarding alternators that give true sine curves, to which you refer, occurs to me. It is well known that some kinds of measuring and metering instruments vary in some way in their indications, with variations in the form of wave in the circuit. For example, a manufacturing company making a meter of this kind, and having a large number in use, that have been calibrated and run on circuits supplied by old style smooth-core armature machines, might in a manner be compelled to maintain the integrity of meters in use by getting as nearly as possible the same form of wave from "iron-clad" armatures. The vigilance of some trade rivals might readily result in the appearance of advertisements of alternators giving "true sine waves." Some time they may, perhaps, warrant them not to give sine waves. It may be noted that the great armature reactions occurring in the modern type of alternator make the wave form change with the armature current; I do not know how nearly such machines, if made to give sine waves—say, when running without load—would maintain the wave form when fully loaded.

In conclusion, I will say that until direct experimental evidence is forthcoming that is much more conclusive toward establishing the reality of the general advantages claimed for sine wave alternators than has yet been produced, an impartial jury must, for the present, find a verdict of not provens and dismiss the case.—Yours, &c. R. Shand.

Lynn, Mass., August 27, 1894.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

Tenders Invited.—Tenders are invited by the General Direction of the French Posts and Telegraphs, 103, Rue de Grenelle, Paris, for the supply of 10,000 galvanised iron crosspieces for telegraph poles. Tenders have to be in by the 20th inst.

——— The Directors of the Great Western Railway require tenders for the supply of a variety of stores, including telegraph instruments, telegraph apparatus, copper wire, telegraph ironwork and tools, telegraph drysalteries, electric light carbons, indiarubber goods, telegraph poles, and yellow pine, &c., &c. Particulars can be obtained at the office of the Stores Superintendent at either Swindon or Paddington Station; and tenders must be sent in by Monday, the 8th prox.

——— The Glasgow Corporation invite tenders for the construction of about half-a-mile of double line of tramway. Tenders have to be sent in to the Town Clerk by the 18th inst.

——— The Electrical Committee of the Bristol Corporation invite tenders for the construction of transformer chambers in certain streets in the Clifton district. Plans, &c., can be obtained of Mr. H. Faraday Proctor, the city electrical engineer, and tenders must be sent in by noon of the 18th inst.

——— The Directors of the London, Tilbury, and Southend Railway Company require tenders for a quantity of stores, for which information can be obtained at the Secretary's office, Fenchurch-street Terminus, London, E.C. Tenders must be in by the 17th inst.

Tenders Received.—The Works Committee of the Dundee Gas Commission have received tenders from Henley's Company and the Silvertown Company for the supply of electric cables for the police office buildings, and these tenders have been referred to Messrs. Urquhart and Small for their report. The cost is expected to be about £325.

Bankruptcies.—A receiving order was issued on September 7th against W. David Gooch, electrical engineer, of 2, Willes-road, Kentish Town (late of 3, Victoria-mansions, Westminster, S.W.).

——— A receiving order, dated September 3rd, has been issued against H. W. Young, O. Buss, and C. W. W. Young, trading as Young and Buss, wholesale ironmongers and electric bell manufacturers, 18, Blandford-street, and 8, Blenheim-street, W. The first meeting in this matter takes place at the Bankruptcy Court, Carey-street, W.C., on the 20th inst., at 11 o'clock, and the examination of the bankrupts on October 30th, at 12:30, at the Bankruptcy Court.

——— Notice is given that the adjourned meeting of creditors in the matter of Arthur Shippey, a bankrupt, will be held on the 17th inst., at Bankruptcy-buildings, Carey-street, W.C., at half-past two o'clock.

Queen and Co. (Philadelphia).—The creditors of Queen and Co. (who have recently suspended) have decided to grant the firm an extension of three years in the hope of thus obtaining a settlement of their claims in full. If at any time during that period the business shows an actual loss the creditors reserve power to cancel this extension agreement and to have a receiver appointed to wind up the Company's affairs. The course above referred to was suggested by the management. The debts are about $200,000 with bills receivable and book accounts of about $80,000.

New Premises.—Messrs. Laurence, Scott and Co. have just opened new premises in Regent-street, Norwich, where they have fitted up a model electric lighting display, and have on show a variety of electroliers and electrical apparatus for all purposes.

Velvo-Carbon.—The Battery and Motor Company send us reports and particulars of tests of the velvo-carbons. These reports and tests have been made by Mr. Andrew Jamieson and Mr. H. T. Barnett. Accompanying the tests are several current and potential diagrams.

Elmore Copper.—It is stated that the tests made by Government departments upon Elmore copper have proved sufficiently satisfactory to warrant the War Department to place the Elmore Patent Copper Depositing Company (Limited) on the list of contractors to the Department.

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Street Fire Alarms.—Mr. Kennedy, the Magistrate at Greenwich Police Court, has this week severely punished a stupid man named Metcalf for interfering with the street fire alarm posts. At two o'clock in the morning Metcalf broke the glass and pulled the bell communicating with the fire brigade, with the result that at this early hour in the morning firemen, fire-engines, and life-saving ladders were turned out on a purposeless errand. It is satisfactory to know that the culprit has been mulct in the heavy penalty of £20, with the alternative of a month's imprisonment. The Magistrate, in giving his decision, stated his intention of severely punishing any person brought before him charged with a similar offence.

Picture Reflectors.—The registered picture reflectors made by Messrs. B. Verity and Sons, and for which that firm claim many advantages, are being fitted throughout the new picture gallery belonging to the Oldham Corporation.

Eighty Kilowatt "Sayers" Dynamo Machine.—For an extensive electric lighting contract which they have in progress in Russia, Messrs. Mavor and Coulson, of Glasgow, have just finished a dynamo constructed on the "Sayers" principle, which is understood to be the largest electric generator yet made in Scotland. Its working capacity is said to be equal to 1,350 16-c.p. lights. The dynamo is to be coupled direct to a Belliss engine of 120 i.h.p., with which it is being tested this week at Birmingham. Interest attaches to this dynamo from the fact that it is stated to be not more than half the weight of any machine of other types whose generating capacity is the same. As may be remembered by those members of the Institution of Electrical Engineers who heard Mr. Sayers's Paper read, and the interesting discussion to which it gave rise, or who may have since read the Paper, the saving in the weight of the machine depends on the novel character of the armature winding which is used in its construction. The dynamo is to be used in a large textile factory in Russia, where there have already been installed upwards of 3,000 lights. Messrs. Mavor and Coulson have supplied all the other plant for the installation, which has been carried out on the concentric system of wiring.

Private Telephones.—The new offices of the *Daily Chronicle* in Salisbury-square, E.C., have been fitted throughout with a telephonic installation by the Private Wire and Telephone Installation Company on the inter-communication system, by which the various rooms throughout the building are enabled to have immediate and direct communication with each other, while dispensing with the central switchboard. The instruments used are magnetos, which are fitted with Hunnings transmitters. The building has also been fitted throughout with electric bells by the same firm.

Electro-Harmonic Society.—The first smoking concert of the season takes place on Friday, the 28th inst., at the St. James's Hall Restaurant, Regent-street, W., at 8 o'clock. An excellent entertainment will be provided, the *artistes* including the Westminster Singers, Messrs. Walter Coward, Harper Kearton, Charles Ackerman, W. H. Brereton, and James Kift. Mr. Leo Taussig is the violoncello, Mr. A. Izard, solo pianist; and the musical direction will, as usual, be under the able directorship of Messrs. T. E. Gatehouse and A. Izard.

Insurance Companies' Accounts.—Those interested in the elaborate accounts issued by the insurance companies may obtain in handy form "The Insurance File," which contains reproductions in reduced fac-simile of the annual reports and balance-sheets of the principal insurance offices in the United Kingdom. The third annual issue of this useful publication is now published, and can be obtained, price 1s., of the Editor, 21, Godliman-street, E.C. In addition to the actual accounts issued by the companies, a chapter is added dealing with the various schemes of life insurance, for which the companies claim special advantages.

Battersea Polytechnic.—The day classes for technical and science subjects open on Monday next, and the evening classes on the evening of Monday week. The instruction in these subjects is associated with laboratory or workshop work. The institute possesses laboratories for chemistry, mechanics, physics, and electrical science, and workshops for engineers, carpenters, plumbers, &c.

Bedford.—A resolution was carried at the last meeting of the Rural Sanitary Authority that the Corn Exchange, Town Hall, and Town Hall offices be wired ready for the electric light the ensuing winter. Tenders are to be invited by the Public Buildings Committee for the work in connection with the electric lighting of the buildings.

Birkenhead.—At the last meeting of the Town Council the plan prepared by Mr. J. N. Shoolbred for the proposed central electric light station was approved, and the Town Clerk was instructed to submit the same to the Local Government Board for their approval in connection with the application for sanction to borrow £20,000 for electric lighting purposes.

Birmingham.—The work in connection with the electric light at the Market Hall is now nearly complete, and the lighting will be effected in about a fortnight. Gas has been burned most unscientifically in this building, and although it has only been used about 15 hours per week, it is now costing at the rate of £522 per annum. From experiments made it has been proved that electric lighting will be found more economical from the 23 arc lights used—16 of 15 amperes and 7 of 10 amperes. Current will be taken from the Birmingham Electric Supply Company's mains in Bell-street. The installation has been designed by Messrs. Lea and Thornbery, and carried out under their supervision by the Walsall Electrical Company. Brockie-Pell arc lamps are used, and the ornamental ironwork has been supplied by Messrs. Hart, Son, and Peard. The electric light is shortly to be introduced into the new meat market, the municipal schools, and the botanical gardens.

Blackburn.—The electric lighting at the Art Gallery and Free Library has proved very successful, and credit is given on all hands to Mr. Walter Leake, the consulting electrical engineer, under whose supervision the work has been carried out.

Bradford.—At the meeting of the County Council, on Tuesday, Mr. Alderman Moulson presented the accounts of the electricity department, which showed that £4,964 had been received for the sale of current, the total receipts being £5,418 against £4,547 for the corresponding half of last year. The gross profit for the half-year was £2,189, against £2,294 for the corresponding half of last year.

Broughty Ferry.—A special meeting of the Police Commission has been held to consider what steps should be taken with regard to the proposed electric lighting of the burgh. In the course of the discussion on the subject a Mr. Lamond was bold enough to inform his fellow members that the electric lighting system had been a gigantic failure at Dundee, and, further, that many of the shopkeepers in that town would be only too glad to get rid of the electric light if they could. That this statement is contrary to the fact is amply proved by Messrs. James Maxwell and Son, who are responsible for a large portion of the private lighting in Dundee. This firm point out that not one of the 200 consumers of electric current in Dundee has asked to be disconnected from the Corporation mains; but that, on the contrary, many of them have extended their original installations. The fact, however, that Mr. Lamond had mis-stated the position in Dundee does not appear to trouble him. He is of opinion that, if the Broughty Ferry authorities allow the Northern Electric Supply Company to obtain the Provisional Order they are applying for, the Police Commission will be able to buy them out on their own terms in a very short time, although even this comforting possibility failed to reconcile him to the project. A motion pledging the Council to neutrality in the matter of the Northern Company's application, on condition that gas be used for the motive power at the generating station, and that this gas be taken from the Council's works, was persevered with. But even this conciliatory attitude was more than Mr. Lamond could entertain; he therefore proposed that a meeting of the ratepayers should be called before a copper was spent on electric lighting, and this view ultimately found favour with the members of the Council.

Burton.—In the discussion of the report of the Gas and Electric Light Committee of the Town Council, Councillor Rugg asked if there was not an enormous waste of electricity when the engines were running in the evening and, if so, whether the Committee could not recommend the purchase of accumulators in which to store the electricity, so that it could be used in public places, and for electrical fans, and for ventilating public buildings. The Council's gas manager replied that there was no waste of electric current.

Church Lighting.—The lighting of the new Catholic church at Norwich, to which reference was made in our last issue, consists of 80 25 c.p. incandescents for the nave, 40 in the aisles, four in the main entrance, and 46 of 16 c.p. in the presbytery. All the brackets and lamp-holders are of aluminium. The whole of the work, which is very effective, has been carried out by Messrs. Laurence Scott and Co., of Gothic Works, Norwich.

Club Lighting.—The Garrick Club, London, W., is now illuminated throughout by the electric light. The effect of the light is described as charming, and the artistic treasures, with which the walls of the building are crowded, can now be inspected as easily by night as by day. It has hitherto been necessary to guard these treasures against the ravages of gas, and many of the members will now be able to view their precious belongings for the first time under the genial influence of the electric light.

Country House Lighting.—Altyre House, the seat of Sir William and Lady Gordon-Cumming, has just been improved at a cost of nearly £15,000, the improvements including a complete system of electric lighting throughout the mansion.

Coventry.—It is stated that the hitch respecting the construction of the proposed electric tramways is likely to be overcome, the Board of Trade having agreed to the diversion of the line on the Warwick road, provided certain conditions are carried out by the contractors. It is proposed to proceed with the work as an unauthorised undertaking, for which Parliamentary powers will be obtained in the next session of Parliament.

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DERRY.—In reference to complaints which have been made as to the extinguishing of many of the public lamps, a report was presented to the Corporation by Mr. Christie, the resident electrical engineer, stating that these faults were not at all attributable to himself or his staff. A letter was read at the last meeting of the Corporation from Messrs. Siemens Brothers and Co., declining to admit that the failures in the cable were due to defective manufacture, or to careless handling on the part of their men, but stating that they would consider the question of defraying the expense to which the Corporation had been put for the reopening of the streets to reach the defective parts of the cable. Messrs. Siemens Brothers and Co.'s responsibility for the working of the cable is in force until May 29, 1895. Mr. Blake, the electrical engineer to the Corporation, had been in consultation with Dr. J. Hopkinson, the consulting electrical engineer, whose opinion on the subject had not yet been received. After a long discussion the Council adopted Mr. Christie's report. The Lighting Committee have paid the local Gas Light Company £450 for the 670 gas lamps which it is proposed to utilise in the supply of electric current to the portion of the city not yet lighted electrically.

DEVONPORT.—The Town Council have received intimations from the Brush Provincial Company and Great Western Electric Light and Power Company of their intention to apply for Provisional Orders to supply the Devonport district with electric current. The matter has been referred to the Streets Committee.

EALING.—*The Times* is responsible for the statement that in connection with the electrical exhibition which is to be held at Ealing to celebrate the introduction of the electric light on Wednesday, the 3rd prox., and following days, "almost every known system of telegraphic and telephonic manufacture and manipulation will be shown." As the main object of the exhibition is to introduce to the Ealing public apparatus connected with electric lighting, cooking, and heating, visitors will be more concerned to learn that the exhibition has met with the co-operation of several leading electrical firms, who will display their special manufactures of lighting, cooking, and heating apparatus. In addition, there is to be a loan exhibition, and practical illustrations of the application of electricity to a variety of domestic purposes. Sir Frederick Bramwell will lecture on "Elementary Electricity," and Mr. W. Lynd on "Edison and his Inventions."

EDINBURGH.—The Electric Lighting Committee of the Town Council have agreed to recommend that a deputation be sent to Westminster, London, for the purpose of examining the electric lamps used in that district for lighting the streets, similar lamps being about to be introduced in the lighting of Edinburgh thoroughfares. The price of gas has been reduced from 3s. 6d. to 3s. 2d. per thousand, and so here, as elsewhere, the electric light proves of direct benefit to the ratepayers.

ELECTRIC LIGHT AND POWER IN NEWSPAPER OFFICES.—The *Sheffield Telegraph* has for some years past used the electric light in its printing and editorial offices, and electric power has been used for the printing machines. The success of the installation has been clearly proved, and the proprietors have just decided to duplicate their electric light and power plant, which at present consists of a Tyne dynamo for use during the day, and a Wilson-Hartnell 500-light dynamo for night use. The duplicate plant will consist of a Willans compound engine, coupled to a Wilson-Hartnell 500 16-c p. light dynamo.

FAREHAM.—A Board of Trade inquiry has been held by Major Cardew, of the Local Government Board, in respect to the proposed transfer of the local Electric Light Company's undertaking to the Municipal Authorities. Considerable opposition to the proposed transfer was made by Mr. Smith and several parties whom Mr. Blake (representing the Electric Light Company) described as the friends or shareholders of the local Gas Company—a family party. Mr. Blake stated that the Electric Lighting Company had brought about a reduction of 9d. per thousand in gas, and had so materially benefitted the ratepayers. Mr. Abraham, a member of the Local Board, said the reason the Board entertained the proposed purchase was that the townspeople had expressed their satisfaction with the light, but had been somewhat misled as to the cost. Major Cardew will shortly issue his report.

GATESHEAD.—A sub-committee appointed by the Town Improvement Committee of the Corporation have had before them a report from the Town Surveyor on the electric lighting question, and it is expected that the Committee's report on the subject will be discussed at the next meeting of the Corporation.

GLASGOW.—As mentioned in our last issue, a report has been issued by the Committee on Gas Supply and Electric Lighting of the Glasgow Town Council. The report embraces the period from June 1, 1893, to May 31st last. The electric lighting accounts show a gross revenue of £18,016, with an expenditure of £9,592, to which is added the depreciation written off capital of £4,393, the balance carried to profit and loss being £4,031. As set off against this balance, interest on loans and the sinking fund represent £4,638, leaving a deficiency on the year's operations of £607. The report states that this deficiency is due to the cost of public lighting, the rate having been fixed at too low a figure to be remunerative. The result, however, of the year's working compares favourably with its predecessor, the deficiency for 1893 being £1,174. The improvement arises from the fact that the Waterloo-street station has been fully employed, the revenue having increased from £7,784 to £18,016, and the expenditure not having increased in the same ratio. The Committee anticipate that this improvement will not only be maintained, but that the use of electricity will be further developed during the coming year, in which anticipation they are confirmed by the numerous applications for current which have been received since the beginning of the year. To meet this increasing demand, the Committee have resolved to lay down at the Waterloo-street Station additional plant. The number of consumers from the Corporation mains at May 31st last was 378, or an increase of 270 over the number at the same date last year. 543,178 units of electric current have been sold during the past year to private consumers alone, and this represents an increase over the preceding fifteen months of 107·14 per cent. The balance-sheet accompanying the report shows that, of the amount of £200,000 for which the Corporation have borrowing powers, £120,000 has been borrowed at 3¼ per cent., and of this amount £116,585 has been expended, leaving a balance in hand of £3,415. A statement accompanying the report gives the following figures:—

Year ending May 31.	Quantity generated. B.T. units.	Total quantity sold. B.T. units.	Quantity used on works. B.T. units.	Total quantity accounted for. B.T. units.	Quantity not accounted for. B.T. units.	No. of public lamps.	Per cent.	Total maximum supply demanded Amperes.
1893	408,529	287,712	13,975	301,687	106,842	26·15	71	7,900
1894	854,766	702,248	13,326	715,574	139,192	16·28	102	16,839

The Tramway Committee's report announced that the weekly receipts showed satisfactory increases. All matters in connection with the transfer of the tramways from the Tramway Company to the Corporation have been satisfactorily negotiated. The Committee had arranged for the cars being illuminated by the electric light, and this would be carried out in a short time. Two lamps were to be provided for the inside and two for the outside, the latter with special regard to sufficient light being provided to enable passengers to read with ease and comfort.

HERTFORD.—The public meeting convened by the Town Council for the purpose of discussing the electric lighting question was held last week. It was pointed out by the Chairman, Mr. A. Hawks, that the Town Council had obtained a Provisional Order, and they must take action in the matter, or they would lose it. A discussion followed the Chairman's remarks, in which Mr. G. A. Munnings, who admitted himself a large shareholder in the local gas company, proposed a resolution that it was undesirable to proceed with the electric lighting scheme. Mr. Munnings was followed by several gentlemen opposing the scheme, including a Mr. Burton, who hazarded the statement that the electric light "could not be satisfactory, or it would be adopted in the British metropolis." Several speakers, in more moderate language, gave the scheme their general support. The electric light would improve the appearance of the town, and show that it was imbued with a spirit of progress. An amendment was subsequently moved that the whole question should be left in the hands of the Town Council. Ultimately the original resolution was carried.

INFERIOR GAS.—The Gas Light and Coke Company were, on Monday last, summoned before Mr. Vaughan, at Bow-street, London, for supplying gas of less illuminating power than that specified under Acts of Parliament. The Company stated that they were quite unable to explain how the deficiency came about. The magistrate imposed a penalty of £25 in one case and 40s. in another, with 25s. costs.

LLANDUDNO.—The grounds connected with Mr. Riviere's Concert Hall are now successfully lighted by electricity. Brockie-Pell arcs are used. The work has been carried out by Mr. Kingsland.

LIGHTING THE HOUSES OF PARLIAMENT.—It is stated that during the present recess considerable further progress is to be made with the scheme of electric lighting at the Houses of Parliament. In consequence of the heavy expenditure entailed it was decided some time back to complete the installation by degrees. This has resulted in the lighting being complete in the lobby, in the Octagon hall, in the principal of the corridors, the main staircases, the dining and smoking rooms, the reporters' gallery, and the House of Lords. Several of the committee rooms have also been provided with incandescent lighting; but there still remains much to be done before the Houses are completely illuminated by electricity. It will possibly surprise many to learn that oil lamps are still used in some of the offices and committee rooms at Westminster, and that it is not an uncommon experience for a Committee to suspend its deliberations while oil lamps are prepared to counteract the effects of a suddenly-developed fog. The main

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corridor of the Houses is still lighted by a few old-fashioned gas jets.

LUTON.—At the next meeting of the Town Council a motion will be discussed that the Highways and Lighting Committee consider and present a report on the question of applying for a Provisional Order for the supply of electricity for public and private purposes within the borough, and the probable cost of obtaining the order.

MIDDLESBOROUGH.—The Electric Lighting Sub-Committee of the Corporation, after inspecting the electric lighting system at Newcastle, Leeds, Blackpool, Huddersfield, and other large towns, have come to the conclusion that the electric light is a paying business, and that profit is made by its adoption. Consumers in all the places visited testified to the fact of the electric light being superior to gas, and said that they would on no account return to the latter method of lighting. The sanitary effects of electric lighting are in the right direction, and the saving to electric current consumers' goods represents a substantial figure. The Committee said they were particularly pleased with the installations at Blackpool, Huddersfield, and Leeds, and recommend the Middlesborough authorities to proceed forthwith with the laying down of an electrical installation at a cost not exceeding £25,000.

MIDLAND INSTITUTE.—A new organ has just been put in at the Midland Institute, Birmingham, by Messrs. Nicholson and Co., of Worcester, at a cost of about £1,200. The organ is supplied with a large French feeder driven by a Crompton motor. This electric blowing apparatus is self-regulating, and supplies wind power at a very small cost in fact, at much less cost than by any other method.

MILL LIGHTING.—It has been decided to light by electricity the extensive range of buildings forming the Draycott Roller Flour Mills, Cam, Gloucestershire, together with the private residence, workmen's cottages and stables connected therewith. The order for the work has been secured by Messrs. Knapman, Hodder and Co., of Cardiff. The motive power is supplied by a steam engine and a large turbine, and the electrical plant includes a battery of accumulators.

MONMOUTH.—The Town Council have appointed Mr. Lailey, C.E., to prepare plans and specifications for the combined scheme for drainage and electric lighting for the borough, the work in connection with which is to be entrusted to Messrs. Bramwell and Harris.

MONTROSE.—At a meeting of the Town Council, on Monday, Provost Mitchell moved that the Corporation should apply to Parliament for a Provisional Order to supply electric current within the Montrose district. This was met by a direct negative from Mr. Strachan, who expressed himself favourable to the introduction of electric lighting to the town; but contended that it would be better for one or other of the two companies which had intimated their intention to apply for a Provisional Order to do the work necessary in connection with introducing the light into the district. They had an offer from a private company to supply electric current 25 per cent. cheaper than gas. The amendment was carried by 11 votes to 5. Notice was given by Provost Mitchell that he should take an early opportunity of calling a public meeting to support him in offering the most strenuous opposition to the lighting of the town being put into the hands of a private company.

NELSON.—As the result of a deputation from the Tradesmen's Association a reduction has been made in meter charges, and discounts are now allowed on electric lighting accounts for prompt payment.

PORTSMOUTH.—At the meeting of the Portsmouth Chamber of Commerce complaint was made that the electric light mains interfered with the working of the telephone instruments, and it was the opinion of several members that during the coming winter, unless something was done, the use of the telephone would be lost for a considerable portion of the day. A sub-committee of the Chamber is to be appointed to deal with the subject.

RAILWAYS FOR SLOW TRAFFIC.—At the meeting of the Associated Chambers of Commerce at Huddersfield a motion was agreed to affirm a resolution passed unanimously at the general meeting of the Association at Newport in 1892, and again at Plymouth in 1893, calling upon the Council of the Association to bring under the notice of Government the importance of offering facilities for the authorisation (without special application to Parliament) of inexpensive lines of railway adapted for slow traffic to meet the requirements of thinly populated districts.

READING.—The new arcade in Friar-street is now open to the public, and of the 20 handsome shops 16 have been furnished with electric light by the Reading Electric Supply Company, the fittings being supplied by Messrs. Williams and Sons and J. W. Dew, of Carey-street. Six electroliers are used for lighting the central part of the arcade, and prove a great attraction. The County Court offices, forming a portion of the new block of buildings, are to be lighted throughout by electricity. The buildings are erected from designs by Mr. F. W. Albury.

REDDITCH.—Some discussion took place at the last meeting of the Local Board as to the erection of additional gas lamps in various portions of the district, but it was decided to let the matter remain in abeyance until the Committee appointed to consider the lighting of the town by electricity had presented their report.

SALISBURY.—At the last meeting of the Town Council it was stated that the new electric light central station works are to be finished by February next.

SOUTHAMPTON.—A busy scene was witnessed in the Empress Dock on Wednesday, when the hired troopship "Victoria" was prepared for her first trooping voyage. For this purpose the South-Western Railway Company set apart a quay opposite to that occupied by the American Liners, where a shed was specially built to provide accommodation for the military. The shed was supplied with the electric light, and this enabled work to be proceeded with at night with the same facility as in daylight.

STAFFORD.—The Electric Lighting Committee's report was presented to the Town Council at its last meeting and adopted. The report states that the work at the station is making satisfactory progress, and that six tenders had been sent in for the supply of cables upon which Dr. Hopkinson, the Corporation's consulting electrical engineer will shortly report.

STOCKTON.—The Board of Trade have agreed to defer the revocation of the Corporation's Electric Lighting Order for two years, on condition that the works are started within that period.

ST. GEORGE (BRISTOL).—The Local Board, at its last meeting, discussed the lighting question, and Mr. Essery pointed out that about £2,000 a year was spent in lighting the district, and he thought the time had come when St. George should be placed in the same favourable position with other parts of the Bristol district, and urged the introduction of the electric light. He was quite sure if they went into details they would find that the cost of lighting by electricity did not exceed that of lighting by gas. He did not recommend so ambitious a scheme as that undertaken by the Bristol authorities, but proposed that a £10,000 installation should be at once proceeded with. Money could be borrowed for 30 years at a low rate of interest. The proposal was accepted, and a committee was appointed to consider the subject, and report to the Local Board.

STREATHAM (LONDON, S.W.).—The "Greyhound," a well-known place of public resort, has been fitted throughout for the electric light by Mr. G. Stegmann. Eighty 16 c.p. incandescents are at present in use, and provision is made for 150 lights. The generating plant is on the premises, engine power being supplied by a 7 H.P. nominal Stockport gas engine.

TELEPHONE EXTENSION.—Skene and Echt have just been placed in telephonic communication with Aberdeen. The service was opened last week.

THEATRE LIGHTING.—The Theatre Royal, Brighton, which has been closed for nearly four months for reconstruction, the introduction of the electric light, refurnishing, &c., was opened last week. The electric light has been fitted throughout the theatre, 600 16 c.p. incandescents being used; 400 of these lamps are placed on the stage and its precincts. The electric lighting work has been carried out by Messrs. F. Geero Howard and E. S. Dashwood, of Berners-street, London, W., and under the personal superintendence of Mr. Dashwood. The stage will, it is stated, prove to be the best lighted theatre stage in England. The current is obtained from the Corporation mains.

TOWING BY ELECTRICITY.—It is stated that an electrical method has been adopted for towing the canal boats of the summit level of the Canal de Burgoyne, which connects the Seine and Saone, crossing in its course the divide between the Channel and the Mediterranean.

ULVERSTON.—The Local Board have communicated with the Board of Trade stating that, owing to the inhabitants showing no desire to embark in electric lighting enterprises, partly from the fact that great expense has been recently incurred in making provision for an efficient supply of gas, it is not the Board's intention to take any steps to introduce the electric light, and they ask the Board of Trade not to entertain any application from outside parties to supply electricity within the Board's district.

WARMINSTER.—The Committee appointed to consider the desirability of extending the electric light through the town have recommended the placing of additional arc lamps at a cost of £184. 10s., and a further expenditure of £50 on an additional dynamo. The Committee's recommendation was approved, and they were instructed to carry out the work.

WELLS (SOMERSET).—At the last meeting of the Town Council an application was made by Mr. Browne, of Shepton Mallet, asking for permission to supply electric current to the city for public and private purposes. Alderman Harte thought the application should not be entertained, because the ratepayers had from £20,000 to £30,000 invested in the gas works. A proposal that the matter be

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referred to a special meeting of the Council, to be shortly held, was carried. It is stated that the majority of the members are in favour of a comprehensive electric lighting scheme.

WESTMORELAND.—The Windermere Electric Supply Company have announced their intention of applying for a Provisional Order to supply electric current within the district served by the Westmoreland County Council.

WHITEHAVEN.—The Town and Harbour Trust have discussed the report of their Electric Light Committee, in which a quotation from Messrs. Siemens Brothers and Co. for cable was recommended for acceptance. The Chairman, in presenting the report, stated that the applications for the electric light continued to come in "in almost too satisfactory a manner." The committee, therefore, recommended the trustees to apply to the Local Government Board for sanction to borrow further money for electric lighting purposes, and it was ultimately agreed that applications should be made for powers to borrow £6,304.

YARMOUTH.—The Electric Lighting Committee have presented their report to the Town Council, and recommend the discontinuance of the temporary installation after September 30th, until such time as the permanent plant shall be ready for lighting the borough. Along the line of the electric lamps which are to be ultimately put down there are about 120 gas lamps, which will not then be required. The Town Clerk has been instructed to give the gas company notice to this effect, as the gas lamps will be put out of use from November 1st.

YEADON.—At a meeting of the Local Board on Monday the electric lighting question was discussed. The Board have obtained a Provisional Order with the usual powers to manufacture and supply current for public and private purposes, and have obtained tenders for the construction of the necessary plant. The lowest of these tenders is somewhat higher than the estimate which was submitted to the ratepayers' meeting which sanctioned the Board's original scheme. Some of the members therefore proposed that the consideration of the subject should be deferred until after the elections in November, but ultimately it was decided to call in expert assistance to advise the Board on the tenders and the samples sent in.

COMPANIES' MEETINGS AND REPORTS.

Electric Construction Company (Limited).

The first annual general meeting of the shareholders in this Company was held yesterday (Thursday) at the Cannon-street Hotel, under the presidency of Sir Daniel Cooper, Bart., G.C.M.G.

The SECRETARY (Mr. James Gray) read the notice convening the meeting.

The CHAIRMAN said: Gentlemen, before you can form a sound opinion on the accounts which the Directors have the pleasure of submitting to you, it is necessary that I should briefly give you some idea of the troubles and difficulties the Directors have had to deal with and overcome in the past year. As you are aware, the old Company was successfully reconstructed last year; but, besides the work of reconstruction, the Board and the Managing Director had to deal with several entanglements that had to be taken over as a legacy from the old Corporation. These matters have been dealt with, and, if not completely straightened out, are now in a comparatively narrow compass. In the end of December the heads of three important departments at Bushbury resigned on one month's notice, without any intelligible cause, and would not be induced to stay a short time longer till their places could be conveniently filled by others. At the same time Mr. Parker, the Works Director, intimated to the Board that he would not renew his engagement, which was to expire in the coming May. The Board had no desire to retain him as Works Director, but they were willing to keep up his connection with the Company, and offered him a very liberal retaining fee as consulting engineer. This Mr. Parker declined to accept. About this time rumours became very prevalent that rival works were about to be built at Wolverhampton, but Mr. Parker strenuously denied that he had anything to do with them. Under these circumstances immediate steps had to be taken to reorganise the establishment, and in April it was found expedient to anticipate the termination of Mr. Parker's engagement by dispensing with his services. Now that the staff has been reorganised, the Board are not sorry that the changes have been made, because they have secured a chief engineer and a technical staff at Bushbury in whose ability and loyalty they have full confidence; but you will understand that such extensive changes could not be made without seriously interrupting the work in hand and the continuous flow of new orders, and that these explanations were necessary before you could come to a just conclusion respecting the accounts submitted to you.

I will now deal briefly with the accounts, which I am happy to think do not seem to require much explanation. And first, as respects the profit and loss account, I cannot say that I am satisfied, although it is quite as good as could be expected under the circumstances already explained. A good deal owing to depression in business, but perhaps more to the reasons to which I have referred, the profits at Bushbury are too small and the general expenses too large. I hope we shall be able to show you next year an improvement in both respects. The item of profit—£15,764. 10s.—on sales of shares and debentures of other companies requires some explanation. If you will refer to the balance-sheet you will observe an asset under the head of shares and debentures of other companies—£147,872 6s. 7d. These interests in other companies were valued by the Directors, when taken over from the old Company, according to the best of their judgment. They had great difficulty in arriving at what they considered a fair valuation, because none of the securities had market quotations. After much deliberation the prices fixed were such as were considered safe, but at the same time they could not then have been realised in the market. The values depended on the development of the undertakings. As it happened, the interests in certain of these properties matured more quickly than was anticipated, and the Directors found an opportunity of realising them before the end of the financial year, with a profit of £15,764. 10s.; this profit, less a proportion for general expenses, it is proposed to apply in reducing the amount at debit of this account, which will thus be strengthened by £12,500 to meet any unfavourable realisations, should such arise. Beyond the account—shares and debentures of other companies—I do not think there is any other item in the balance-sheet requiring explanation, but I shall be ready to answer any inquiries for further information. During the past year there has been extreme depression in business generally, and very keen competition in electric manufactures; but, as you see from the report and accounts, we can fairly say that we have held our own.

As to the future. I believe we have at Bushbury the finest electric works in the kingdom, and they are situated in a locality where work can be executed quite as economically as anywhere. Mr. Blackburn, the recently appointed Chief Engineer at Bushbury, has had wide experience in all kinds of electrical engineering, and is supported by a technical staff and a body of artisans at least equal to any other in the United Kingdom. All are determined to maintain the high character of the work hitherto turned out by our establishment, and we believe this can be done with greater economy than heretofore. The future, of course, depends to a large extent on the business activity, not only in this, but in other countries which we supply with our manufactures. All I can say is, we expect to obtain a fair share of what work is going, and to carry it out with reasonable profit to the shareholders. The business was never in so stable a position as it is to-day, and I do not think there is any cause to be apprehensive of the future.

Before moving the formal resolution I may add that a moderate increase of capital would be of advantage to the Company. There remains of the £100,000 Preference capital £74,010 unissued. The rate of dividend—7 per cent.—we think too high, considering the improved position in which the Company now stands, but there are various difficulties in the way of reducing the rate. A quotation on the Stock Exchange for the Preference shares has been obtained, and as we cannot redeem the portion issued, it would probably be impracticable to obtain another quotation for a new issue at a lower figure. The Directors have come to no conclusion on the subject, but it is probable that they may resolve to offer the balance of the present Preferred shares to the shareholders, giving ample time to pay up the calls, and thus the existing shareholders would receive, as they are well entitled to, the benefit of the high dividend payable on these Preference shares. I now formally beg to move—"That the accounts and report, with the recommendations therein contained, now submitted by the Directors, be approved and adopted."

Mr. J. W. BARCLAY: In rising to second the motion I have only to add, on behalf of the Directors, an expression of our great confidence in our present staff at Bushbury, and in the body of skilled workmen and artisans the Company have now in their service there. You are all aware how much the success of such a Company as this depends on the loyalty, the capacity, and the goodwill, not only of the staff, but also of the workmen engaged in carrying on the business. Amidst the competition which is going on now-a-days co-operation is necessary, and it is a matter of great satisfaction to the Board to think that they have now a staff of men and a body of officers in whom they have full confidence—not only as regards their loyalty, but also their capability for carrying out the work entrusted to them. On the other hand, I think that I may say the Directors have very much at heart a desire to enlist the confidence of the workmen, and, so far as lies in their power, they will be very anxious to take such measures in the interest of the staff and the workmen as will show them clearly that the Board are not merely a Board sitting here in London, but also a body of gentlemen who are really interested in the welfare of their employés. I now beg to second the motion.

Mr. WILLIAMS inquired why the travelling expenses—£1,463—had been so heavy; and he also thought that the item of postages and stationery—£910—was also very large.

Dr. DRYSDALE asked whether Mr. Parker had taken up with the other works alluded to by the Chairman?

Mr. COOKE said he wished to know whether Mr. Parker was starting a rival Company, and, if so, how this was likely to affect their Company through its being in want of capital, as the Chairman had stated. It seemed from the balance-sheet as if there was any amount of capital in the concern, although on the other side of the statement it appeared as if most of it was lost. He also saw that there was a contingent liability on certain of the shares held by them under the heading of "Shares and debentures of other companies." He supposed that the Chairman would not care to state what this liability was. They only had £8,753 cash in hand; and with "sundry debtors" amounting to £32,700, they would probably find themselves in an unpleasant position if calls were made.

Mr. HANCOCK regarded the report as very dispiriting. He considered that the handing over to the Electrical Power Storage Company of their electrical storage was somewhat scandalous. In explanation of that, he believed they received an assurance from the Chairman that their Company would have from that Company alone a dividend of £9,000 a year. He found, however, from the profit and loss account that the interest and dividends received by them on debentures and shares held by

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them in all the other companies amounted to only £5,680, and he thought that this amount ought to be larger than £9,000, seeing that £9,000 was to be the minimum. The accounts also rather pointed to a not very satisfactory future for them. Only £3,000 was written off for depreciation, and he supposed that this depreciation referred to the item of £300,000 under the heading of "Properties, Patents, and Goodwill." Some of the patents, however, must be fast running out, while others must be very nearly run out. He thought, for instance, that the patent for the electrical storage battery must be very near to an end. A sum of £3,000 written off against £300,000 was, he considered, very small, and it would either have to be very largely increased in the future or else some day they would come to a dead loss which would have to be written off. He thought they had sustained a great loss by the termination of Mr. Parker's services. A leading feature in the prospectus of their Company was the great value that Mr. Parker's services would be to them. From time to time they had been assured that the greater portion of their profits had been derived from Mr. Parker's labours and inventions.

The CHAIRMAN: No, that was never stated.

Mr. HANCOCK, continuing, said that he had it in print, and that the statement had been repeatedly made. The various undertakings carried out by them—for instance, the Liverpool Overhead Railway Company—had been most skilfully executed, mainly by Mr. Parker. The Directors might have their own views as to the loyalty of Mr. Parker, but as regarded that gentleman's ability he considered that their Company had sustained an immense loss in losing his services. It would involve, he held, much stricter attention to economy in the working of the concern if they were to look for profits in the future. About £360,000 had been written off their capital; and, taking the difference between the par value of the shares at present—£2—and their existing market value, this loss was increased to about £500,000.

The CHAIRMAN stated that this loss had not been made in any way by the present Company.

Mr. HANCOCK, resuming, expressed his opinion that the cause of much of this loss was owing to the fact that the Board had been drawn from two sources—Mr. Spencer Balfour and his allies and Mr. Irving Courtenay and his allies in other companies. He considered that the Directors of such a company ought to be drawn from a larger area, and from outside sources, as new ideas would thus be brought into the concern instead of its being continually carried on in the same groove. He did not agree with the Directors' recommendation in the report that the vacancy at the Board should not be filled up. He held that one or two or more Directors should be elected on the Board, and that they should be drawn from an independent source, but connected with the same kind of business. Probably, it was a matter of figures, but it was stated that there were to be 14,620 Preference shares, whereas in the balance-sheet now before them there was a deficiency of 1,625 (or £3,250) in this number.

The CHAIRMAN, in reply, said: We have an executive committee, and we meet daily when necessary. We are always at work and always watching over the interests of the Company. Mr. Barclay takes charge of that, and you could not have a more efficient man to watch over your interests. With regard to the old Directors, the less you say about them the better. We are not answerable for what took place when you had 13 or 14 Directors. We have been clearing out all that coterie, and we have none of the allies referred to. When you talk about Mr. Irving Courtenay's allies, I am his only ally, and you can throw stones at me if you like. Mr. Irving Courtenay and I came on this Board together, and it was a bargain that we should do so.

A SHAREHOLDER stated that a net profit of £18,467 was shown on the past year's working, but this profit was reduced to £2,700 if they took away the profit made on the realisation of shares and debentures of other Companies.

The CHAIRMAN: I alluded to that in my speech. I said that the profit at Bushbury was not to our satisfaction.

Mr. BARCLAY, in further reply, pointed out that the Chairman had stated that the Directors considered that the travelling expenses and the postages and stationery were too high. Last year, however, there was a considerable amount of postage connected with the reconstruction of the Company. It must also be remembered that the Directors had only had one year's trial. They were appointed in the beginning of 1893. In June the Company was reconstructed, and until the present time they had hardly got settled down to the real work of the Company, what with the reorganisation of the staff, the reconstruction of the Company, &c. The Chairman had stated that it was hoped the general expenses would be much less next year. With respect to Mr. Parker, he though that all who were interested in electricity were aware that a prospectus was issued last April or May with Mr. Parker's name on it as consulting engineer; and the Company with which Mr. Parker was connected was now building electrical works at Wolverhampton. He did not exactly know the object of Mr. Hancock's depreciatory remarks, and he did not think it advantageous to *bonâ-fide* shareholders to refer to the old Company. The new Company had nothing to fear. Except as regarded this Company the present Directors were never connected with Mr. Balfour. With reference to the contingent liability on certain shares held by them, it would be misleading to mention it; and practically they did not estimate the liability as of very much importance. The Directors had carefully considered the question of depreciation, and they thought that if they maintained the works in their present condition, and wrote off £3,000 annually for depreciation, this provision would not be so very bad. If they carried this out they would have £30,000 in the course of ten years. This would be a neat sum to go to depreciation of the works, which would be fully maintained during the same period. As regarded what Mr. Hancock had said concerning Mr. Parker, he could only say that the Directors differed from him entirely. They had had twelve months' experience of Mr. Parker in various aspects, and whatever might be that gentleman's reputation in the engineering world, he thought that their Company had made a very satisfactory change in the management at Bushbury. That was all he felt called upon to say at the present time. As had been said, the profit at Bushbury was not satisfactory, and it could hardly be expected to be satisfactory under the circumstances, when the attention of the Managing Director and of the Directors had been so largely occupied in the reconstruction of the Company and, subsequently, in dealing with the reorganisation of the whole of the staff at Bushbury. There was an interregnum at the works, but the idea that they would be put into a corner there had not been realised. They hoped, under the new auspices, that they would now be able to show better returns; at any rate, with capable men and prudent management, he thought that they ought to show satisfactory results. He did not think that in the past two years very satisfactory results had been shown in the manufacturing world, and their Company was not in an exceptional position in this matter. He added, in reply to a further question, that no proceedings had been taken to restrain Mr. Parker from being connected with the other company referred to. The action which had been taken against Mr. Parker and Messrs. Parker and Co. (Limited) was with respect to a patent, and this matter was in abeyance. Messrs. Parker and Co. stated that the patent in question was its own, and this assertion was disputed by their Company.

The motion was then adopted, and resolutions were afterwards passed re-electing Sir D. Cooper to his seat at the Board and reappointing Messrs. J. Meston and Co. as auditors.

A vote of thanks to the Chairman and Directors terminated the proceedings.

Direct Spanish Telegraph Company (Limited).

The following report of the Directors of this Company for the half-year ended June 30th last is issued, and will be presented at the half-yearly general meeting of shareholders, to be held on Friday, the 21st inst., at the offices of the Company, Winchester House, E.C., at 12 o'clock:—

The accounts for the half-year show, after providing for debenture interest, a balance to the credit of profit and loss of £4,075. 15s. 10d. The traffic receipts show a decrease of £868. 12s. 9d. as compared with the corresponding period of 1893, this decrease being due to the continued stagnation of business in England, Spain, and France. The working expenses are £43. 4s. 1d less than those for the corresponding period of last year.

The Company's cables, and the land-lines in connection with them, have continued in good working order throughout the half-year. The construction of a new breakwater at Bilbao placed the Company under the necessity of moving the shore end of the Falmouth-Bilbao cable to a point outside the new breakwater further down the bay. The removal was effected without any appreciable interruption of communication, and the cost is chargeable to the Harbour authorities of Bilbao.

The £62,000 Six per Cent. Debentures, which matured on May 1, 1894, have been paid off, and £30,000 new debentures have been issued, bearing interest at the rate of 4½ per cent. The difference of £32,000 was provided for by making the final call of £1 per share on the 12,931 Ordinary shares, and by taking £19,069 from the reserve fund.

After adding the usual sum of £2,500 to the reserve fund, the balance of profit and loss amounts to £1,575. 15s. 10d. To this the Directors propose to add £951. 15s. 10d. from interest and profit on investments, and recommend the payment of the dividend at the rate of 10 per cent. per annum on the Preference shares, and a dividend, free of income-tax, of 1s. 8d. per share, being at the rate of 4 per cent. per annum on the capital paid up from the due date of payment, on the Ordinary shares of £5 each. The reserve fund will then amount to £21,270. 19s. 11d.

As the attendance of shareholders at the autumn general meetings is very small, and as the Articles of Association require only an annual meeting to be held, the Directors propose that in future only one general meeting shall be held—viz., in the month of March, but intend to pay an interim dividend in October, if earned.

NEW COMPANIES, STATUTORY RETURNS, &c.

COVENTRY ELECTRICAL ENGINEERING COMPANY (LIMITED).—This Company was registered on September 11th, with a capital of £5,000, in £1 shares, to acquire and take over as a going concern the business of electrical engineers and machinists now carried on at Ryley-street, Coventry, and to carry into effect an agreement, dated September 7th, between William H. Eaves, Frederick T. Jackson, William J. Butlin, and Eliza Eaves, and Ernest F. Peirson (as trustee for the Company), and to carry on the business of an electric light company, electricians, hydraulic, gas, electrical, pneumatic, mechanical, and general engineers, suppliers of electricity, manufacturers of electrical apparatus, wire drawers, metal tube manufacturers, iron and brass founders, metallurgists, machinists, &c. The subscribers, with one share each, are William H. Eaves, Frederick T. Jackson, William J. Butlin, Mrs. Eliza Eaves, Thomas H. Matterson, George F. Cowan, and Ernest F. Peirson. The first Directors are Thomas H. Matterson, Frederick T. Jackson, and William H. Eaves.

HAMPSTEAD GENERAL ELECTRIC FITTINGS COMPANY (LIMITED).—This Company was registered on September 6th, with a capital of £1,000, in £1 shares, to carry on the businesses of civil, mechanical, electrical and general engineers, &c., and suppliers of gas, water, electrical and other appliances. The subscribers, with one share each, are:—P. C. Gilchrist, Mrs. P. C. Gilchrist, W. W. Roff, William H. Roff, Oscar H. Stovell, R. H. Hoare, and G. Thomson. The first Directors are: Percy C. Gilchrist and Walter W. Roff. Mr. Percy C. Gilchrist may remain in office until death or resignation.

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WILLIAM LANCASTER AND CO. (LIMITED.)—This Company was registered on September 3rd, with a capital of £25,000 in £10 shares, to acquire the business of a cotton mill and weaving shed machinery manufacturer at Moscow Mills, Oswaldtwistle, Lancaster, and to carry on the business of machinists, mechanical engineers, metal workers, tool makers, metallurgists, manufacturing chemists, electrical engineers, and suppliers of electric light, heat and motive power.

LIQUOR REGISTER SYNDICATE (LIMITED).—This Company was registered on September 7th, with a capital of £18,000, in £1 shares, to acquire, develop, and generally deal with inventions, letters patent, patent rights, &c., and to carry on the business of electricians, electrical and mechanical engineers, suppliers of electricity, and manufacturers of and dealers in mechanical and electrical appliances for registering the receipts of moneys and sales of goods. Among the signatories to the Memorandum of Association (each with one share) are :—C. W. S. Crawley, electrical engineer ; and C. F. Wilkins, electrician. The first Directors are :—Norman Tronson, Hugh E. Saunders, Charles W. S. Crawley, and one duly qualified person to be appointed by Messrs. Nalder Brothers and Co.

C. PASS AND SON (LIMITED).—This Company was registered on Aug. 31st with a capital of £100,000, divided into 5,000 Ordinary and 6,000 £6 per Cent. Cumulative Preference shares of £10 each, to carry on the business of smelters and refiners of metals, ores, &c., at Bedminster, Bristol.

SCIENTIFIC AND GENERAL ENTERPRISE SYNDICATE (LIMITED).—A Company has been registered under this title with a capital of £5,750, in 5,000 Preference shares of £1 each, and 15,000 Deferred shares of 1s. each. The object of the Company is to acquire and develop certain patents, which are not described.

SUBVENTIONED RAILWAYS CORPORATION (LIMITED).—This Company was registered on August 29th with a capital of £400,000 in £5 shares, to construct, equip, maintain and work public works of all kinds, including electric light, telephonic, telegraphic, and electric and general supply works.

FIELD'S M.P. DEVELOPMENT ASSOCIATION (LIMITED).—The annual return of this Company, made up to November 14, 1893, has been filed. The whole nominal capital of £100,000, in £1 shares, has been taken up, and 85,000 have been issued as fully paid. Upon the remaining 15,000 shares the full amount has been called, resulting in the payment of £14,530.

GLOBE TELEGRAPH AND TRUST COMPANY (LIMITED).—The annual return of this Company, made up to August 10th, has been filed. Out of a nominal capital of £5,000,000, divided into 250,000 Preference and a like number of Ordinary shares of £10 each, 180,042 Preference and 180,227 Ordinary shares have been subscribed for and allotted, the full amount called, and £3,602,690 paid.

HAMPSTEAD ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The undertaking of this Company has been abandoned, as they have failed to obtain the necessary Parliamentary powers.

MOSLEY AND COMPANY (LIMITED).—Owners of patents for depositing zinc by electricity upon steel, iron or any other metals. The statutory return of this Company, made up to June 30th, has just been filed. Out of a nominal capital of £11,000 in £1 shares, 6,657 has been taken up, and the full amount called, resulting in the total payment of £6,657.

NEW ELECTRICITY SUPPLY COMPANY OF CROYDON (LIMITED).—The statutory return of this Company, made up to January 24, 1893, was filed on June 26, 1894. The Company has a nominal capital of £40,000 divided into 100 Founders' and 7,900 Ordinary shares, all of £5 each, and of these 29 Founders' shares have been taken up and allotted.

ORIENTAL TELEPHONE AND ELECTRIC COMPANY (LIMITED).—The annual return of this Company, made up to July 18th, has been filed ; 171,497 shares of £1 each have been issued as fully paid to the shareholders in the old Company, and the signatories have subscribed and paid for one share each. The capital is £200,000, in £1 shares.

OTIS ELEVATOR COMPANY (LIMITED).—The annual return of this Company, made up to August 6th, has been filed ; 2,000 shares have been taken up out of a capital of £50,000, in £10 shares, and of these 650 have been issued as fully paid. The full amount has been called and paid on the remaining 1,350 shares. The principal shareholders are :—The Brush Electrical Engineering Company (Limited), with 699 shares, and Messrs. Otis Brothers and Co., of New York, with 420 shares.

PLANET ELECTRICAL ENGINEERING COMPANY (LIMITED).—The annual return of this Company, made up to August 18th, has been filed. The nominal capital is £30,000, divided into 4,000 Ordinary shares of £5 each, and 2,000 £6 per Cent. Preference shares of like value, of which 3,482 Ordinary and 160 Preference shares have been taken up. Of these 800 Ordinary shares were issued as fully paid, and the full amount has been called on the remainder. The sum received in respect thereof is £14,210.

SALISBURY ELECTRIC LIGHT AND POWER SUPPLY COMPANY (LIMITED).—The statutory return of this Company, made up to July 13th, has been filed. The capital is £20,000, in £1 shares, and 257 of these have been taken up. In response to a call of £1 per share, the full amount has been received. The principal shareholder is John M. Benett-Stamford, J.P., of Tisbury, Wilts, with 250 shares.

SINGLE WIRE MULTIPLE TELEPHONE SIGNAL COMPANY (LIMITED).—The annual return of this Company, made up to June 21, 1894, has been filed. Out of a nominal capital of £5,000 in £10 shares, 254 shares have been taken up, and the full amount called, resulting in the total payment of £2,540.

SPANISH NATIONAL SUBMARINE TELEGRAPH COMPANY (LIMITED).—The annual return of this Company, made up to August 24th, has been filed. Out of a nominal capital of £500,000, divided into 49,900 Ordinary shares of £10 each, and 1,000 Founders' shares of £1 each, 23,719 of the former class have been taken up and allotted. Of these 23,715 have been issued as fully paid, and the full amount has been called and paid on the remaining four shares.

ST. NICHOLAS CONSTRUCTION COMPANY (LIMITED).—The statutory return of this Company, made up to September 1, 1893, was not filed until June 29th last. Only the 7 signatories' shares out of a nominal capital of £40,0000, in £20 shares, have been taken up, and although the full amount has been called, nothing has as yet been paid.

CITY NOTES.

BOLCKOW, VAUGHAN AND CO.—The Directors of this Company announce that the results of the half-year's working to June 30th last are fairly satisfactory, but that it has been decided not to recommend an interim dividend, but to wait until the results of the full year's working are known. A similar course was adopted last year.

CITY AND SOUTH LONDON RAILWAY.—The traffic returns of this Company for the week ended September 9th were £840, as against £754 in the corresponding period of 1893, being an increase of £86. The total receipts for the half-year amount to £8,576, as against £8,148 for the corresponding period of 1893, an increase of £428.

CITY OF WESTMINSTER ELECTRICAL SYNDICATE (LIMITED).—A general meeting is to be held on the 17th prox., at 10 a.m., to receive the Liquidator's report and an account of the winding up of the Syndicate. The meeting will be held at 39, Eccleston-place, London, S.W.

COMPAGNIE FRANCAISE DU TELEGRAPHE DE PARIS A NEW YORK.—In reference to the proposed winding-up of this Company, a meeting is to be held on the 29th at the Paris offices. In order that the resolutions proposed at the meeting may be validly passed it is necessary that the total shares represented by voters be over £42,000.

DALZIEL'S CABLE NEWS AGENCY (LIMITED).—An extraordinary general meeting of the members of this Company was held on the 29th ult., at which a resolution was passed that the Company be wound up voluntarily, and that Mr. J. M. Henderson, of 2, Moorgate-street Buildings, London, E.C., be appointed liquidator.

LONDON, WALTHAMSTOW, AND EPPING FOREST RAILWAY.—Some details are given of the scheme of this railway, the construction of which was authorised during the last session of Parliament. The promoters have powers to use either steam or electricity. The railway commences at South-place, Finsbury, E.C., and proceeds underground through St. Luke's, Hoxton, Shoreditch, Kingsland, Hackney, and Upper Clapton, some of the most densely populated districts in London. From Upper Clapton the railway continues through Walthamstow, Chapel End, and Chingford, skirts Epping Forest, and terminates at High Beech. The railway will thus afford accommodation in a district now only partially catered for. Connections are to be effected with the Great Eastern, Midland, and London, Tilbury and Southend Railways, and to the Midland Railway in particular the new line should be of especial service, as it will enable a service of trains to be run from Moorgate-street viâ the Tottenham and Hampstead line to South-place, Finsbury, the terminus of the new railway. The capital of the Company is £2,100,000, and the total length of the line 14 miles. It is supported by the three companies with which it communicates, and has so far met with the approval of the County Council. The railway is to be constructed on the Greathead shield principle.

NORTH BORNEO TELEGRAPHS.—The British North Borneo Company has received a telegram in connection with the laying of the telegraph line across the country, to the effect that about 90 miles of the total track has been cut, and that gangs of men are now engaged in exploring the mountain route and cutting posts.

PORTRUSH ELECTRIC RAILWAY.—Viscount Templetown, M.I.E.E., has been elected a Director of this Railway in succession to Lord Kelvin.

SOCIETE FRANCAISE DES TELEGRAPHES SOUS-MARINS.—The report of the Directors of this Company states that the traffic receipts for 1893 amounted to £29,900, against a little over £30,000 for 1892. An increase of £630 over 1892 has been received in subventions and guarantees, due to an increased payment by Curaçao. A further sum of £2,000 will be received next year as a subvention from Guadaloupe. The Directors think that, considering the circumstances under which the business of the Company has been carried on during 1893, the receipts are satisfactory. Negotiations were some time ago entered into for a cable to connect the West Indies with New York direct, or viâ Bermuda, but these negotiations fell through, and the Société devoted its attention to the scheme for cable communication with the Azores, which, however, was not successful, the concession being granted to an English company. The Société are energetically working on their original scheme for a cable to New York, and the Directors look with hope to a satisfactory result being attained in the near future. A satisfactory increase is reported of work from the Company's station in Hayti. The general meeting of the shareholders will be held on the 27th inst.

STEEL COMPANY OF SCOTLAND.—The shareholders of this Company at their annual meeting in Glasgow on Tuesday agreed to raise £250,000 to meet debentures falling due. The new issue is to be £150,000 Five per Cent. first-charge stock and £100,000 Six per Cent. second-charge stock. The Chairman, in the course of his remarks, said that the present prices of steel were unremunerative.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended September 7th (after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited), were £2,887.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share	Last Dividend.	Name.	Previous Week's Price, Sept. 5.		Price Wednesday, Sept. 12.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Sept. 12.	
			TELEGRAPHS.					£ s. d.		Highest	Lowest
£1,012,880	Stock	10 0	Anglo-American	41	44	40	43	5 4 3	Jan., Apr., July, Oct.	..	..
£2,933,560	Stock	20 0	Do. Preferred	76	78	76	78	5 15 5	" "	78½	77
£2,933,560	Stock	5/0	Do. Deferred	7½	8	7	7½	..	.. ..	7¾	7⁹⁄₁₆
£184,500	100	4%	*African Direct Teleg. 4% Deb. (Reg. & Bearer)	102	105	102	105	3 16 9	January and July	..	..
130,000	£10	3/0	Brazilian Submarine	12½	13	12½	13	5 0 0	Mar., June, Oct., Dec.	13	12¾
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1906)	109	113	109	113	4 9 3	June and December	..	–
10,000,000	$100	$1¾	Commercial Cable Capital Stock	139	143	140	145	4 17 9	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	12	13	12	13	6 3 1	February and August	..	–
6,000	10	10%	Do. Preference 10 per Cent.	19	20	19	20	5 0 0	" "	..	..
12,931	5	1/7½	Direct Spanish (£4 paid)	4½	5	4½	5	3 4 0	April and October	..	..
6,000	5	10%	Do. Preference 10 per Cent.	9½	10	9½	10	5 0 0	" "	..	–
£30,000	Stock	4½%	* Do. 4½% Debentures of £50 each	105%	108%	105%	108%	..	.. ..	..	..
60,710	20	2/0	Direct United States Cable, 1877	8½	9½	9	9½	5 5 3	Jan., Apr., July, Oct.	9½	9½
400,000	10	5/6	Eastern	15¾	16	15¾	16	4 1 3	" "	16	15¾
70,000	10	6%	Do. 6 per Cent. Preference	16½	17	16½	17	3 10 7	" "	16⅞	..
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	117	120	117	120	3 6 8	May and November	118½	..
£102,100	100	5%	* Do. 5 per Cent. Debentures, 1899	106	110	106	110	4 11 6	February & August	..	..
250,000	10	2/6	Eastern Extension	15¾	16	15¾	16	4 7 6	Jan., Apr., July, Oct.	15¾	15¾
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	115	118	115	118	3 7 10	February & August	..	..
£62,700	100	5%	* Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103	106	103	106	4 15 0	January and July ..	..	..
£95,100	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb., 1900	103	106	103	106	4 15 0	" "	..	..
£300,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.)	103	106	103	106	3 15 8	February & August	104½	..
£200,000	£25	4%	* Do. 4% Mauritius Sub. Debs.	108%	111%	108%	111%	3 12 11	May and November	..	..
180,227	10	8 9	Globe Telegraph and Trust	8¾	9½	8¾	9½	4 18 11	Jan., Apr., July, Oct.	9½	9
180,042	10	6%	Do. 6 per Cent. Preference	15½	16	15¾	16½	3 13 10	" "	16½	15¾
150,000	10	5 0	Great Northern	20½	21½	20½	21½	3 10 1	Jan., April, and July	21½	20¾
£190,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	103	106	103	106	4 14 4	March & September		..
17,000	25	37/6	Indo-European	46	48	46	48	5 4 2	May and November	46	..
37,548	10	5/0	London Platino-Brazilian	5	7	5	7	..	" "	.	..
£100,000	100	6%	* Do. 6 per Cent. Debentures	106	109	106	109	5 10 1	March & September	..	..
£100,000	£100	4%	*Pacific European Tel. 4% Guar. Debs. "Red" 1942	104	107	104	107	3 16 9	..	106	..
11,839	8	4/0	Reuter's	3	5	3	5	..	April and October	..	..
3,381	£100 Cert.	25/0	*Submarine Cables Trust 6 per Cent.	107	112	107	112	5 8 1	" "	109	108
15,600	10	5/0	West African Telegraph	3	5	3	5	..	January and July	..	
£249,900	100	5%	* Do. 5 per Cent. Debentures	100	103	100	103	4 17 1	March & September	102	100
30,000	10	2/0	West Coast of America	2	3	2	3	..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	100	105	100	105	7 11 3	June and December	103½	..
88,321	10	9d.	West India and Panama	1¼	1½	1¼	1½	.		1⅜	1⁵⁄₁₆
34,563	10	6%	Do. 6 per Cent. 1st Preference	10½	11	10½	11	5 9 1	May and November	10¾	10½
4,669	10	6%	Do. 6 per Cent. 2nd Preference	9	10	9	10	6 0 0	" "	9⅜	..
£80,000	100	5%	* Do. 5 per Cent. Debentures, 1917	107	110	108	111	4 10 9	June and December	..	..
64,242	15	7/6	Western and Brazilian	7½	7¾	7½	8½	..	May and November	8	7¾
33,129	7½	7/6	Do. 5 per Cent. Cumulative Preferred	6	6½	6	6½	..	..	6½	6⁵⁄₁₆
33,129	7½	4/6	Do. 5 per Cent. Deferred	2	2½	2¼	2¾	.	..	2½	2½
£171,900	100	6%	* Do. 6 per Cent. Debs., Series "A" 1910	106	109	106	109	5 10 7	February & August	..	..
£214,800	100	6%	* Do. 6% Mort. Debs., Series "B" 1910	106	109	106	109	5 10 7	" "	..	..
$1,211,000	$1,000	7%	*Western Union 7% 1st Mort. (Building) Bonds	115	120	115	120	5 17 11	May and November	–	..
£166,900	£100	6%	* Do. 6 per Cent. Sterling Bonds	100	103	100	103	5 16 6	March & September	..	..
			TELEPHONES.								
44,000	5	10/0	Chili Telephone (fully paid)	1	2	1	2	..	..	..	..
224,850	10/0	2⅘d.	Consolidated Telephone Const. & Maintenance	¼	½	¼	½	..	May and November	..	..
171,504	£1	6d.	Oriental Telephone and Electric (fully paid)	½	⅝	½	⅝	..	Yearly	.	..
484,597	5	3/4	National	4⅞	5⅛	4⅞	5⅛	4 17 7	June and December	5¹⁄₁₆	4¹³⁄₁₆
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	14	15	14½	15½	3 17 5	" "	15	14½
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	13½	14½	14	15	4 0 0	" "	14⅜	..
119,234	5	3/4	Do. 5% Non-Cumulative 3rd Pref.	5½	5¾	5½	5¾	4 6 11	.	5⁹⁄₁₆	..
1,000,000	Stock	4½%	* Do. Debenture Stock, 4½%	108	111	109	112	4 0 11	January and July	111	..
58,000	5	1/0	United River Plate	1½	2½	1½	2½		" "	2⅜	..
£146,733	Stock	5%	Do. 5 per Cent. Debenture Stock	88	91	88	91	5 6 5	" "	90	–
			ELECTRICITY SUPPLY COMPANIES.								
40,000	£10	..	City of London Electric Lighting (fully paid)	12½	13½	12½	13½	..	..	13½	13½
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	14½	14¾	14½	14¾	4 1 4	..	14⅝	14⁹⁄₁₆
19,900	£5	..	Electricity Supply Co. for Spain	..		..			–	..	..
£30,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	4½	5½	4½	5½	3 12 7	–	4¹³⁄₁₆	4¾
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	..		..		..	–	..	..
8,322	£5	..	House-to-House Electric	..		..		–	–	..	–
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	..		..		–	..	..	–
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..		..		–	January and July	..	–
45,000	£5	2/6	Liverpool Electric Supply (fully paid)	6¾	7	6¾	7	–	..	..	–
111,000	5	..	London Electric Supply	½	¾	½	¾	.	..	..	..
49,900	£10	5/0	Metropolitan Electric Supply (fully paid)	8½	9	9½	9¾	2 11 3	..	9¾	9
£150,000	Stock	4½%	* Do. 4½% Debs. (Bonds of £10, £20, and £40)	6	7 pm	7	8 pm	..	June and December	..	..
6,452	£10	..	Notting Hill Electric	4½	5½	4½	5½	–	..	..	..
19,930	£5	2/0	St. James and Pall Mall	7	7½	6¾	7½	.	..	..	..
20,000	£5	7%	Do. 7 per Cent. Preference	8½	8¾	8½	9	3 17 9	–	8¾	8⅝
59,900	5	2/0	Westminster Electric Supply (fully paid)	6½	6¾	6½	6¾	3 6 8	–	6⁹⁄₁₆	6⁷⁄₁₆
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
90,000	3	1/6	Brush Electrical Engineering	2⅞	3⅛	2⅞	3⅛	5 16 6	..	3¹⁄₁₆	2⅞
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	2⅜	2⅝	2⅜	2⅝	4 11 5	..	2½	2⁹⁄₁₆
£125,000	Stock	4½%	* Do. 4½ per Cent. Debentures	109	112	109	112	4 0 4	March & September	110½	..
20,000	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref.	1¾	2¼	1¾	2¼	–	January and July	..	..
12,139	5	..	Edison and Swan United	–		–		..	..	–	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	..		..		..	..	–	..
120,000	2	..	Electric Construction	½	¾	½	¾	..	–	..	..
12,845	2	..	Do. 7 per Cent. Cumulative Pref.	1½	2	1¾	2½	–	–	..	1⁷⁄₁₆
91,195	2	10/0	Elmore's Patent Copper Depositing	1½	1¾	1½	1¾	..	–	1¾	
20,000	5	..	Fowler-Waring Cables (fully paid)	½	1½	½	1½	..	–		
50,000	10	10/0	India Rubber, Gutta Percha, &c., Works	23½	24½	23½	24½	5 2 6	February & August	24	23¾
£200,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	104	106	104	106	4 6 2	March & September	–	–
15,995	£10	6/4	International Okonite Ordinary	..		..		..		..	..
16,000	£10	–	Do. 8 per Cent. Preference	–		–		–	December and June	–	–
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid)	–	½	–	½	..	..	–	..
78,949	5	3/6	Swan United (£3 10s. paid)	..		..		..	May and November	..	..
37,350	12	12/0	Telegraph Construction and Maintenance	40	42	40	42	5 14 3	March and July	42	41
£150,000	100	5%	Do. 5 per Cent. Bonds	102	105	102	105	4 13 6	January and July	..	..
37,514	£5	–	Woodhouse and Rawson Ordinary (£3 15s. paid)	–		–		..	..	–	..
41,098	£5	–	Do. Preference (fully paid)	–		..		..	..	–	..
£63,870	10	10/0	W. T. Henley's Telegraph Works Ordinary	7½	8½	7½	8½	5 17 8	..	..	..
£30,000	10	..	Do. Preference	..		..		..	..	..	..
			RAILWAYS AND TRAMWAYS.								
£630,000	Stock	1%	City and South London Railway	36	38	36	38	1 16 2	May and November	37½	..
7,000	10	5%	Do. 5% Perpetual Preference	12½	13½	12½	13½	3 14 1	May and November	13½	..
£67,130	Stock	4%	Do. 4% Perpetual Debenture	121	123	121	123	3 5 1	..	..	..
37,500	£10	1%	Liverpool Overhead Railway	7½	7¾	7⅞	8½	1 4 7	..	..	..
6,295	10	5%	Do. 5% Preference	12¼	13	12¼	13	3 16 11	..	..	..
£125,000	Stock	4%	Do. 4% Debenture	111	113	111	113	3 10 10	January and July	–	–

* In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption.

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NOTES.

It will be news to electrical engineers to learn that they are working under better legislative conditions than those who are in charge of gas undertakings. It will also be news to those who have endeavoured to secure the ear of this or that provincial town council to learn that electrical engineers "have not been hampered with the cry of monopoly." The minimum charge clause, which figures in every Electric Lighting Order, but which for business reasons is never enforced, is, according to an article in the *Journal of Gas Lighting* by Mr. Norton H. Humphreys, another gas grievance, though one would think that the hardship of having always to be in readiness to supply was reduced to something approaching zero when cheap and efficient means of storage are available. Nevertheless, if gas engineers want similar powers, we feel sure electrical engineers will be pleased to assist them in this respect, and delighted to see them put their powers into operation. Nothing could be more calculated to hasten the advent of the electrical millenium than harrying gas consumers by charging for gas not actually used.

But, to quote Mr. Humphreys' own words, "we have, however, not yet exhausted the advantages afforded to electricity as compared with gas." Electric light companies, he points out, may test indoor wiring and refuse to supply current to customers who disturb their neighbours' light by the use of improper appliances. We were under the impression that users of gas engines were *obliged* to fit their supply pipes with "anti-fluctuators," and would point out that a leak in a house wire in Belgravia may very possibly give rise to complications in Westminster, a contingency for which there is no gas analogue.

Lastly, it would appear that "electricians have a unit of price that is really a unit," and Mr. Humphreys proposes that gas should in future be sold by "hundreds" as "it carries a better impression to have a low-priced unit than one that runs into shillings and pence." How short-sighted were those prospective suppliers of electric energy who some years ago urged the Board of Trade to enlarge the supply unit tenfold, so that they might be able to reduce their charges by something more appreciable than a halfpenny at a time, and yet by steps of something less than 6 per cent. But perhaps the gas people are contemplating a series of inappreciable jumps *upwards*. It only remains for gas engineers to complain that they started business without a rival, before the era of municipalisation had dawned, and without a municipal purchase clause. Truly, electrical engineers have not properly realised the advantages of their position.

The discussion on the Liverpool Overhead Railway, which is concluded in our columns this week, and which is followed by some Correspondence, would have been of even greater interest if a few more railway men had taken part in it. Mr. A. McDonnell drew attention to the ambiguous use of "train-mile" in attempting to base comparisons between different systems, and Mr. A. F. Aspinall in the Correspondence called attention to "engine-mileage." A unit of passenger-mileage is but little better, for differences of frequency of service and of speed cannot be neglected. The only possible mode of comparison is to estimate from general experience how much it would cost to run a given electric line by steam or otherwise. In a long discussion, such as that on the Liverpool Overhead Railway, the speakers are answered by each other rather than by the authors. The cost of carbon brushes, amounting to no less than £6 per week at first, and even £2. 10s. per week in March last, is rather remarkable; but equally satisfactory was Mr. Siemens's statement that one of his locomotives on the City and South London Railway had run 50,000 or 60,000 miles with the set of brushes delivered with it.

Our readers will remember that in *The Electrician*, Vol. XXXI., p. 311, we described a 30-ton gearless electric locomotive, which was manufactured by the General Electric Company, of America. In the same issue we commented on the performance of this engine. We now learn that the manufacturing company referred to has recently brought out a larger and modified form of this locomotive. The latest pattern weighs forty tons, and is stated to give a draw-bar pull of 14,000lb., or about one-sixth of the weight. This is a much more reasonable allowance than was made in the former case. Instead of one motor truck there are now two, each having the four wheels fully utilised for adhesion. We welcome the news that this 40-ton engine "is now standing in the factory yard," and hope that it will soon leave the yard for the rough-and-tumble duties of a permanent way. Electric traction in America possesses not a little interest for the British electrical engineer, and it is instructive to observe the pleasure with which the American electrical engineer hails the advent of a 30-ton locomotive in 1893 and a 40-ton locomotive in 1894. We have not many

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electric locomotives in this country, perhaps; but, such as they are, they largely make up in efficiency, and in the amount of tractive force per ton of driving machinery, what they lose in numerical strength. On the Liverpool Overhead Railway a tractive force of 750lb. per ton is obtained, as against 373lb. per ton of the locomotive recently manufactured in America, and 234lb. per ton of the steam engines of the District Railway. The principal reason for the high figure attained by the Liverpool locomotive lies in the careful disposition of the load on the wheels, giving a tractive force which is simply impossible with separated locomotives and coaches.

The economy of connecting lamps in series may be studied by those who are interested in the question, with reference to the curves which we reproduce from Dr. Fleming's forthcoming book on "Electric Lamps and Electric Lighting." At the time when Dr. Fleming arrived at the results embodied in these curves, it is probable that modern lamps of 2½ to 3 watts per candle were not regularly on the market. In the first curve 16 c.p. appears to correspond to about 0·625 ampere, or, at 100 volts, 3·9 watts per candle, and 22·5 c.p. to 0·67 ampere, or 3 watts per candle. The former condition corresponds to the old lamps, and the latter to modern ones. In problems of this kind the absolute candle-power does not matter at all. Mr. T. B. Sharp informs us that he reduces his current from 3½ amperes to 1½ ampere, and gets "a pleasant mellow light." There is a great difficulty in making photometric measurements of "pleasant mellow light" from a red hot poker or any such subdued source of light. Unfortunately, neither Dr. Fleming's curves, nor those supplied by Prof. Ayrton, and published in *The Electrician*, Vol. XXIX., p. 281, nor anything in Mr. Ram's book, give a clue to what Mr. Sharp really gets, for it is beyond the limits of their experiments, and seems to correspond to less than half a candle-power. Whatever it is, it seems to be very agreeable to Mr. Sharp, and, according to his ammeter, saves four-sevenths of his current.

It appears, from a letter which we print this week, that in some cases the use of a solid carbon for the top, and a cored carbon for the bottom in an alternate-current arc, will get rid of the band of violet light to which we alluded a fortnight ago; but we believe that this is not complete cure. The vagaries of the alternate-current arc, especially when small—say, less than 11 amperes—are at present inexplicable, or, at all events, unexplained.

The alternate-current meter invented by Mr. Thomas Duncan, of the Fort Wayne Electric Company, while it appears from the maker's tests to be an accurate instrument, marks no great advance. The principle of the instrument, which is briefly described in another column, may be said to combine those of the Shallenberger and Ferranti-Wright meters. It is an ampere-hour instrument, and, if we may be allowed the expression, it measures all the amperes that pass through, whether wattless or business amperes. For lighting purposes, even with arc lamps, such a meter may suffice; but with motors on the circuit it must register in favour of the supply company. We are still waiting for an alternate-current meter that can be made in quantities and stocked by manufacturers or agents like continuous-current meters, ready to be put into circuit on any alternate-current service, whether supplying glow lamps or motors, whether with flat-topped magnetism waves for increased transformer efficiency, or flat-topped current waves for arc lamps, or sine waves for American use.

Some radical improvement of alternate-current motors, whereby they may be run on a circuit with 100 periods per second as well as at a lower frequency, seems to be the only hope for uniformity. At present neither voltmeters, ammeters, house-meters, arc lamps nor motors for alternate currents can be safely stocked and catalogued by dealers. Motors, it is true, can be bought at the purchaser's discretion; but the speed and output are not under his control as with a continuous current motor. Measuring instruments in nearly all cases have to be adjusted, if not specially calibrated, for the particular frequency. If a standard of 100 could be kept, the difficulty would disappear; but low frequencies are sometimes used, as a concession to motor makers. Is it worth while for makers of arc-lamps to carry out elaborate experiments with the view of designing a mechanism which is suited for a current of any frequency between 40 and 100, and for flat-topped or for sine waves? Probably not.

A correspondent informs us that we will possibly confer a boon to mankind by kindly informing him if there is any substance in nature that will (though it may be colourless) turn black or other colour when in contact with electricity. We should be glad to send him a bit of pole-finding paper if we knew his address, but we do not know how he is going to bring it "in contact with electricity." We know nothing about "electricity"; the word is very rarely used except by accident in the editorial columns of *The Electrician.*

Cable Interruption:	Date of Interruption.
Zanzibar-Mombasa	September 4th.
Benguela-Mossamedes	September 16th.

International Telephony.—Madrid and Paris will be shortly telephonically united. On the Spanish side, the wires have been stretched as far as Saragossa; in France, the line has already been carried from Paris to Tarbes.

Edison Feeder and Thomson-Houston Dynamo Patents.—The Edison "feeder," patent No. 3,880, of 1880, expires by due process of law on Monday next, and the Thomson-Houston arc light dynamo, patent No. 3,928, comes to a similar end to-day week.

Budapest.—A proposal to construct an electric tramway between Budapest and Budafok is under consideration. The contract for the ironwork required for the Budapest underground electric railway—about 2,000 tons—has been given to the Rima Murany Salgo Tarjan Ironworks Company.

Manchester Municipal Technical School.—The syllabus for the session 1894-95, issued by the Manchester City Council, contains a full description of the classes to be held. A large amount of useful information is given, and the book is made additionally interesting by a number of illustrations showing the interior views of the laboratories.

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Popular Lectures.—The programme of popular evening lectures, at the Merchant Venturers' Technical College, Bristol, includes a lecture by Prof. H. S. Hele Shaw, on "Graphic Methods in Science," and another, by Prof. Wertheimer, on "Electricity *versus* Gas." These lectures will be delivered on Wednesday evenings during the winter session.

"L'Eclairage Electrique."—Within a month of the disappearance of *La Lumière Electrique*, M. P. H. Ledeboer, a well-known contributor to the French technical press, has stepped into the breach with a similar publication called *L'Eclairage Electrique*. We hope M. Ledeboer's plucky venture will meet with the success it deserves. The offices of our new contemporary are at 24, Rue Chauchat, Paris.

Heriot-Watt College.—We have received the calendar of the Heriot-Watt College, Edinburgh, for the forthcoming session. The courses of lectures and practical instruction in electrical engineering and electro-technical subjects, which are under the direction of Dr. R. M. Walmsley, are well arranged, and they have been designed to meet the needs of day and evening students. The new session commences on October 1st for the evening work, and on October 9th for the day work.

Destruction of Lighting Plant at Little Rock, Arkansas.—The city electric lighting plant at Little Rock, Ark., was recently disabled by some unknown miscreant putting sulphuric acid on the commutator and armature coils of the dynamos. The plant had been in operation since May 7th, and was furnishing current to lamps for street lighting. A former employé of the city was suspected of the crime and was arrested. Superintendent Fish, the electrician in charge of the station, was suspended by the mayor when the matter was brought to his attention.

Telegraphs and Telephones in Western Australia.—There has been a considerable increase in the receipts from the telegraphic and telephonic systems in Western Australia during the past financial year, no doubt due to the great development in mining operations which is taking place in that colony. The following table shows the receipts from the two sources during the past two years:—

	1893-94.	1892-93.
Telegraphs	£19,204	£15,509
Telephones	2,004	1,602

The World's Telegraph Offices.—The International Telegraph Bureau, at Berne, has just issued the official list of telegraph offices throughout the world. This work has now reached its ninth edition, the object of its publication being to assist in calculating the charges to be collected on international telegrams. The list contains the names of all offices notified to the Berne Bureau as open for international telegraph correspondence. Accompanying the list is some useful information concerning the collection of telegraphic charges in various parts of the world.

Fatality at Leicester.—A youth named Hugh Smith met with an extraordinary death early on Monday morning at the Midland Station, Leicester. He was, in company with Joseph Attfield, in charge of the dynamo connected with the electric light. Attfield suddenly heard a cry, and found Smith on the floor with blood flowing from his mouth, ears, and nose. The railing round the engines was bent, but there was no appearance of the youth having come in contact with the live conductors. He died in a few minutes from loss of blood. Under these circumstances, the officials, who subsequently inspected the place, are unable to account for death. The most favoured hypothesis is that the deceased was examining the bearings of the engine, when his sleeve became entangled in the shafting, and that after being hurled on to the brass guard he was thrown to the ground.

Remarkable Views on Electric Currents.—A German electrical contemporary publishes a communication from Dr. Stricker and Herr Deutike, in which it is announced that the authors have discovered some very remarkable properties of the electric current. According to these investigators, in every closed circuit there exist two currents flowing in opposite directions, one a current of positive and the other a current of negative electricity. Among other things they state that Volta's fundamental experiments depend not on the contact, but on the approaching or receding of the heterogeneous metals, the source of the current being the mechanical work exerted by the experimenter; and they claim that the ions do not migrate through the whole electrolyte. Their deductions appear to be based on experiments, but it remains to be shown that the experimental evidence warrants such departures from recognised views on the subject.

Obituary.—We regret to record the death of Mr. Ernest Cunard Cummins, electrician of the Western and Brazilian Telegraph Company's repairing steamer "Norseman." Mr. Cummins was out shooting at Santa Catharina, Brazil, when the gun of a companion accidentally went off, wounding him seriously in the leg, and he died within a few hours from his injuries. He had been in the Western and Brazilian Company's service for many years, and was considered an able electrician. A general favourite, his death will be mourned by many friends, both at home and in Brazil.—The death is also announced of Mr. R. E. Maunsell, clerk-in-charge, the Eastern Telegraph Company's Station at Porthcurnow, Penzance. On Saturday last Mr. Maunsell was mounting a horse outside his house, preparing to go for a ride, when the animal reared and threw him off, and then kicked him heavily in the face. Mr. Maunsell sustained a severe concussion of the brain, and died after only a brief interval of consciousness.

Electric Heating of Cars.—In winter time the heating of the cars running on the Salève Electric Rack Railway (see *The Electrician*, Vol. XXXI., p. 494, September 8, 1893) is effected by current taken from the main circuit. The heaters consist of two resistance frames, placed under the seats at either end of the car. Each seat is 0·82m. long, 0·3m. high, and 0·18m. deep, and contains 42 spirals of 1·5mm. galvanised iron wire, each spiral containing 5·92m. of wire, and being 24mm. in diameter, so that the total length of wire in the two heaters amounts to no less than 500 metres. All the spirals of each heater, and the two heaters themselves, are connected in series. The current absorbed is 15 amperes, which, at a pressure of 500 volts, represents 10 H P. The temperature of the iron wire rapidly reaches 100°C., and even during the severest weather the car is warmed to 15° or 20°C. in 10 minutes or a quarter of an hour.

Science Sifted Out.—A contemporary of the name of *Science Siftings* presents its readers with the following startling piece of information:—"Sir William Preece (*sic*) has told us of the possibility of telegraphing without wires by means of the magnetic currents in earth and water. Is it not conceivable that the Arabs of Africa may be acquainted with these possibilities and have been applying their knowledge of them to the transmission of news? This is one of the most plausible explanations. There is nothing new under the sun, not even concerning electricity; and a theory has even now been put forward that the peculiar cylinders discovered among the ruins of Nineveh, bearing, not characters, but faintly marked lines, may be nothing more nor less than the cylinders of some ancient Assyrian phonograph. Should this supposition prove correct we may yet hope not only to read the writings, but even to hear the voices of those Wise Men of the East whose civilisation antedates ours by many thousand years."

Telegraphy and the Bursting of the Gohna Dam.—Details of the bursting of the Gohna dam on the 26th ult. have been received at Brindisi by mail, and wired thence by Reuter. On August 24th, at 8 o'clock in the morning, an automatic bell placed within a foot of the top of the dam sounded the first note of alarm. The warning was communicated throughout the whole of the threatened territory almost instantaneously by means of telegraphic messages, bonfires, rockets, the beating of drums, and other signals, and the people immediately fled with all their cattle and personal belongings into the hills. In this way ample warning was given and the apprehended loss of life averted. At Hardwar all Government buildings, with the exception of the telegraphic office, were destroyed. Here an incident occurred which exemplifies the excellent behaviour of the telegraph staff throughout the entire district affected. The commissioner of Hardwar ordered the chief of the telegraph office to leave his post when the flood was advancing, but the man wired back to headquarters that he would stop till the last moment and save himself if necessary by running

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up the hill. The whole overflow was discharged in about two hours.

The "Manhattan" Incandescent Arc Lamp.—Our American friends seem never likely to tire of devising novel methods for prolonging the life of the arc lamp. Last year (Vol. XXXI., p. 502) we described the "Marks" lamp, shown before the Chicago Electrical Congress; to-day the American journals contain descriptions of a variant on the "Marks" lamp, called the "Manhattan" lamp. Its most important feature is an outer globe, air tight at all points except at the bottom, where there is a hand-hole, and an inside globe which acts as a rarefied chamber. On the formation of an arc the enclosed air is heated and rarefied, the surplus air escaping through the lower vent. The contained oxygen is soon reduced by combustion with the carbon points to carbon monoxide, and this, with the remaining nitrogen, surrounds the arc, and protects the points from further combustion. By this system the burning of carbons in these enclosed chambers half-inch carbons will, it is said, burn 80 hours without retrimming, and without any blackening or discolouration of the globe. Owing to the high potential at which it is possible to burn the arc in this enclosing chamber, the efficiency of the lamp is greatly increased.

Electric Communication with Rock Lighthouses.—At the conclusion of the inquiry into the recent stranding of the Cape liner "Dunottar Castle," on the Eddystone rock, Mr. Garrett, on behalf of the owners, said they courted the inquiry because it seemed to them to attract attention to the absolute necessity for having telegraphic communication between such places as the Eddystone Lighthouse and the shore. In this case the value of the ship and cargo was over £300,000, and there were 400 lives on board, and the ship was within measurable distance of being totally lost for the want of assistance, which might readily have been obtained from Plymouth if there had been the means of communication. Mr. Baden-Powell, who appeared for the Board of Trade, said that as to the propriety of communication between lighthouses and the shore, the subject had been under consideration for some time, and the idea was much applauded by those who owned ships and knew the dangers of the coast; and it was a question upon which he thought an expression of opinion might be given by the Court. After giving judgment the Court added, with reference to the suggested electric cable between the Eddystone Lighthouse and the shore, that the Court would consider the subject and make some remarks upon it in their report.

The Telephone in the German Army.—An interesting military experiment took place last month between Berlin and Potsdam. A telephone line was laid on the march by two cavalry patrols, each consisting of an Uhlan officer and two Uhlan under officers; one starting from Berlin, the other from Potsdam, very early in the morning. Each patrol was furnished with a complete telephonic apparatus carried by one of the under officers, and a supply of steel wire wound on reels, each containing 1 kilometre of wire. The laying of the line began in Berlin in the following manner: The end of the wire was connected to the town circuits in Berlin, and the spool fixed on a carrier in such a way that the wire could unroll as the man rode along. A second man rode behind, furnished with a sort of fork on the end of his lance, making it about half as long again; in this he caught the wire, and as they went along threw it into the upper branches of the trees lining the chaussée. Choosing roads furnished with trees, they rode along; the officer first, and behind the two men running the wire, about 30 paces apart. When the first bobbin was finished, they halted. The telephone was connected, and a horn blown to signal to the starting point, a similar signal being the reply. Conversation having been held, the new bobbin was joined up and the process continued. At Teltow the two patrols met; the two ends were signalled, and then the wires joined together, and speech was excellent from Berlin to Potsdam. The order was then given to take up the circuit, which was done. The laying of the circuit of 30 kilometres took not more than four hours.

Gas and Electricity in Berlin.—A report on commerce and industry in Berlin during 1893 gives interesting figures relating to gas and electric light, which show that the competition of the latter is beginning to tell. For many years back the yearly increase in gas consumption ranged from 4 to 6 per cent.; in 1892 it fell to about 3¼ per cent., while in 1893 the production actually fell nearly 1 per cent. The fall is exclusively due to private lighting, which took 1¾ million cubic metres less than in 1892, while the public lighting took 600,000 cubic metres more, and the supply for heating, &c., to private consumers also rose about 800,000; the total consumption falling by 300,000 cubic metres. The fall in production to a very great extent is due to better results as to losses in mains, &c. This fall is ascribed to four causes: bad trade, competition of the electric light, the increased use of the Auer incandescent burner, which is much more economical than the old types; and, finally, the Sunday rest, legally enforced since July 1, 1892. The population has risen in the year by 33,500 persons, about 2 per cent., and the consumption per head has fallen from 81·0 to 78 9 cubic metres. The output of gas motors connected has risen from 4,340 to 4,758 H.P., the output of the engines varying from 60 H.P. downwards. On the other hand, these somewhat disappointing results are far surpassed by the electric power stations. The production of energy from private plants is enough to supply 3,870 arcs, and 69,360 16-c.p. glow lamps, being an increase of six arcs and 14,400 glow lamps. The Berliner Elektricitätswerke, on the other hand, feeds 4,931 arcs, 102,705 glow lamps, and 322 motors. The total increase is 780 arcs, 31,790 glow lamps of 16 c.p. and 130 motors. This increase corresponds to an increase of 19·96 per cent. in the total consumption. The consumption of electricity for private lighting is about 25 per cent. of the energy used for this purpose as gas, against 21·62 per cent. last year (1892).

Gas and Electric Light Conduits.—At the recent Congress of the Société Technique du Gaz en France, at Nimes, an account of an explosion of gas which occurred in the vicinity of some electric light cables was given by M. Gaston Gautier. The explosion took place in Nantes. The three-wire system is in use; the wires being naked, and resting on porcelain supports. The branch wires are insulated. The contract under which the Electric Light Company work compels them to put a cable under each footpath, except in narrow streets. The street in question had but one footpath, and only one main had been laid; and the branch which crossed the street was formed of two insulated wires, separated, and placed in a cast-iron conduit having lead joints. At the spot where the explosion seems to have originated, a branch electrical service crossed the street in a cast-iron pipe about 3½ inches in diameter. The principal conduit having been uncovered at this point, it was found that the negative wire of the branch was broken at the entrance to the pipe. A trench opened in the direction of the pipe revealed right and left—about 16in. on one side and 5ft. on the other—two lead pipes conveying gas into the neighbouring houses. Each of these pipes was enclosed in a box made of deal, which had been steeped in sulphate of copper. But the vertical sides of one of these boxes had been sawn at a certain spot, doubtless to allow for deflection; and there was a rupture at the junction of the two parts of the other box, which made connection. It was precisely at these two places that large holes were found extending lengthwise along the pipe. Undoubtedly, a very considerable escape of gas took place through the perforations, and, following the line of wooden troughs, reached the electric light mains, and formed with the air contained therein an explosive mixture. The perforations must have been formed very quickly, and have preceded the explosion by only a short interval, as the openings were too large to have existed any length of time without giving indications of their presence by allowing a large escape of gas through the soil or in the consumer's house. It therefore appears reasonable to admit that the perforations were produced under the action of an electric short-circuit. As a result of this explosion the following regulations were agreed to by the parties:—No work to be done by either of the companies in the vicinity of the mains of the other without due notice being given; the Electric Light Company to substitute earthenware casings for those of cast iron for their branch services; and branch gas service-pipes in the neighbourhood of electric light mains to be laid in wooden boxes into which there will be run natural bitumen.

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MOTIVE POWER AND GEARING.*

BY E. TREMLETT CARTER.

(Continued from page 511.)

Theory and Action of the Steam Engine.

Engine Horse-Power.—Every engine is required to be able to develop a certain amount of power for the performance of useful work, and to be capable of running at any value below and up to a certain value above a standard or normal power. As a rule, an engine is also required to be able to develop power at a certain normal speed, and to be capable of working above or below this speed, within certain limits which are fixed by the class of work for which the engine is designed. In maintaining itself in motion, the engine will expend some power against the frictional resistances of its moving parts; so that the total power whi h it must develop will always be greater than the useful power which it is required to give off. In a steam-engine or other heat engine the total power developed by the working substance within the engine is called the indicated horse-power (I.H.P.), and the power given off is called the actual or brake horse-power (B.H.P.). The difference represents the internally wasted power, due to engine friction. The normal power which the engine is designed to develop or give off is called the rated horse-power, and in many cases this is of much lower value than the maximum power which may be obtained from the engine.

In all steam engines except the rotary type, which will be considered separately, the energy of the steam is exerted on a reciprocating piston, usually so connected to the crank shaft that the piston makes two *strokes* during each revolution of the shaft. We may, therefore, consider the I.H.P. as being the product of the number of revolutions or strokes per minute into the average work done during each revolution or stroke. If the engine is working on a steady load, and at a steady speed, the work done during every revolution will be constant. In double-acting engines the steam is exerted alternately and similarly on both sides of the piston, so that the work done during each revolution is just twice the work done in one stroke. In single-acting engines the steam is idle during each alternate stroke, and the indicated work done in each revolution is the same as during one working stroke. Calling w the work done by the steam in each working stroke, N the number of revolutions per minute, p_e the mean effective pressure of the steam in pounds per square inch, A the area of piston acted on by the steam in square inches, and L the length of stroke in feet, we therefore obtain the following expression for the I.H.P. of any single cylinder:—

$$\text{I.H.P.} = \frac{k\,w\,\text{N}}{33{,}000} = \frac{k\,p_e\,\text{A}\,\text{L}\,\text{N}}{33{,}000}. \quad . \quad . \quad (84).$$

In single-acting engines the constant k is equal to 1; in double-acting engines it is equal to 2. In engines having more than one cylinder the total I.H.P. of the engine is equal to the sum of the I.H.P.'s of the separate cylinders, as determined by the above equation.

In order to determine the mean effective pressure of the steam throughout the working stroke, it will be necessary to ascertain the variations of steam pressure and of back pressure on the piston during this period. Since the variation of back pressure on the opposite side of the piston is the same as the variation on the side under consideration will be during the return stroke, the mean effective pressure is usually determined by taking the algebraic mean of the absolute steam pressures on only one side of the piston during an entire to-and-fro motion of the piston, the pressure being considered positive when it is an effort, and negative when it is a resistance. The diagram representing this complete variation of steam pressure on only one side of the piston is called an *indicator diagram*. It is usually drawn on rectangular axes, with ordinates of pressure, and abscissæ representing the positions of the piston. The value of p_e is found by taking the intercepts of the ordinates between the upper and lower portions of the diagram, the mean being found by any convenient process. If the tracer of an integrating planimeter is passed round the diagram, the reading on the instrument will represent the value of w.

Steam Economy.—Having now fixed the quantities upon which the power of a steam engine depends, it will next be necessary to consider their influence upon the all-important question of steam economy. Not only is it requisite that the engine shall be able to give off a certain B.H.P., and to work as occasion requires at full load, half load, and so on, but it is essential to commercial success that the steam consumption under these conditions shall be low. The actual B.H.P. having been fixed upon, it is possible to obtain it by an immense number of combinations of the quantities in equation (84), as well as to subdivide the power among two or more cylinders on the same engine. These variations of the several quantities lead to the creation of the diverse types of steam engines. With respect to N, the engines may be classified under *high speed* or *low speed*; with respect to N and L combined, they are classified as *high piston speed* or *low piston speed* engines; with respect to p_e, the distinction between *high pressure* and *low pressure*, between *simple*, *compound*, and *triple* expansion, and between *condensing* and *non-condensing* engines arise. Besides these types, we may mention the classification under *horizontal* and *vertical* engines, and the distinction arising from the type of valve in use in the engine.

The sources of ineconomy in steam engines may broadly be classed under the two heads: failure to obtain indicated work from the energy of the steam, and dissipation of the indicated work in overcoming engine friction. We will now proceed to make a detailed examination of these two sources of ineconomy, considering them in relation to the various types of engines and the quantities upon which those types have been stated to depend. We will commence with a study of ineconomy arising from failure of the engine to obtain indicated work from the steam supplied to it.

Distribution of Steam in the Cylinder.—The first requisite is an exact knowledge of the distribution of steam in a single cylinder during one complete revolution of the engine shaft. In Fig. 25 let O A represent the clearance space behind the

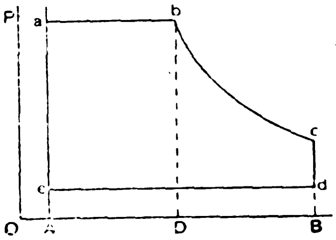

FIG. 25.

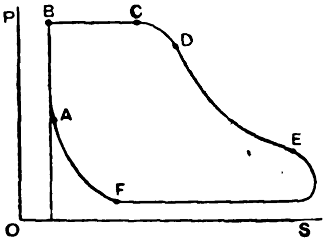

FIG. 26.

piston at the beginning of the stroke (assuming the steam port to be closed), and let A B represent the length of the stroke on the same scale. The clearance is expressed as a length by dividing its volume by the area of the piston. Let ordinates drawn above O B represent the absolute steam pressures in the cylinder. In order to obtain work from the intrinsic energy of steam, a portion of steam is admitted into the cylinder during the early part of the stroke, is then isolated or "cut off," and is expanded during the rest of the stroke. This may be represented by the line $a\,b\,c$, the piston commencing to move at A under full steam pressure, moving to D under full pressure, cutting off steam at D, and expanding the steam from D to B. At c the steam is released by the opening of the exhaust valve, and the pressure may be supposed to fall to d, the ordinate of which represents the pressure of the exhaust. The return stroke may be assumed to take place against this back pressure; and on reaching e the piston is once more subjected to full steam pressure by the opening of the steam valve. The volume of steam in the cylinder at the point of cut-off is represented by the distance, O D, and is equal to the clearance volume plus the volume swept through by the piston. The ratio of expansion is therefore

$$\text{R} = \frac{\text{L} + c}{l + c}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (85)$$

where c is the length of the clearance space.

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The steam admitted to fill the clearance space does work on the piston only during the expansion period, and is therefore to a certain extent idle. During admission, however, it does internal work on itself, superheating or drying itself, and this work may be partially utilised in the subsequent expansion.

In practice it is impossible, as well as undesirable, to get such a distribution of steam as that shown in Fig. 25. It is impossible, because the sudden opening and closing of the valves which give the sharp angles at *a*, *b*, *c* and *e* cannot be obtained in practice, and because a perfectly uniform back pressure during the entire back stroke is inconsistent with the conditions of working. It is undesirable, because of the shocks to the working parts which would result from the sudden changes in pressure and from the reversals of motion, and because it is not economical to allow the whole of the clearance space to be filled with live steam at each stroke. Fig. 26 may be taken as typical of what usually takes place, to a greater or lesser extent, in the distribution of steam during one revolution. The point of steam admission is shown in this diagram at A, and the line A B is usually called the admission line. In many engines, admission takes place before the end of the return stroke, in order that there may be a considerable opening of the steam port by the time the stroke commences. Late admission is shown by a rounding of the diagram at B. From B to C, where the steam is on the point of being cut off, is called the steam line. If the ports are well designed and the valves are properly set, the line B C will be practically horizontal; but where the steam is wiredrawn by constricting passages, there will be a gentle slope from B towards the cut-off. From C to D the valves are closing and cutting-off the steam, the rounding of the curve being due to increasing wiredrawing at the valves. E is the point of release, and from D to E the steam undergoes expansion. Pre-release of steam is very common practice, in order that the exhaust valves may be well opened by the time the back stroke commences. Late release of steam causes excessive back pressure during the early part of the return stroke. The exhaust continues until the point F is reached, and there may be either a steady or a variable back pressure during this period, according to the quality of the steam and the amount of opening of the valves. If there is water in the cylinder, re-evaporation of some of it during the return stroke may occur, causing a rise in back pressure. The point at which the exhaust port commences to close is always earlier than the end of the stroke, in order to enclose a small amount of exhaust steam and compress it into the clearance space. This compression is shown on the diagram between F and A. It is capable of easy proof, besides being in accordance with experience, that it is neither economical to allow the clearance space to be filled with fresh boiler steam at every stroke nor to completely fill it, up to boiler pressure, with compressed exhaust steam. The amount of compression which it is best to allow depends on the type of engine and on the ratio of expansion in the cylinder. With a cut-off at a quarter stroke, and a back pressure of 5 per cent. of the initial steam pressure, the best period of compression may be as much as 42 per cent. of the back stroke, while where the back pressure is 15 per cent. of the initial pressure, the best period will not exceed 26 per cent. of the stroke. Compression has another value beside in the economy of steam, for the rapidly increasing back pressure which it exerts on the reciprocating parts of the engine serves to arrest their momentum and to prevent an injurious knock on the bearing brasses.

Failure to Perform Indicated Work.—The passage of steam through the engine, including the jacket, &c., without the production of the full amount of indicated work represented by the range of temperature between admission and exhaust, arises from numerous causes, among which we shall particularly notice the following:—

1. Initial condensation of steam in the cylinder.
2. Insufficient expansion of steam during the working stroke.
3. Radiation and conduction of heat from the acket and cylinder steam.
4. Leakage of steam across the valves and piston.
5. Uneconomical distribution on account of badly designed or carelessly set valves.

Besides the foregoing avoidable sources of loss, it will be necessary to notice the reduction of available indicated work on account of

1. Avoidable lowering of the initial temperature of the steam; and
2. Avoidable raising of the exhaust temperature of the steam.

Initial Condensation.—One of the consequences of a distribution of steam such as that represented by Fig. 26 is a periodic fluctuation in temperature of the steam in the cylinder. Assuming the steam to be supplied in a saturated condition, the temperature at any point in the stroke may be determined from the absolute pressure at the point; from which it will be seen that, where any considerable amount of expansion takes place, there must be a considerable fall in temperature during the working stroke. Besides this, on release there is a further fall in pressure to that of the exhaust, and therefore a further fall in temperature. It is evident that the steam will always tend to equalise its temperature with that of the metal of the cylinder walls. An interchange of heat consequently goes on between the steam and the walls which, if permitted to take place on a large scale, will cause great waste of steam. Just before the closing of the exhaust port the cylinder is at its lowest temperature, as a rule, because it has had all the time from the point of cut-off up to the commencement of compression to give up its heat to the cooling steam. During the brief compression there is little time for any very great rise of temperature of the walls to occur, so that on the opening of the steam valve live steam rushes into a metal cylinder very much cooler than itself. Condensation of the saturated steam, in order to heat up the walls, is the inevitable consequence; and a greater volume of steam than is represented by the available space passes through the steam port. During the working expansion, a certain amount of re-evaporation may occur, thus partially recovering the useful effect of the steam; or, what amounts to the same thing, an equivalent weight of steam may fail to be liquefied isentropically. The re-evaporation is due to the lowering of pressure on expansion, when the hot water will have enough heat to enable part of it to attain the state of vapour. In the majority of engines, the condensed water has by no means completely evaporated at the point of release, the result being that a wasteful back pressure is set up during the exhaust stroke on account of the plentiful re-evaporation which goes on during that period. Various practices have been introduced in order to diminish the ineconomy of steam due to initial condensation, but there is probably no type of reciprocating steam engine in which this effect does not to some extent occur.

Prevention of Condensation.—Reference has already been made to the action of a hot jacket upon the working substance in a cylinder, and to the influence of a steam jacket upon the working liquefaction of steam. As a method of preventing initial condensation of steam, the use of a steam jacket has been found very beneficial. As far as the author has been able to ascertain, no instance of the economy of steam being injured by the use of such a jacket is to be found; while, in some types of engines, the improvement in economy is very marked. The effect of a live steam jacket is to tend to maintain the cylinder walls constantly at the temperature of the initial steam; but, owing to the movement of the piston, a heat gradient is set up in the cylinder walls, the inner strata of the walls being caused to fluctuate in temperature. Some condensation therefore takes place, even in the best jacketed engines; and the amount of this condensation is, other things being equal, proportional to the depth of cylinder wall which is affected by these fluctuations of temperature. It has already been shown that this depth is a function of the periodic time of the steam cycle. With rapid cycles the cooling steam has little time to abstract heat from the inner portion of the walls; with slow cycles the penetration of the cooling influence is very deep. In the former case the jacket is of little use; in the latter case the reduction of loss from condensation by its use is considerable. These considerations are completely borne out by actual trials

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of high and low speed engines, in which it has been found that the value of the steam jacket is well marked in the latter type of engine, but scarcely appreciable in the former type. Some experiments mentioned by Prof. Cotterill* indicate that in the case of iron cylinders the depth to which the fluctuation of temperature penetrates, sufficiently to produce more than 0·2 per cent. of the fluctuation at the innermost surface, is given by the following table :—

Revolutions per minute	25	50	100	200	300	400	600
Penetration in inches..	0·894	0·632	0·447	0·316	0·258	0·224	0·182

(To be continued.)

ALTERNATING CURRENTS IN A DIVIDED CIRCUIT.

BY ALEXANDER RUSSELL, M.A.

The problem of finding the alternating currents in a divided circuit, when mutual induction is appreciable, is best solved by a geometrical diagram. The algebraical expressions for the impedance, &c., which have been appended in order to make the solution mathematically complete, can all be deduced from the diagram by elementary trigonometry. We can generally see much more easily from the figure what will happen on varying the frequency, resistance or inductance, than from the algebraical expressions.

Let (R, L), (S, N) be the resistances and self-inductances of the two branches, and M the mutual inductance. As usual, let $p = 2\pi\, n$, where n is the frequency. Let A_1, A_2 be the effective values of the currents, *i.e.*, the readings on an ammeter when placed in the two branches respectively. Also let V be the effective voltage across the two branches.

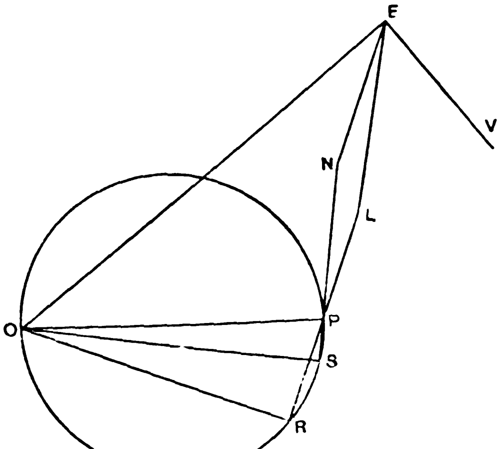

Fig. 1.

Then in the (R, L) branch the effective voltage V may be resolved into three components—$R\,A_1$, $p\,L\,A_1$, and $p\,M\,A_2$. The first component $R\,A_1$ drives the current A_1 through the resistance R, $p\,L\,A_1$ balances the back E.M.F. of self-induction, and $p\,M\,A_2$ balances the E.M.F. of mutual induction. It must be carefully remembered that M may be either + or −, depending on how the two coils are connected together. Similarly, in the (S, N) branch, the component E.M.F.'s are $S\,A_2$, $p\,N\,A_2$, and $p\,M\,A_1$. Also $p\,L\,A_1$ is perpendicular to $R\,A_1$, and $p\,M\,A_2$ is perpendicular to $S\,A_2$.

By the polygon of E.M.F.'s, V, $R\,A_1$, $p\,L\,A_1$, and $p\,M\,A_2$ form a closed figure. Similarly, V, $S\,A_2$, $p\,N\,A_2$, and $p\,M\,A_1$ form a closed figure.

Hence the general figure, showing how these quantities are related, is shown in Fig. 1, where $O\,R = R\,A_1$, $R\,L = p\,L\,A_1$, $L\,E = p\,M\,A_2$, $O\,S = S\,A_2$, $S\,N = p\,N\,A_2$, $N\,E = p\,M\,A_1$, $O\,E = V$.

* *See* Cotterill, "The Steam Engine," Chap. X.

Let N S meet R L in P. Then a circle goes round O R S P. Since S N and L E are both perpendicular to O S they are parallel, and also L R and E N are parallel. Hence P L E N is a parallelogram. We have now to show how to construct this diagram in any given case. A straightforward way of doing this is as follows :—

Draw (Fig. 2) two lines, $O\,S = S$ and $S\,P = p\,(N - M)$ at right angles to one another, and join O P.

Then (Fig. 1) draw $O\,R = R$, $R\,P = p\,(L - M)$, and join O P. Describe a circle on O P as diameter. Make the angle P O S (Fig. 1) equal the angle P O S (Fig. 2). Join S P. Make $R\,L = p\,L$, and $S\,N = \frac{N}{N - M}\,S\,P$. Draw N E and L E parallel to P L and P N respectively, and join O E. Then a little con-

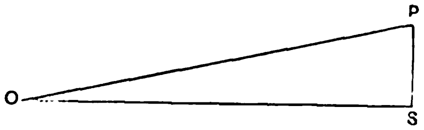

Fig. 2.

sideration will show that this is the diagram drawn to scale for the case of $A_1 = 1$ ampere. If we wish to find the currents, &c., for the case of $O\,E = V$ volts, we merely alter our scale so that O E equals V units. Then the lengths of the lines E L, E N, and E P, divided by $p\,M$, give the currents A_2, A_1, and A, where A is the current in the main circuit. The angles these lines make with E V, where E V is perpendicular to O E, give the respective phase differences between the currents and the E.M.F.

The joint impedance of the two branches is equal to $\frac{V}{A}$, which equals $p\,M\,\frac{O\,E}{E\,P}$. Measure a length, E D, equal to this along E P, and draw D F and D G perpendicular to E V and

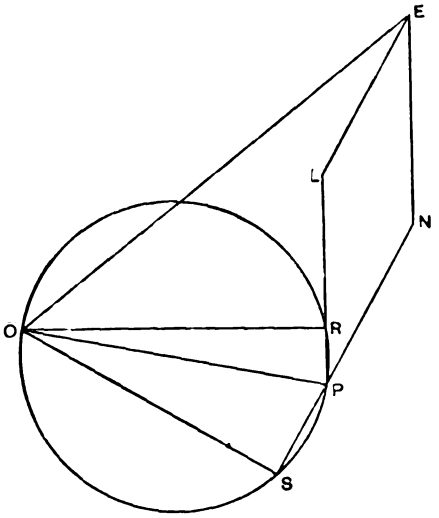

Fig. 3.

E O respectively (not shown in the figure). Then E F is equal to the effective resistance, and E G equals the effective reactance.

Three cases arise in practice, and we shall consider them separately :—

1. M less than either L or N.—This is the case shown in Fig. 1. We can see from the figure that when the frequency is very small, the phase difference θ between A_1 and A_2 is very small. When the frequency is very great, this phase difference is again very small. Hence, for some intermediate value of n, θ is a maximum.

2. M between L and N in value.—Suppose that M is greater than L. In this case $p\,(L - M)$ is negative, and P is below R. The general diagram is shown in Fig. 3. The phase difference θ increases as the frequency increases, and approaches 180deg. when n is large. In this case the currents are almost opposite in phase. Hence the current in the main

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circuit is very little greater than their difference. It follows that if the currents in the two arms are nearly equal they will be very much greater than the current in the main circuit. This will be the case when L is nearly equal to N; the current in the (R, L) branch being nearly in the same phase as the main current, L being less than N. Just as when a condenser shunts a choking coil, we get a so-called "circulating current," so also in a branched circuit when the self-inductances are nearly equal and the mutual inductance lies in value between them we get a circulating current. These circulating currents are often very useful in alternating-current work.

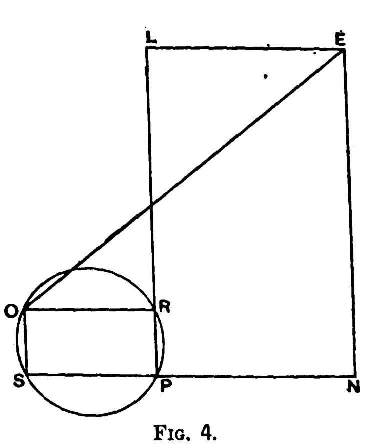

Fig. 4.

The following are two examples of this case worked out graphically.

(*a*) Two coils (100, 0·5), (100, 1), M = 0·6, are connected in parallel, and an alternating E.M.F. applied to their terminals, the frequency being 16 ($p = 100$) to find the currents, &c. Draw O R = 100 (Fig. 3), R L = 50, R P = 10. On O P as diameter describe a circle. Find the angle P O S by a construction as in Fig. 2. Make $SN = \frac{5}{2} SP$. Complete the parallelogram P L E N and join O E. Now make O E = 1,000; then O R = 100 $A_1 = 625$, &c.

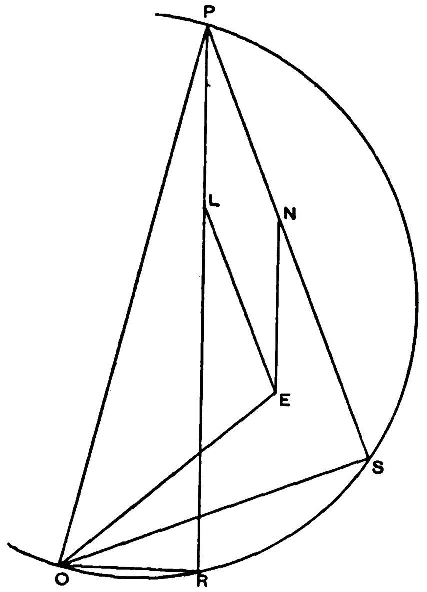

Fig. 5.

Hence $A_1 = 6·25$ and $A_2 = 5·83$ amperes. The angle E O R = the angle of lag of $A_1 = 38\frac{1}{2}$deg. $= \alpha$. The angle E O S = the angle of lag of $A_2 = 66$deg. $= \beta$.

(*b*) The frequency being increased to 80, in the last question, to find the currents.

The construction is shown in Fig. 4. We find

$$A_1 = 1·41,\ A_2 = 2·83,\ A = 3·16 \text{ amperes},$$
$$\alpha = 45°,\ \beta = 135°.$$

3. M negative.—The diagram for this case is shown in Fig. 5. It is easy to see that θ is zero when $p = 0$, and again when p = infinity; hence, for some value of the frequency, θ attains a maximum value. The diagram Fig. 5 is a worked-out numerical example for two coils (53, 0·29), (117, 0·18), and M = − 0·14, $p = 500$, V = 1,000 volts. We find that:

$$A_1 = 9·3, \quad A_2 = 10·2, \quad A = 19·2 \text{ amperes}.$$
$$\alpha = 40\text{deg.} \quad \beta = 18\text{deg.} \quad \text{Impedance} = 52 \text{ ohms}.$$

Prof. J. J. Thomson has solved the general problem in "Recent Researches in Electricity and Magnetism," Chapter VI. He explains the anomaly of circulating currents by dynamical principles as follows:—"The actual solution is that which makes the kinetic energy (of the loop) as small as possible, consistent with the condition that the algebraical sum of the currents should be equal to the current in the main." The following formulæ can be proved trigonometrically from the general diagram. (3) is also obvious from other considerations.

M < L and N or M negative.—θ is a maximum when

$$p^2 = \frac{RS}{(L-M)(N-M)}, \quad \ldots \quad (1)$$

M > L and < N.—θ is 90deg. when

$$p^2 = \frac{-RS}{(L-M)(N-M)}, \quad \ldots \quad (2)$$

$$\left. \begin{aligned} VA_1 \cos\alpha + VA_2 \cos\beta &= RA_1^2 + SA_2^2 \\ &= VA\cos\gamma \end{aligned} \right\} \quad \ldots \quad (3)$$

$$\left(\tan\alpha - \frac{pL}{R}\right)\left(\tan\beta - \frac{pN}{S}\right) = \frac{M^2p^2}{RS}, \quad \ldots \quad (4)$$

$$\frac{A_1^2}{A^2} = \frac{S^2 + p^2(N-M)^2}{(R+S)^2 + p^2(L+N-2M)^2}. \quad \ldots \quad (5)$$

Effective resistance—

$$= \frac{RS(R+S) + p^2\{R(N-M)^2 + S(L-M)^2\}}{(R+S)^2 + p^2(L+N-2M)^2}. \quad \ldots \quad (6)$$

Effective inductance—

$$= \frac{NR^2 + LS^2 + 2MRS + p^2(LN - M^2)(L+N-2M)}{(R+S)^2 + p^2(L+N-2M)^2}. \quad (7)$$

(Impedance)^2—

$$= \frac{R^2S^2 + p^2\{L^2S^2 + N^2R^2 + 2M^2RS\} + p^4(LN - M^2)^2}{(R+S)^2 + p^2(L+N-2M)^2}. \quad (8)$$

THE ELECTRICAL EQUIPMENT OF THE LIVERPOOL OVERHEAD RAILWAY.

BY THOMAS PARKER, M. INST. C.E.

(*Continued from page 579.*)

DISCUSSION.

Mr. S. B. Cottrell did not think he could add anything to the general description of the railway; but having had it under his observation during the first twelve months of its working, he might mention one or two points of interest. As had been stated, the only serious damage to the structure during the period mentioned was caused by fire. The conductor, as laid, had flexible copper connections at each joint, and as a result, a very considerable amount of creeping took place. The conductor was now coupled in lengths of 90ft. with rigid copper fish-plates, flexible expansion-joints being introduced at every third length; the creeping had entirely ceased and the conductor could be kept in very good line and level, whereas, before, foul joints continually occurred, and it was difficult to keep the conductor in line and level. During the first month or two short circuits occurred frequently, but now they very seldom happened; in fact, there had only been 19 since the beginning of 1894, each one of which was caused by the collecting-slippers touching the running rails when going through a cross-over road. The motors had come well up to the workshop tests. Only two of the whole number had required re-winding, and even then about 80 per cent. of the old coils were re-used. At first there was some little trouble with the brushes, the commutators frequently requiring to be skimmed up; but by a modification of the brush-holder that had been very much reduced. Originally the commutators required skimming up after running about 6,000 miles, but now they would run 9,500 miles, and one

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had run 16,000 miles without skimming. The carbon brushes cost at first about £6 per week. That had been already reduced to £2. 10s., and it was hoped shortly to get it to £1 per week. The brushes used were flat carbon ones; round carbons had been tried and also copper gauze, but without success. The stations, as described, were lighted from accumulators; but during the winter months the accumulators were worked at very nearly their maximum output, in order to increase the life of the batteries; arrangements had therefore been made for lighting the stations by means of two sets of lamps, one in series off the main conductor, the other in parallel off the accumulators. An automatic switch was arranged so that, should a short circuit occur, the lights were automatically switched on to the accumulators. Of course, that meant some slight fluctuation in the light, but it was so trivial that it did not matter. The automatic signals were a new departure, but had answered admirably, effecting a very considerable saving in the working expenses. In the six months ending December 31st, the failure of signals to go to danger and to come off was 1 in 24,000 and 1 in 1,200 operations respectively. In the two months ending February 28th the signals had so much improved in working that failures were 1 in 212,000 and 1 in 2,000 operations, the cause of these failures in most cases being not electrical but mechanical. During the last two months he had gone very carefully into the cost of haulage, that was, since the Electric Construction Corporation had handed it over to his Company. With coal at the present price of 8s. 3d. per ton the haulage worked out at 3·48d. per train mile. With coal at its normal rate, as at the corresponding time last year, of 6s. per ton, it would only be 3·34d. per train-mile. Those figures included all wages, stores, &c., or, in other words, what came under the term of locomotive expenses. He entirely agreed with Sir Douglas Fox that for a traffic like that at Liverpool short trains at frequent intervals was the best system. Last August Bank Holiday 40,000 passengers were carried in about eight hours, and the platforms were never overcrowded. That was done by a three minutes' service of trains, and he had reason to hope that a three minutes' service would soon be required to deal with the regular daily traffic.

Mr. ALEXANDER SIEMENS noticed that several speakers had mentioned that it was a great advantage to have the motors on the cars, and not a separate locomotive. That matter had to be decided in each case on its particular merits; it could not possibly be universally true that a locomotive was the best, or that motors on the cars were the best. He might illustrate this by referring to Table A in the first Paper, where a comparison was given between the weights of motors and locomotives, which came out very much in favour of the motor system adopted in Liverpool. There were only two carriages, and, of course, the arrangements for working the two motors on the carriages from the one end or the other were comparatively simple. But the moment a railway was dealt with, where more carriages were wanted to run at the same time, the question of the switching arrangement was very serious. He did not know whether in most cases it would not preclude the use of motors on the carriages. In the same way, the multiplication of small motors on all the carriages meant a serious increase in cost, which, of course, was also not to be solved generally, but each case must be looked into. For instance, in Table A, the electric motors of the South London Railway, which had been made by his firm, did not weigh 10½ tons, but 13½ tons; they were 3 tons heavier than those of the Liverpool railway. On the other hand, those locomotives were powerful enough to draw at least two more carriages easily; though it could not be done on account of the accommodation for shunting in the City being insufficient. But supposing that five carriages were put on instead of three, the total weight of the train would be 45 tons, and the weight of the full train would be 802lb. per passenger against 871lb. in the Table, and against 752lb. for the Liverpool Overhead Railway. If the electric locomotives were properly used and fully utilised, the discrepancy was not so great as appeared in Table A of the first Paper. In Table B the "tractive force in lbs. per ton of train" was given as 120 for the 150-ampere motor on the Liverpool trains, and as 100 on the City and South London train. He wished to contrast that with the figures given by Mr. Preece, who stated that the locomotive at the Chicago Exhibition was giving a 6,000-lb. pull, and was meant for a 500-ton train. That was 12lb. per ton of train. Mr. Siemens had also been at Chicago. He did not see the actual trial of the locomotive, but the company were kind enough to give him some information; and, among other things, it was stated that the locomotive was capable of developing 500 B.H.P. at 30 miles per hour. As they proposed working with 500 volts, that would amount at least to 750 amperes of current. That was the mere electrical horse-power, no allowance being made for loss in friction or from other causes. To supply that current to the locomotive there was a single rod with an ordinary trolley wheel; but he was certain if 750 amperes ever attempted to get through those trolley wires the trolley wheels would melt away in no time. Great caution must therefore be exercised as to the importance to be attached to the figures given. It had been already pointed out by Mr. Preece why the experiments on the Elevated Railway in New York had failed. Mr. Siemens had had similar experience with that line. His firm, in 1881, offered to run one of the short lines by electricity, fitting up the line at their own expense, on the condition that, if it worked properly, they should have the fitting out of the whole system. It did not, however, suit the Stock Exchange in New York, and the offer was not accepted. Similar reasons appeared to have prevented the success of the experiments actually carried out. He was sorry to know that in the Liverpool power station the dynamos were driven by ropes instead of direct. He thought that double limb magnets were also a retrogression. There had been plenty of experience in 1885 of dynamos with double limb magnets of about the same size, and it was found that the horse-shoe magnet type was preferable in every way. In reference to experiments with ordinary drum-winding on the car, the author of the second Paper had stated that he found that the Eickemeyer winding was better. Mr. Siemens had wanted some idea as to how the motors of the two locomotives which their firm supplied to the City of London, acted, and he had received a letter from Mr. Mott, the resident engineer, stating—

"I have pleasure in sending you the following information, as requested:

					Miles.
"1. Loco. No. 16.	Total mileage to January 28, 1894			......	59,221
Loco. No. 15.	do.	do.	do.	......	49,580

"2. It has never been necessary to make any considerable repairs to these locomotives, except the alteration to the resistances which is now being done."

The second locomotive was delivered later than the other, hence the difference in the mileage. He did not believe there was a steam locomotive which had run close upon 60,000 miles without any repairs or alterations. The expense of brushes had been said by Mr. Cottrell to be £2 per week, but one of these locomotives had run with the same pair of brushes since it was delivered. He was rather astonished to hear Mr. Preece speak of hideous overhead wire and disparage it. He was always under the impression that the telegraphic wires were the great eyesore, and that if a line was properly put up, as, for instance, in South Staffordshire, it certainly was not such a frightful eyesore as Mr. Preece had tried to make out. Mr. Preece had also touched upon a point which he was afraid was greatly misunderstood. He had said that two amperes might career about Liverpool, eating away gas and water pipes. It was not the amperes that did anything. The possibility of pipes being damaged depended upon the pressure under which those amperes were sent about. If the difference of potential between the end of the line and the power-house was only 2 or 3 volts, 200 or 300 amperes might be about, and they would not damage a pipe. Of course they would interfere with telegraphs and telephones, but they could not do any damage to the pipes.

A great point was to be able to start an electric locomotive with less loss of energy than under the present system, where resistance was inserted at first, or other means were adopted; and he would suggest that a very good way, although it might not seem to be so at first, was to put on the locomotive a motor generator, and supply a high-pressure current from the power-house at 2,000 volts to the generator, and to put motors on the axles of the locomotive. That system, taking into consideration the cost of the conductors, the extra cost of the motor generator set, was not very much more expensive in capital outlay than the present plan of supplying a 500-volt current direct to the locomotive; but it did introduce additional complication; and, putting the whole arrangement into £ s. d., it would be found that the present system, although wasting a good deal of energy at the starting of the locomotive, was preferable, because it was simpler. He thought it was probably necessary to reassure the Dock Board about the sparks of the electric railway—that they were not of the same nature as sparks from a locomotive, where particles of carbon were flying about, which constituted a real danger to any inflammable substance that might be near. The sparks of an electric railway occurred near the rails, and were, of course, only particles of iron, which could not fly any great distance, and there was absolutely no danger whatever from them. Then there was a further interesting question touched upon by the author of the second Paper, who wished it to be believed that the mean efficiency from indicated horse-power to electrical horse-power on full load was 88 per cent. Only a few weeks ago, certain figures had been published about a direct-driven set which gave similar efficiencies, and they were promptly denied by "one who knew," who said that such efficiencies in steam engines and dynamos were simply impossible; and he certainly thought that, with the addition of the rope-driving, 88 per cent. was too high. On the other hand, he thought that, in the trial detailed, the author had hardly done himself justice, because if the figures given were compared with those which were attained on the City and South London Railway, and communicated to the British Association in 1892, it would be found that the average speed, including stops, which for the Overhead Railway was given as 12 3 miles per hour, was nearly

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13 miles per hour on the City and South London. Then the average watts per train mile, the trains being about the same weight, were given in the Paper as 32,650; whereas on the City and South London line only 21,320 watts were used per train mile, which was a very great difference. He was sure there must be some mistake, because he could not imagine that the motors of the Liverpool line were so very much less efficient than those of the City and South London Railway. The great point for electrical traction was to have a frequent service. That was what had been pointed out as the reason why the average curves were much smoother the greater the number of trains there were; and, generally speaking, it could be laid down that where an electrical service was to be introduced on any line there ought to be frequent service; it was perfectly impossible to introduce electrical traction satisfactorily on railways where there were only three or four trains a day.

Mr. R. W. Blackwell had built that first road in America to which Mr. Preece had referred in 1884, and during the succeeding years, as electrical traction progressed, had to meet all those objections which had been mentioned with regard to the overhead wire. Throwing aside other questions, he would like to say a word in that regard. In America, between 1883 and 1890, it was said by every city, by every electrical company, by every tramway engineer, and by every æsthete, that an overhead line in a street was an abomination never to be tolerated, and should never be allowed under any circumstances. The consequence was that the pioneers of electrical traction in America began their work with the idea of perfecting the conduit system, which could be worked without the use of a visible conductor. They effected that result, and, when they did so, the cars ran fairly well; but when the question came to the financial test, and to the test of regular work, it was found that it cost approximately £7,000 a mile to put in a more or less efficient underground conductor, and that it cost about £700 a mile to put a first-rate, practicable conductor overhead. The reason why the overhead conductor had been adopted in the States had been simply that financial and practical reason. He thought everyone believed it was possible to make an underground conductor that would work; but nowhere had it, to the best of his knowledge, been made anything like a financial success, with the possible exception of that at Budapest. On the other hand, he believed it was absolutely demonstrated to the extent of some £30,000,000 invested in electric tramways in the United States, that every overhead trolley wire that had been erected had proved a financial success, had increased the dividends, and had served the purpose of the public in increased and more rapid transit. In the earlier days of electric traction elevated conductors were undoubtedly rude and unsightly in many cases; but so much attention had been paid to the elaboration and perfection of details of suspension and insulation that the trolley line of to-day was quite another thing. It seemed to him that such objections as might be urged against the aërial wire were vastly less important than those which were connected with any system that involved interference with the street surface and the maintenance of an open slot. Many great continental cities had lately adopted the trolley system, and, from a personal inspection of lines in Bremen, Hamburg, Brussels, Frankfort, and other towns, he was convinced that the method of construction there adopted left little to be dessired.

Mr. Stephen Sellon thought there was no necessity to go so far as the Niagara Railway in order to find a gradient of 1 in 20. There were plenty of tramways working at that gradient; for example, the electrical tramways at South Staffordshire and at Leeds, and the City and South London Railway. Referring to the abomination of the wires over the streets in Boston and other places, which made the overhead system so objectionable, the overhead wiring had been much modified to meet English ideas, and very little objection could be raised by anybody viewing the system as applied on the electric tramway in South Staffordshire, from a public road. In the American system, the trolley-arm worked from the centre of the car, which had no lateral movement; and therefore the conductor over the centre of the line was necessary. A large number of pull-over and span-wires had to be used for this purpose. In South Staffordshire a different kind of trolley-arm was adopted, having a radial motion enabling the conductor to be placed on a single row of poles alongside the road, dispensing altogether with any span or pull-over wires. The overhead system as there adopted showed a marked improvement upon the American principle; and it was not fair that the system should be condemned because in America an act of vandalism was committed in its application. Looking at the question of economy, he thought it would be absurd to suggest a conduit system in a district where it could not pay. Overhead installations, therefore, became necessary; and, no doubt, engineers in this country were quite able to reduce the objections, and not necessarily to have the overhead system as it was found in America. The remarks coming from Mr. Preece, the Chief Engineer to the Post Office, in objecting to he overhead system were somewhat extraordinary, as in Mr. Sellon's opinion it was no more objectionable to put up a few overhead wires, than it was to put up the usual structures of poles and innumerable wires that were seen along the whole of the roads in the country. It might be interesting to give a few figures in connection with the South Staffordshire tramways system, which was originally worked by steam, and of which eight miles were, in 1892, equipped with the overhead electric installation. While the line was working by steam, the gross earnings per car-mile reached the sum of 1s. 1½d., and the cost of working per car-mile was 1s., leaving a very short margin of profit. On the introduction of electrical traction in 1893, working expenses were reduced to 50 per cent. of the gross receipts. Referring again to Mr. Preece's remarks, that important body, the Joint Committee on Electric Powers Protective Clauses, had decided that railway companies, telephone companies, and gas and water companies should be called upon to protect themselves, so long as certain reasonable regulations (which regulations were not to place any restrictions on the commercial working of electric traction) were complied with; and from past experience he was sure that any serious conflict between the Post Office and any electrical traction installation, by which the Post Office might seek an injunction to stop the working of a tramway, would be due to the fact that the latter had not responded to the reasonable requirements nor to the well-known courtesy of the Chief Engineer to the Post Office. In conclusion, he would venture to express the opinion that the successful completion of the unique work described in the Paper was due to the fact that mere electrical theorists had had no part in the matter.

Mr. Alexander McDonnell was acquainted with the South Staffordshire tramways, and could see nothing, so far as the wires were concerned, in the least objectionable there. In the Paper, a comparison had been made between trains on the Liverpool Overhead Railway and on the Metropolitan Railway. Unfortunately the word "train-mile" was used a little too loosely. A train-mile, when comparing the expenses of one railway with another of similar traffic, or the expenses of the same line one year with another, was exceedingly useful—not perfect by any means, but still of very good practical use; but to compare a train weighing 38 tons and carrying 115 passengers with another train weighing 157 tons and carrying 400 passengers was going too far. The system of electrical traction upon the Liverpool Overhead Railway was exceedingly well adapted for the trains and traffic there; but for such a line as the District or the Metropolitan Railway, with the traffic on them, it would be found that it was not adapted in any way, so far as was known at present. Where there was a system of trains running at intervals of three to four minutes, electric traction was tolerably economical; and, taking the District system, where between the Mansion House and Victoria there was a three or four-minute service, supposing the electric traction was sufficiently powerful to deal with a train of 150 tons, there might be economy; but when places like Wimbledon, Ealing, Willesden and Richmond were considered, where there was a half-hourly service of trains, it certainly would not be economical. Electric traction seemed very good where there was a fairly developed traffic of light trains running very often; but it certainly was not at all suitable for developing traffic on a railway of light traffic. In the case of a tramway, traffic must be developed by horse traction or locomotive traction, and when it was developed electric traction might be useful; but to lay down the whole of an electric system, with its fixed plant, for a tramway system with cars running every 20min. or 30min. would certainly not be economical, although it might be economical in a 3 or 4 minutes' service. It was stated that the locomotives on the overhead system in New York burned 54lb. of coal per train-mile for trains of about 92 tons weight. Upon an ordinary branch line a train would have about five carriages, weighing about 50 tons, and a tank-locomotive of probably about 45 tons, making 95 tons altogether. Such a train would seat about 200 passengers if full, which of course it never was. A locomotive would work that for about 18lb. of coal a mile, so that 54lb. was to him quite unintelligible. The cost of working such a train by locomotive power would be about 6d. a mile. It was stated that the electric traction cost about 4d. a mile when the trains were run frequently; but the authors had omitted to take into account the depreciation and renewal of stock. The 6d. a mile that Mr. McDonnell was speaking about included everything—drivers, coals, ordinary repairs and renewals. He expected that in electric traction the depreciation would be considerable—that the life of a great part of the stock would be very short. Of course, the life of the fixed plant, stationary engines, and so on, would be long; but the motors and things of that sort would in all probability be short-lived, and to that 4d. a mile the depreciation should be added. To suppose for one moment that, because the electric system was good and economical upon a railway such as that described in the Paper, it could be used for anything like an ordinary railway system was quite beyond his comprehension. For a railway such as the London and North-Western, with trains varying between 80 tons

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and 500 tons in weight, and with speeds varying between 20 miles and 60 miles an hour, the system was not adapted, and any kind of comparison made between them could not be fair. Without in any way suggesting that the system adopted on the Overhead Railway at Liverpool was not exceedingly well adapted there, he considered that it was not at present suitable for other railways, not even the most similar in kind—namely, the Metropolitan.

Mr. W. WORBY BEAUMONT wished, first, to ask the authors if there was any reason, other than that stated in the Paper, why the plates forming the flooring of the viaduct were bent hot, and if they could not have been put in cold. He was under the impression that a machine might have been made at no great cost which would have bent the plates cold at a low cost compared with the expenditure in bending them hot. Another point was the one on which Mr. Trotter had remarked, with reference particularly to some of the diagrams. It was known that for the working of any set of machinery, or for any electrical installation, the load factor might be said to give an indication of the expenses and of the profit that might be obtained at any particular time. The diagrams shown accentuated the remarks, he thought, made by Mr. Greathead on previous occasions as to the great cost at present incurred in getting a train into motion electrically and also in shunting operations, as, for instance, on the City and South London Railway. He thought it might be shown that to a very large extent that waste might be avoided. Taking a datum line as in the diagrams given in the Proceedings Inst. C.E., Vol. CXII., pp. 246, 247, it was found in almost all cases that the diagram representing the power taken in getting an electrically moved train into motion was of the character referred to by Mr. Trotter. As soon as the train had fairly started, the time occupied being, as shown by some of the diagrams, only from 10sec. to 15sec., the power taken fell to about one-half; it was of various heights further on until a stop was reached, and again this was repeated. It was not only that the power as compared with that taken by the steam-locomotive to get the train into motion was, for the greater part, waste power; but it meant that the power which must be available at the central station must be that represented by the full height of the power diagram. It was not that a mean load had to be available, but that at any moment the power represented by that full height must be available, the engines running for that purpose. Of course, the power was not always used, and the engines, and particularly the boilers, were working at a great disadvantage; because, although that power was not taken, it must be ready to be supplied at any moment. He had shown on a previous occasion that it would be possible by mechanical means to avoid taking more power than was necessary for keeping the train in motion. Mr. Siemens had mentioned a method of getting over that difficulty electrically, and had explained why it was bad or insufficient; and, having proved that it was not satisfactory, had said it was better to waste the small amount of power shown between the two lines midway on the top of that diagram, rather than to use a method which he had said was not a good one. That, therefore, could hardly be said to have been of assistance with regard to this problem; and although on several occasions it had been mentioned that electrical methods might be adopted, it had not, he believed, been shown that electrical methods could be used which would avoid the necessity for a great deal more power than would be required by a locomotive engine in moving its train. As Mr. Trotter had pointed out, until a train was actually in motion, or so long as the locomotive engine was getting it into motion, it was actually doing little work, and the steam was only used in that degree. To get over the difficulty, two motors might be coupled as on the Elevated Railway, in series, getting the train more rapidly into motion and avoiding some of the electrical difficulties that would otherwise occur; but, at the same time, the power required for getting the train into motion within a given time was just as great as if the motors were in parallel. As far as was yet known, electrical methods could not be said to be satisfactory for surmounting that difficulty; but it could be got over mechanically, and it only remained for engineers to adopt the methods that had previously been pointed out.

Dr. EDWARD HOPKINSON, in offering a few criticisms upon the second Paper, did not wish it to be supposed for a moment that his object was to detract from the excellent results achieved. Those results were most striking, but, at the same time, some statements had been made which appeared to him to be open to very serious exception. With regard to the question of efficiency of engines and dynamos at the generating station, the author had given the electrical efficiency of the generating dynamos as 97·7 per cent. That, no doubt, could be attained in well-constructed machines, and fairly represented the electrical efficiency at Liverpool. But the author had gone on to say that the efficiency, as between the I.H.P. in the cylinders of the steam-engines and the electrical H.P. as delivered from the terminals of the dynamos, was 88 per cent. Anyone who had experience of the frictional diagrams of large steam-engines, and especially the friction caused by rope-driving, would recognise in that a very startling result, and one that he was not at all prepared to accept. Perhaps the highest efficiency ever realised as between electrical H.P. and I.H.P. had been obtained with a Willans engine. Everyone who was familiar with that engine would state from the perfection of workmanship exhibited, that the friction must be exceedingly low; and yet the best results ever obtained by Mr. Willans with a great variety of dynamos by the best known makers had never exceeded 87 per cent. The efficiency was usually 85 to 87 per cent., and the few results obtained above 86 per cent. were, it would be admitted, probably due to the fortuitous concurrence of various small sources of error, which happened to run together in a favourable direction. Taking the author's figure of 88 per cent., and the electrical efficiency at 97·7 per cent., it meant the loss in friction of engine, ropes and dynamo, and by electrical friction of various kinds in the armature, was only 10 per cent. Such a result all who had any experience of rope-driving would at once say was absolutely impossible; in fact, before it could be accepted, the author would naturally be asked to give the friction-diagrams of engines only, the friction-diagrams of engines and ropes, and finally the friction-diagrams of engines and dynamos running without load. The motors were, no doubt, the most important and the most difficult point to deal with in traction work. The armature-resistance of each motor was given as 0·67 ohm, and the magnet-resistance as 0·37 ohm, making a total of 1·04 ohm. When the motors were in series, as at starting, the current was about 130 amperes. Doubling the resistance for two motors the result was 2·08 ohms., which, multiplied by 130, gave the loss in volts at 270. Therefore, the electrical efficiency of the motors throughout the early part of the run up to the point at which the two motors were placed in parallel, was 44 per cent.; after they were placed in parallel, with a current of 90 amperes, the efficiency was of course improved, but still did not reach more than 80 per cent. He was very far from saying—in fact, quite the reverse—that the author had been wrong in designing the motor with a large number of convolutions on the armature in order to have a very high resistance, and consequently exceedingly low electrical efficiency with a heavy load. It was known that if the spare electromotive force at starting was not absorbed in the armature and the magnet coils it must be absorbed in the external resistance. He mentioned this simply to draw attention to the fact that these motors at that period of their running had this extremely low efficiency, and to show the direction in which better results might be obtained in the future. In remarking upon a Paper* which Dr. Hopkinson had read before the Institution last year, the author had given the resistance of the City and South London motors at figures about one-third the resistance of the Liverpool Overhead Railway motors. Their power was about the same; but the author, by putting more convolutions on, absorbed the power in the motors instead of in the external resistance. To effect that, the device of putting the motors first in series and afterwards in parallel had been adopted. In that the author had done right; but it would only have been proper on his part if he had acknowledged to whom that device was due. It was due, as a matter of fact, to Dr. John Hopkinson, but had been taken up by the late Sir William Siemens more than ten years ago. Here, again, it was matter of regret that the author, in describing the motors, and especially the system of direct driving, should not have thought it necessary to refer to what had been done previously in that direction, and more particularly to the work of the late Sir William Siemens. Electrical engineers had not advanced so far in traction work that they could yet afford to ignore the pregnant suggestions made by Sir William Siemens at a time when the subject was in its infancy. For the same reason, he would notice that the form of conductor and the method of supporting and insulating it were exactly the same as had been adopted on the City and South London Railway; but of that he had no reason to complain, as imitation was not uncomplimentary. The most important point in the Paper was the statement that the tractive force of each motor was 1,450lb. with 100 amperes. In discussing Dr. E. Hopkinson's Paper last year, the author had given 1,450lb. as the tractive force of two motors.

Mr. PARKER: One motor.

Dr. E. HOPKINSON said, taking the figures as applying to one motor and following out the results, if the author had given the number of convolutions of the armature and the number of lines of force, not through the magnet but through the armature, the tractive force with any current could be at once determined; but this he had not done, and the result must be judged by the subsequent part of the Paper. It appeared, as far as could be judged from the small-scale diagrams appended to the Paper, that the mean current during the time of running was 110 amperes; that for one-fifth of the time the current was 100 amperes with the motors in series; for three-fifths of the time it was 150 amperes with the motors in parallel; and for one-fifth of the time it was cut off altogether, thus giving the mean current 110 amperes

* Minutes of Proceedings Inst. C.E., Vol. CXII., pp. 209 *et seq.*

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while the current was on, which agreed with the Author's result of 90 amperes while running. Taking the curve of tractive force and current and deducing therefrom the tractive force corresponding with the currents given in the Paper, this extraordinary result followed; that the average tractive force per ton of train was 55lb. It had been ascertained that on the City and South London Railway the average tractive force was 13lb. per ton of train. There was therefore the extraordinary discrepancy between 13lb. and 55lb. per ton for trains weighing practically the same, and working under much the same conditions. From the work done by this 55lb. per ton of tractive force, must be deducted the energy which was required to give the train its velocity. The total amount of work done in one section of the line of average length was 3,521,000 foot pounds, and the energy required to give a train of 39 tons a velocity of 21 miles per hour was 1,295,000 foot pounds. Hence, deducting this amount, which of course it was proper to do, the final result was that the tractive force required to work the trains on the Liverpool Overhead Railway was 35lb. per ton, *i.e.*, the force required to overcome the resistance only and not to give the train acceleration. That was a result much more than double the figure previously given for the City and South London Railway, and also greatly in excess of common experience. There were therefore good grounds for expressing the opinion that the Author had made the mistake of confusing the tractive force of one motor and of two motors; and that affected the comparison instituted by Mr. Greathead and by Sir Douglas Fox between electric and steam traction.

All systems of traction must be finally judged by the cost at which the service required was provided, and in that respect excellent results had been obtained at Liverpool. It was interesting to observe that, when local circumstances were taken into account, the results were almost identical with those obtained on the City and South London line as ascertained from the balance sheet for the half-year ending December 31, 1893. The weight of the trains and the speeds attained were about the same, but on the City and South London line there were somewhat steeper gradients and sharper curves, and the railway was in tunnels; on the other hand, at Liverpool there were somewhat more frequent stops. The total cost of traction on the Liverpool Overhead line, including current supplied for signalling and lighting, was 3·975d. per mile, with coal at about 55·10d. per ton; whereas, on the City and South London line, including current for lighting but not signalling, it was 6·22d. per train-mile with coal at about three times the price for the same calorific value, and a higher rates of wages obtaining. If the coal in the two cases had cost the same, the City and South London cost would have been 4·9d. per train-mile. It might, therefore, be taken as proved beyond doubt that such railways could be worked electrically at a cost for motive power of 4d. to 6d. per train-mile, according to the price of coal. But these results would undoubtedly be further improved upon in the future. On the Liverpool Overhead line the repairs amounted to 0·95d. per train-mile, whereas on the City and South London line, which had the advantage of having been working for three years, and therefore was in all its parts thoroughly well tested, the cost of repairs of all descriptions was only 0·7d. per train-mile; in fact, he had been recently informed by the engineer of the railway that many of the locomotives had now run over 100,000 miles, and that the cost of repairs upon them during the last 30,000 miles had not exceeded 0·03d. per train-mile.

Mr. T. Parker, in reply to the discussion, referring to Mr. Hedges' remarks on the Niagara Falls Electric Railway, compared it with the overhead wire system of tramways in South Staffordshire. On the latter line, the gradients reached as high as 1 in 16, sharp curves occurring upon some of them. The cost of working this system (each car carrying 34 passengers, being equipped with two motors, and weighing, without passengers, about 6¾ tons), during the six months ending December 31, 1893, including car drivers' wages, maintenance of generating plant, car motors, feeders, trolley wires and superintendence, was 4·16d. per car-mile. In the case of the Blackpool tramways, for which the Author designed the dynamos and motors, the cost of running during the year 1891 amounted to 3¾d. per car-mile, this amount including costs usually charged to haulage, but exclusive of traffic expenses, repairs to permanent way, and general management expenses. It had many mechanical and electrical defects in the method of conveying and collecting the current. In the Madras tramways, with which he was now engaged, the slot was not in the centre of the road as at Blackpool, but in the groove of one of the rails, and ¾in. wide. The difficulty of securing satisfactory collection from underneath the road through the slot and past the points, had previously prevented that mode of slot from being brought into use, but he had now surmounted those difficulties, at a cost of about £1,600 per mile over ordinary road.

The great amount of power required in starting the trains on the City and South London line had been pointed out by Mr. Trotter, and upon that point he would refer him to Fig. 7., p. 554, *ante*, which showed that the trains at Liverpool required less energy at starting than when in motion, and the advantage of placing motors in series for starting and afterwards in parallel. Attention had been directed by Mr. Preece to the rope-driving used at Liverpool, and in reply to his remarks, Mr. Parker could only state that he had most careful tests carried out, and had submitted them to the Institution in all good faith. The data used in comparing those tests was taken chiefly from high-speed engines and direct driving; and there was no definite proof that high-speed rapidly-reciprocating engines did not absorb as much power in arresting and accelerating their parts as was required to drive ropes arranged as at Liverpool. With regard to electrical leakage, the Liverpool Overhead Railway was very favourably situated, as the iron structure afforded an easy return for straying currents. The point to be considered was whether the progress of electrical engineering should be retarded by the telephones and telegraphs claiming to remain monopolists, or whether the necessary modifications should be made to enable them to work side by side with other electrical enterprises. It was highly satisfactory to him to hear Mr. Cottrell speak in such terms of the railway, and state that he had been able to reduce the cost to 3·34d. per train-mile. The arrangement of the switches on the motor cars had not been discussed. It was such that when the brake was applied the switches immediately flew out and cut off the current from the train.

In comparing the energy used on the City and South London line with that used on the Liverpool Overhead Railway, Mr. Siemens had not given the whole data. The trains at Liverpool were 12 per cent. heavier, ran at an average speed 24 per cent. greater, and made an average of 50 per cent. more stops in the same distance; therefore comparison of energy used was misleading, unless those features were considered. Mr. McDonnell had stated that the trains at Liverpool were suitable for the Overhead Railway, because they ran at short intervals and were small trains, but would not be adapted to the District or the Metropolitan Railway. There was no difficulty in running heavy trains at short intervals on the Metropolitan Railway, as the light trains were run at short intervals in Liverpool, and with the same proportionate economy, with all the advantages of cleanliness and freedom from combustible gases in the tunnel. In comparing a branch-line locomotive for coal used, it did not appear that Mr. McDonnell had taken into consideration the high speed and number of stops on the Liverpool Overhead Railway. In stating the costs of working, there had been no omission to take into account the depreciation and renewal of stock, as that was part of the contract with the Liverpool Overhead Railway. With respect to the life of the dynamos and electric motors, he had no hesitation in stating that the depreciation would be found to be less than with steam engines, and they were much more easily renewed and repaired. He asserted that the electric system of traction was thoroughly suitable for the Metropolitan Railway, and superior in every respect to the locomotives in use. In discussing mechanical appliances for tramways, to enable motors to be run at constant speed, Mr. Beaumont had dealt with a subject that had engaged much attention; but the difficulty of getting mechanism of any kind to work in the space available, and yet have a reasonable life, had not been surmounted.

The efficiency, 88 per cent., between I.H.P. in the cylinders and power delivered at the dynamos, had been questioned by Dr. E. Hopkinson. This Mr. Parker had referred to in replying to Mr. Preece. The tractive force on the City and South London line with a current of 150 amperes was given by Dr. Hopkinson as 50lb. per ton of train. The motors at Liverpool with the same current gave a tractive force of 120lb. per ton of train; so it would appear that the motor at Liverpool would start a train twice as heavy with the same current, or be in the same degree more powerful to accelerate the load. A motor must be judged by the manner in which it served the purpose for which it was built. In words Dr. Hopkinson had admitted that the motors were rightly designed, yet had condemned them by figures. The figures would perhaps be correct if the motor ran at a constant speed, but where it was necessary for motors to be constantly starting and accelerating as at Liverpool, the figures given by Dr. Hopkinson did not apply.

Mr. Greathead, in reply, observed that no criticism had been made in reference to the structure, and he would therefore say a few words about other matters. He had hoped more would have been said on behalf of steam locomotives. Astonishment had been expressed by Mr. McDonnell at the high coal consumption on the Manhattan Railway, 54lb. per train-mile, as compared with the coal consumption on a small branch line in England; but he had overlooked one very important factor, viz., the distance between the stations. That had a most important effect upon the coal consumption of a railway. He had the curiosity a few days ago to calculate what the coal consumption would be upon the inner circle of the Metropolitan Railway if the stations, instead of being on an average half a mile apart, were one-third of a mile apart, and found that to obtain the same speed the coal consumption would be almost doubled. On the Manhattan Railway the stations were about one-third of a mile apart, and the coal consumption was not

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excessive for the work the locomotives were doing. Reference had been made to the leakage of 2 or 3 amperes at Liverpool. It was often difficult to determine whether Mr. Preece was serious in making his remarks. Those remarks were made gravely, almost solemnly, but Mr. Greathead concluded from the fact that the Company had never heard anything from the Post Office, that they were not really serious. The leakage of current from the main conductor would readily find its way along the iron structure, and would probably none of it reach the earth. In reference to what Mr. Siemens had said, as to the currents required for the motors at Liverpool compared with those required for the experiments on his locomotives, it might be interesting to give some figures as to the actual current employed in working the two railways. He found at Liverpool, taking the output of the generating station and the train-miles as the basis of calculation, that during January and February each train on an average took 36½ E.H.P. On the City and South London Railway, where the speed and the weight of train were about the same, the average power taken was 33 E.H.P. per train; so that in the actual work there was very little difference. But in the case of the Liverpool line, there were included in the demands upon the current the working of the brakes, the working of the automatic signals and of the tools at the shop, and also the lighting of the generating station, the stations, and the trains. Further, the trains had to make a great many more stops, the average distance between the stations on the City and South London Railway being about 1,100 yards, while on the Liverpool Overhead Railway it was only 750 yards. On the former line, the lighting of the trains and stations was included, and formed, of course, a larger portion of the whole than at Liverpool, the lights being required throughout the day's working.

CORRESPONDENCE.

Mr. JOHN A. F. ASPINALL thought it had been attempted to compare to a certain extent the working of an electric line with an ordinary railway worked by locomotives, somewhat to the disadvantage of the latter, and that it would be well in the early stage of such comparisons to put the figures upon a proper footing. The working expenses for motive power had been stated in the Paper to be about 4d. per train-mile, and the consumption of fuel at about 16lb. per train-mile for trains of about 38 tons weight, running at 12 miles per hour; and those figures were compared with statistics of the New York Elevated Railway, where 54lb. of coal were used per train-mile. If the comparison was to be a fair one, electrical railways, such as had hitherto been constructed in England, should not use the train-mile as the divisor for the figures of the main lines of the country. When dealing with railways worked by locomotives, the engine-mile was the only figure which could be applied in order to put the comparison upon a proper basis. In order to explain this, if an ordinary railway had 1,000 engines, it was quite possible that 300 of them might never run a train-mile, but might be employed dailing in shunting and marshalling heavy loads, pulling them in and out of sidings, and adding to the expenses of the locomotive department as a whole without increasing the divisor, as the mileage run in that case was called engine-mileage and not train-mileage. If the engine-mileage figure of ordinary railways were taken, it would be found that one at least of the largest railways in Great Britain was able to do all that additional work and to run very heavy goods trains, entailing considerable expenditure, at a figure slightly exceeding 6d. per engine-mile, including the amount required for the maintenance and the renewal of the whole of its stock; whereas, the 4d. per train-mile spoken of as being the cost on the electrical railway did not include any sum for renewals of stock, which, sooner or later, would have to be provided. If the amount shown in the half-yearly accounts of the Liverpool Overhead Railway as having been spent on working stock and generating stations—namely, £73,744—were taken as a fair figure, it was evident to any one familiar with the subject that a proper provision for the renewal of plant would require an expenditure of about 2d. per train-mile, which would make the cost for locomotive power on the Liverpool Overhead Railway about equivalent to that of working any ordinary light railway. To confirm these figures, he would refer to the Paper* on the City and South London Railway, by Dr. Edward Hopkinson, in which the cost of working that line in several half-years was given, showing that the locomotive expenses varied from 9·1d. at first to 7·1d. in the half-year ended December, 1892. So far as appeared in the Paper, even those figures did not include any sum reserved to meet the depreciation of the plant. With regard to the consumption of coal, he would ask why the authors had gone to New York to ascertain what a locomotive consumed in doing a given amount of work? There was no first-class railway in England that Mr. Aspinall knew which consumed more than an average of 41lb. of coal per engine-mile, which included the consumption for its heaviest goods and passenger work; but the work done by these electrical railways was not heavy but extremely light, and, even if compared with the work done by any of the express trains between London and the North, the consumption of coal did not show very favourably. He noticed that Mr. Parker had stated in the second Paper that the consumption of coal was 22½lb. per train-mile during April and May, and that it was only during August that the 16lb. was approached. If the authors had been anxious to ascertain what a locomotive dealing with suburban traffic consumed, they need only refer to Mr. Stroudley's Paper of ten years ago, where they would find that his four-wheel coupled tank-engine was doing the work with a load stated in the Paper at a consumption of about 16lb. of coal per mile. He laid special stress upon this matter, because if a comparison was to be made about fuel consumption, it should be made with English railways and not with American, where but little care was taken about economy in fuel, possibly because the price of coal was about one-half that in England.

* *Minutes of Proceedings* Inst. C.E., Vol. CXII., p. 209.

The selection of the Metropolitan District in Table B, or even the Great Northern suburban train in Table A of the first Paper, was not a happy one; as he had not the slightest doubt that the Liverpool Overhead Railway, with its easy gradients and curves, its low speed and light trains, could be well worked by properly-designed locomotives at a cost of something under 6d. per mile, including all charges for running and for the maintenance and depreciation of locomotive stock, if the drawback of the possibility of sparks and smoke was not considered.

In reference to the design of the carriages, he must express surprise that after the careful examination that had been made of the elevated railways of New York, cars constructed like those described in the Paper should have been put upon the Liverpool Overhead Railway, as one of the most striking things on the elevated railway in New York was the way in which the cars were rapidly filled or emptied by the central passages and end platforms. In the Liverpool cars side doors had been constructed, which were inconvenient, with the further objection that, when they were opened on entering a station, they tended to sweep the narrow platforms. As to the construction of the ironwork of the viaduct, and the bridges on the railway, he had nothing but admiration for the simplicity and neatness of the design, and would say that the machinery for bending and drilling the plates was both well designed for its work and of the simplest possible character.

Mr. R. E. CROMPTON congratulated the author of the second Paper on having obtained a very high economical efficiency from the boilers, engines and dynamos; but he had given the electrical horse-power at the terminals as 88 per cent. of the horse-power in the cylinders, a figure which Mr. Crompton believed to be impossible under the circumstances. He had no doubt the author had obtained a very high figure; but would show that the efficiency mentioned must be considerably below 88 per cent., when rope-driven sets, such as those described were used. The Sulzer engines made by Messrs. Carels, of Ghent, had the best reputation for high mechanical efficiency on the Continent of Europe. Having made careful inquiries, he had found that those manufacturers rarely succeeded in obtaining an engine efficiency exceeding 90 per cent., and that they were doubtful whether 91 per cent. had ever been recorded with a condensing engine, which must include the friction of the air pump, &c. If it were supposed that Messrs. Musgraves' engines were as efficient as those of the Sulzer type, and if 2 per cent. at the dynamo-pulley only were allowed as the loss in the rope drive, the result was 88 per cent., which was the figure claimed by the author at the terminals of the dynamo after all the mechanical and electrical losses of the dynamo had been taken into account. It was true that the author claimed an electrical efficiency of 97·7 for the dynamos, so that it was possible, if they were direct-driven, and the bearings were thus relieved from the side stress, that they might have a commercial efficiency of 96 per cent.; but a long series of experiments made by Mr. Crompton at Chelmsford had shown him that when dynamos were driven by ropes or belts so that there was side stress on the bearings, a commercial efficiency exceeding 95 per cent. could not be obtained; 95 per cent. of 88 per cent. was about 84 per cent., and that in all probability would be found to be the maximum efficiency actually obtained when the author repeated his experiments with carefully calibrated instruments. On the excellent evaporative result he had obtained from the boilers when burning small Lancashire slack the author was to be specially congratulated, having effected results not hitherto attained in electrical works using that class of fuel. The coal consumed per kilowatt hour for the month of September was exceptionally low, and compared favourably with the best figures obtained in any electric lighting station, the only one approaching it being that of the Kensington station in London, which used 4·95lb. of Welsh coal per kilowatt-hour.

(To be concluded.)

Electric Locomotives.—The well known Baldwin Locomotive Works at Philadephia have just completed their first electric locomotive.

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GAS TRACTION AT BLACKPOOL.

We do not know whether it is consistent with the dignity of a President of an Engineering Society to chuckle; but, if it be so, we feel sure that the President of the Institution of Mechanical Engineers must have so far indulged himself on receipt of the prospectus of the Blackpool, St. Anne's and Lytham Tramway Company. Was it not but five short months ago that he ventured to depart from the usual dull groove and impart a little wholesome criticism of engineering methods into a Presidential Address, and by so doing did he not draw down upon him the anathema of electric traction men because he pointed out the obvious fact that directness, at any rate, is not one of the advantages of electric traction, and because, looking at the matter from this point of view, he was sanguine of the "ultimate possibilities" of self-contained gas-motor cars? To-day we have a line, which most of us hoped would have added at least another eight miles to the present meagre total of electric tramway mileage in the United Kingdom, adopting Lührig gas-motor cars.

Nevertheless, we do not think that the electric motor car is in consequence about to be relegated to the scrap-heap, or even to a back seat. The line which is in contemplation is very level throughout; it runs along a breezy sea front, and those who travel by it will consist mainly of holiday-makers, volunteers, and golfers, none of whom are likely to prove over particular with regard to such disagreeables as smell, heat, and noise. If gas traction is in reality destined to prove a formidable rival to electric traction, it will have to

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contend with electricity not merely under the highly favourable conditions which obtain at Blackpool, but in narrow streets, where no sea-breeze assists in the deodorisation of the stuffy thoroughfares, where travellers are a trifle exacting, and not likely to look favourably upon a box-full of small nuisances, and where it is not usually a case of Hobson's choice, as it will be at Blackpool. If the public gladly suffer gas-motor cars at Blackpool, it will be time enough for makers of electric motors to prepare to meet a serious rival.

From the mere engineer's point of view a reduction in the number of transformations of energy, and a saving of a certain percentage in operating expenses are great accomplishments, but in tramway matters it is not so much cheap traction as comfort and convenience that win the day. And in these respects the gas-motor car leaves very much to be desired. It is the public, not the engineer, who ultimately decides the question. Coming, however, to the question of cost, electricity may be relied upon to hold its own. A comparison between the working of an undertaking like the Liverpool Overhead Railway with the running of a lot of little tramcars may, at first sight, appear greatly out of proportion. The cases are altogether so different, it may be said. On the one hand there is a train, consisting of three or more heavy coaches, and capable of carrying nearly a hundred passengers; and, on the other hand, there is a single car, the maximum carrying capacity of which does not exceed forty persons. But what if it is found that the expenses involved in running the heavy train a mile are little more than 20 per cent. greater than the sum it is proposed to pay for conveying the light car a similar distance? It has been arranged that the Blackpool-Lytham tramway shall be run by a syndicate, for seven years, for a sum of 4½d. per car-mile, with a minimum of 163,000 car-miles per annum. The contractors for the electrical equipment of the Liverpool Overhead Railway found that they could make a handsome profit out of their arrangement to run the railway for 4d. per train-mile; and that railway is now being run at a cost of about 3½d. per train mile. Adding to this last-named sum the charges which are necessary in order to make the two cases cover as nearly as may be the same items of expense, it will be found that the relative costs stand at 5½d. per train-mile at Liverpool, as against the proposed 4½d. per car-mile at Blackpool. When the comparisons are based upon the costs per possible passenger-mile or per ton-mile, they show even more favourably on the side of electric traction. It is conceivable, of course, that 4½d. represents a sum hugely greater than the actual cost of running a gas car; but we do not think it probable that this is so. Commercial considerations would conflict with any temptation to try and reap gigantic profits in the case of so novel a project; and it seems likely that the figure covers no more than the working expenses and a reasonable profit. But electricity need not, as a matter of fact, go so far afield as Liverpool to be justified of her children. The historic Holroyd Smith electric tramway at Blackpool itself, pioneer concern as it was, cost, on the same basis as that upon which the Blackpool gas-motor contract has been made, only 2¾d. per car-mile to run, and that on such a diminutive mileage as 98,000. An electrical syndicate, therefore, might well have made a seven years' contract for less than 4½d. per car-mile, and withal have reaped the reward of conscious merit and of an excellent bargain.

This being the case, we hold to the belief that there remains yet a great deal to be done before gas traction can assume a formidable rivalry with electric traction. Gas traction may, of course, be vastly improved in time; but so will its electrical competitor.

THE CHEMICAL THEORY OF ACCUMULATORS.—I.

BY E. J. WADE.

The reversibility of the primary or ordinary galvanic cell, as embodied in the secondary or storage cell, is but one more example of the universal law of action and reaction. Hardly had the voltaic pile been invented before it was discovered that when at work it developed some resisting or opposing force, which tended to choke down the flow of current; and, further, if it were connected to a pair of metal plates or wires dipping into some saline conducting liquid, these latter themselves acquired the power of giving a momentary current after disconnecting from the pile. Gautherot first observed this phenomenon in 1801 while decomposing salt water with wires of silver and platinum. Two years later Ritter obtained the same effects with gold wires, noticed the formation of metallic films and peroxides by electrolytic action, and embodied the results of his observations in his secondary pile, which consisted of discs of copper separated by pads moistened with saline solutions, and which, when charged up by a battery composed of a larger number of elements than itself, could give out transitory currents of considerable intensity. These secondary currents were rightly thought to be due to the recombination of the acids and bases set free when the salts were decomposed by the passage of the primary current. Some years later, however, it was observed that similar currents could be obtained from platinum wires which had been used to decompose dilute sulphuric acid, or even pure water, and as in this case the metal was not oxidised, and there were no salts present to be decomposed, it was maintained that they must have a physical rather than a chemical origin, and the wires were said to be "polarised," while the phenomenon itself was termed "polarisation." During the years that followed numerous investigators were constantly at work on the subject, but nearly all from the same point of view, and with the same object. They regarded polarisation effects as of no value in themselves, but studied them in order the better to be able to destroy or reduce them to a minimum, and so increase the efficiency of primary cells, and it was during this period that the Daniell, Grove, Bunsen, and other constant current batteries were invented. It was conclusively proved, however, that polarisation was always due to purely chemical causes, and in the cases just mentioned was caused by the decomposition of the water itself into its constituent gases, which were liberated at either pole, and generated secondary currents during their recombination. Platinum wires, which had been immersed in oxygen and hydrogen gas respectively, gave currents in dilute acid just the same as those which had had a primary current passed through them, and Sir W. Grove constructed his well-known gas battery, which he described in 1842, on this principle. Although Grove set up his battery by the addition of oxygen and hydrogen previously prepared, he could, as he well knew, have energised it equally well by sending a current through it and decomposing the water, and it may be considered, therefore, as the earliest form of reversible battery which was fully recognised as such. In fact, no storage cells of more recent date present the principle on which their action depends in a simpler or more striking form than does this gas cell of Grove, and besides which it embodies some of the chief points that go to the making of a good accumulator in such a complete manner that, although practical difficulties stand in the way of its adaptation commercially, it will always possess a very considerable theoretical interest.

The line of research, however, that it might naturally be thought to have suggested was not followed up, because in those days the need of a cell for the storage of electricity was not felt, and even if one had been invented it could have been of very little use. Primary cells were then the only known source of dynamic electricity on any practical scale, and to have set up a number of these merely to charge a smaller number of accumulators, instead of using them direct for the purpose in view, would obviously only have been a waste of both labour and material.

Gaston Planté was the first to investigate polarisation phenomena with a view to their utilisation instead of their elimination, and in 1859 he commenced the series of researches

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which are embodied in his well-known work. The experiments he carried out, and the apparatus he employed, were of the very simplest nature. Rods of various metals were in turn placed in a small acid voltameter or electrolytic cell, and a current passed through it from two or three Bunsen cells; then, by means of a simple form of mercury switch, the battery was cut out of the circuit, and the voltameter at once connected to a sensitive galvanometer. In this way he carefully examined the polarisation in dilute sulphuric acid of all the ordinary metals, and found that every one of them gave secondary currents, although in some instances very slight and transitory; but that those obtained with lead electrodes far exceeded the others both in duration and intensity.

Guided by this observation, he then constructed his famous spiral form of lead accumulator; investigated the best method of "formation" for increasing its capacity, and utilised a number of such cells to carry out a variety of experiments on the heating and other effects of very large currents, which it would have been almost impossible to obtain without their aid. His book should be carefully read by everyone interested in the subject, not only on account of its suggestiveness and the information it contains, but also as an example of the results that may be obtained from the minute and accurate observation of the simplest phenomena, and of the thorough way in which scientific research should be conducted. Although, owing to the limitations of electro-chemical knowledge at that date, his explanations of some of his experiments were necessarily incorrect, later investigations have never, in the smallest particular, impugned the accuracy of his experiments and observations themselves, while many of the points to which he drew attention have only been rediscovered in quite recent years. He noticed the evolution of oxygen from the peroxide pole on breaking the charging circuit; the formation of peroxide at the spongy lead pole when discharged; the presence of unstable compounds (peroxide of hydrogen and persulphuric acid) in the electrolyte; and he further remarked that these latter were produced in greater abundance with lead than with platinum electrodes. Even yet, however, the time was not ripe for the commercial development of the storage cell, and no further advances were made in this direction for some years; but, as soon as the evolution of the dynamo-electric machine reached such a stage as to render the production of large currents at high E.M.F.s a comparatively easy and inexpensive matter, interest in the subject was revived. In 1881 Faure took out his patent for preparing the active material of lead plates from a paste of oxides applied to their surface in order to obviate Planté's long and wearisome process of formation from the electrodes themselves, and the modern history of the accumulator may be said to commence from that date. Since then no alteration in principle has taken place, although the cells have been enormously modified as regards the details of design, construction, and management, so as to render them far more durable and efficient. At first the "pasted" cell was considered to be in every way an advance on the earlier "formed" type, and was for a time employed almost exclusively; but, latterly, improved forms of Planté cells have come into very considerable use, together with a third class, in which the active material is prepared independently by special processes, not only from oxides, but from chloride and other salts of lead, and is then used either alone or with a supporting and conducting frame cast round it; and nowadays all three kinds very fairly divide the honours between them.

The interest and avidity with which the Faure cell was received and taken up caused inventors to turn their attention to the construction of accumulators with electrodes of other metals than lead, for it was perceived that these offered greater possibilities as regards the amount of energy that could be stored for a given weight of metal. Sutton's copper-lead cell, Reynier's zinc-lead cell, and the Thomson-Houston zinc-copper cell are amongst some of the earliest forms of the different combinations tried, and the problem has been again and again attacked, but with such little success that the present day, with the exception of the Waddell-Entz zinc-copper cells on the Third Avenue tramcars, New York, none but lead-lead peroxide cells are in practical use, and the mere term "accumulator" or "storage cell" is tacitly understood to imply this combination, unless specially qualified, the others being regarded by the majority as but little more than electrical curiosities.

The sharp distinctions thus made between lead storage cells and all others, whether primary or secondary, has given rise to a very general notion amongst those who have not specially studied the subject that there must be some fundamental difference in their principles of action by which this may be accounted for, and it is worth while, therefore, endeavouring to show that this impression is an erroneous one, and not at all in accordance with the real facts of the case.

Theoretically, there is no difference between a storage or secondary cell, and a primary cell; both are apparatus for the conversion of chemical into electrical energy. The use of lead peroxide as a depolariser was known to Faraday and others long before Planté prepared it electrically, and if some chemically-prepared peroxide is packed round a plate or rod of lead, and put in dilute sulphuric acid with another plate or rod of lead, surrounded with porous or spongy metal that has not been allowed to oxidise, the combination forms what would ordinarily be termed a primary cell, but one having the same properties as any lead accumulator, whether of the Planté or Faure type. On the other hand, if, instead of putting fresh materials into an exhausted Daniell cell, a current is passed through it in the reverse direction, it forms a Thomson-Houston accumulator; if an exhausted Leland-Chaperon cell is treated in the same way it becomes the germ of the storage cell of Desmazures and many others, and, as has been shown above, the Grove gas cell is a primary or secondary cell, according to the way in which it is set up. In reality, therefore, every secondary cell is a possible primary cell, and every primary cell a possible secondary cell. Even a Grove or Bunsen cell might be recharged electrically if special appliances were provided to collect and retain the fumes or gases that escape during the discharge; and Planté showed that every one of his combinations gave some signs, however slight, of secondary currents. The whole question resolves itself into one of the degree of practical reversibility. Whether it is possible, by passing a current in the opposite direction, to exactly reverse the changes that took place while discharging and restore a cell to the same condition, both chemically and physically, that it occupied at first; or whether it is easier to re-energise it by removing the spent materials and substituting others in their place. Here, then, lies the superiority of a lead-lead peroxide cell to all others. If properly treated it may be regenerated electrically, and so nearly restored to its original chemical and physical state that it can be discharged and charged in this way hundreds or even thousands of times before the total results of the slight changes that do take place depreciate it sufficiently to incapacitate it from further use; while with all other cells the changes that occur with each charging are relatively so large that although every possible means has been tried to reduce them to a minimum, they rapidly deteriorate, and require constant attention and repairs. The reason for the more complete reversibility of a lead cell is entirely due to the chemical behaviour of certain of the compounds into which that metal enters. Lead alone amongst all the metals forms a sulphate that is practically insoluble and unacted upon in water or dilute sulphuric acid, and it also combines with oxygen to form a peroxide having a good electrical conductivity, and equally unaffected by those liquids. When, therefore, a lead-lead peroxide couple is discharged in dilute sulphuric acid, the lead sulphate, which is the ultimate product formed at both poles, does not dissolve up in the solution, but remains on the surfaces of the plates ready for reduction and reoxidation when the current is reversed. Any local action that goes on when the cell is not at work also results in this insoluble sulphate, which tends to form a protecting film on the metal, and thus reduces losses from this cause to a minimum. The compounds formed when any metals other than lead are used as negatives—not necessarily in sulphuric acid, but in any other practically possible electrolyte—are all soluble, and dissolve in the liquid as fast as they are formed, and this simple fact has up to the present barred the way to any substantial progress with these classes of reversible cells.

Without going into the details of the difficulties that have to be met it is sufficient to point out that up to the present,

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and in spite of the numerous devices that have been tried, it appears almost impossible, firstly, to redeposit the metal either completely or in an efficient condition, and, secondly, to prevent a very serious amount of local action, because fresh surfaces of the metal are constantly exposed as the first portions dissolve up. If, however, these obstacles in the way of further progress can be successfully removed, and there is no fundamental reason why this should not be done, the use of lead for the negatives, at any rate, of storage cells would, in all probability, become a thing of the past; for, as regards its electrical behaviour, there is a good deal to be said against that metal, both theoretically and practically, as is suggested by the fact that it is hardly ever employed in primary cells.

Theoretically, the amount of energy that 1lb. of lead would generate, if wholly converted into lead sulphate, could be produced by about ¼lb. of zinc or iron, or about ½lb. of copper, in spite of the electro-negative character of the latter metal. Practically, the very property of lead, which at present constitutes its superiority to other metals—that is, the insolubility of its sulphate—at the same time seriously limits its efficiency by reducing the energy actually obtainable per pound of metal to a small fraction of the amount theoretically possible. In the first place, the active material requires a grid, or support, of inactive material, which, even in the best forms of pasted cells, will weigh as much as itself, and in Planté cells may be many times its own weight. Secondly, under the best conditions, not more than half the active material is really acted upon, unless the cell is run down below the normal limits, because the sulphate formed on its surface effectually screens the inner portions. The combined effect of these two causes is that not more than 5 per cent. to 15 per cent. of the total weight of electrodes is usefully employed; or, say, 1oz. to 2oz. per lb. of plates.

(*To be continued.*)

THE CONSTRUCTION OF RESISTANCES.*

BY D. K. MORRIS.

Resistances of various kinds are very widely used to facilitate every species of electrical measurement. All cable-testing whether for faults or for insulation, involves the use of resistances of definite value, and resistances capable of absorbing power are of great use in testing continuous-current machines, while similar resistances, designed so as to be non-inductive, are necessary in making tests of transformers or alternators. In fact, almost every electrical test involves the use of resistances of some form or other. The object of the present Paper is to give an outline of the principles which determine the construction of resistances for different purposes, and of the various devices commonly adopted to fulfil the requirements of each.

Resistances may be divided into two groups:—

(1) *Resistances of a fixed and definite value*, which include; first, those not intended to carry appreciable currents, such as standards of resistance and resistance box coils; and, second, resistances designed to carry considerable currents such as are used in potentiometer work. In all these, the changes of resistance, due to unavoidable alterations of temperature, should be a minimum.

(2) *Rheostats and Resistances for the absorption of Power.*—In these, the rise of temperature, due to the current passing through them, must be kept below certain assigned limits, while economy of construction is usually a most important factor in deciding the materials used.

Before proceeding to constructive details, it will be convenient to give an account of the resistance materials most frequently met with.

In the first group, where the variation of resistance with temperature is to be minimised, we have practically only four alloys to deal with—platinum silver alloy, German silver, platinoid and manganin.

In the second group there is a wider choice of materials, for the accurate value of the resistance is not so important;

Data of Resistance Materials.

—	Composition.	Specific resistance at 15° C. (= ohms per cm. × 10^9)	Change of Resistance % for a rise of 1° C. at 15°.
For Wires.			
Manganin	Cu, 84%; Mn, 12%; Ni, 4%.	46,800	less than ·001%
Platinum Silver ...	Pt, 33%; Ag, 67%	31,700	·024%
German Silver	Cu, 50%; Ni, 25%; Zn, 25%	30,100	·027%
Platinoid	same as above with 1 to 2% of Tungsten	41,900	·031%
Manganese Steel ...	a Steel containing 12% of Manganese	68,400	·125%
Iron	......	10,600	·480%
Miscellaneous.			
Carbon	......	about 4,000,000	–·026%
Mercury	......	95,400	+·071%
Dil. Sulphuric Acid	1 of acid to 12 of Water.	3,300,000,000	–1·5%
Sulphate of Zinc ...	Saturated solution at 15°C.	50,000,000,000	–2·3%

besides some of the previous, we have manganese steel and iron wires, carbon in various forms, and some conducting solutions.

In the table which I have prepared here you will see the composition, the specific resistance at ordinary temperature, and the temperature coefficient which I have calculated so as to answer to the definition at the head of the last column; the figures in this table are largely taken from the recent Paper by Profs. Dewar and Fleming on the "Electrical Resistance of Metals and Alloys at Low Temperatures." Of course, the materials commercially obtainable under these various names often differ much from the figures here quoted, not only in specific resistance, but even more in temperature coefficient.

The relative values of the figures in the last two columns—that is, of the specific resistance, and its percentage variation per degree centigrade, are, except for the non-metallic materials, illustrated graphically on this diagram (Fig. 1). Along the base line we have degrees of temperature centigrade from the freezing point up to 200 degrees,—just short of the point at which paper is charred; while the ordinates represent the specific resistance; that is, the resistance of a centimetre cube in C.G.S. units (electromagnetic).

This is the way it is usually given. In order to give one a practical idea of its meaning, it is, I think, convenient to bear in mind, that, very roughly, the specific resistance divided by 100 is equal to the resistance in ohms of a mile of No. 17 B.W.G. wire; or, again, it is equal to the resistance of 100 yards of No. 28. For instance, given that the specific resistance of iron is 10,600, we can say at once that 100 yards of No. 28, or a mile of No. 17, iron wire have each of them a resistance of 106 ohms approximately.

The line for copper has been added on the diagram to show how very small its resistance is compared with our other materials. The temperature coefficient at any point on a curve is represented to some scale by the slope of the curve divided by the ordinate at that point. For instance, copper, which, as you know, has nearly as large a temperature coefficient as iron, has a much smaller slope, but a correspondingly smaller ordinate.

We see from that diagram that manganese steel, which contains 12 per cent. of manganese, has by a long way the highest specific resistance of any substance available in the form of wires, if we except one or two alloys of which we know very little. As an instance of such an alloy there is a resistance material which has been brought out comparatively recently by Messrs. Krupp and Co., of Essen, which they call "Kruppin." Its specific resistance is said to be 83,000, which is greater than that of manganese steel, while its temperature coefficient is about the same.

Manganin, which is, I think, used much more on the Continent than here, is remarkable as having very little or no variation of resistance with temperature. It is an alloy con-

* A Paper read at a Student's Meeting of the Institution of Electrical Engineers, March 16, 1894.

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taining about 84 per cent. of copper, 12 per cent. of manganese, and 4 per cent. of nickel. The form of its resistance-temperature curve is shown in Fig. 2, there being a temperature of maximum resistance. The specimen tested by Dewar and Fleming in the experiments for the Paper previously referred to had its point of maximum resistance almost exactly at ordinary temperatures—about 15°C., but slight variations in its composition seem to shift this point considerably. However, even at 200°C., the decrease of resistance per degree rise of temperature was only $\frac{1}{100}$th per cent., which is still less than half that for any other substance.

You will see from the diagram that iron wire, which is rather handy for absorbing power, fully doubles its resistance by the time it gets fairly hot; while if carbon is used, in the shape of incandescent lamps, its resistance, when taking its full current, is practically one-half of what it is when measured cold.

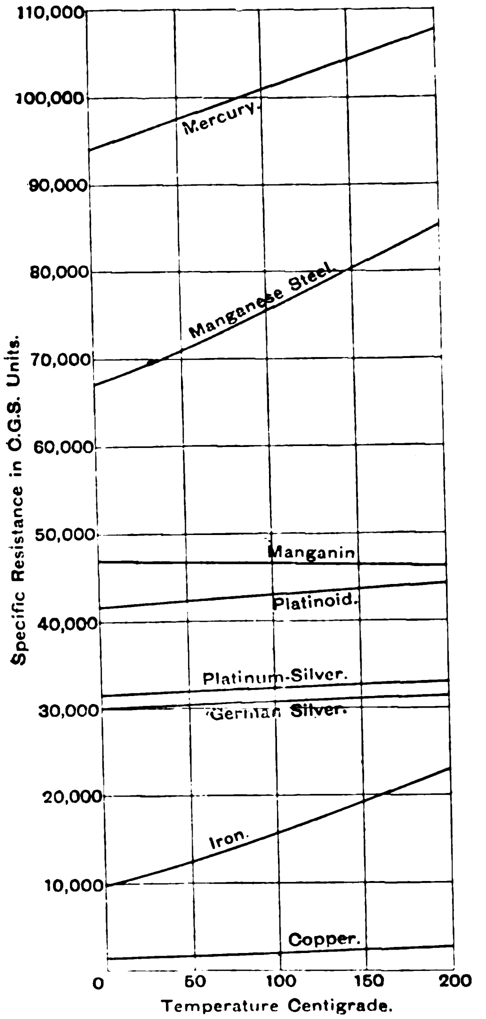

FIG. 1.—Resistance-Temperature Curves of Metals used for Resistances, the curve for Manganese Steel being drawn to Half Scale of Ordinates.

The temperature variation of resistance of the liquids with which we are concerned is much greater, being, in the case of a saturated solution of sulphate of zinc, a diminution of resistance of as much as 2·3 per cent. for a rise of 1°C.

Having now gained some idea of the properties of resistance materials, we can go on to the resistances themselves.

(1) *Resistances of a Fixed and Definite Value.*—First, not intended to carry appreciable currents.

Standards of Resistance.—The first standard of resistance which was at all practically used was that introduced by Werner Siemens. It consisted of a column of mercury 1mm. in cross-sectional area, and a metre in length—mercury being chosen because of the ease with which it can be obtained in a state of purity. This, of course, was only an arbitrary standard.

The elaborate researches which have been conducted on the evaluation of the ohm and other "absolute" units have had as their object the expression of these units in terms of the mechanical units which were previously in use, so that they might not have to depend ultimately on the electrical properties of any given metal or alloy. It has been decided that the best way of constructing a reproducible standard is that used by Siemens in the construction of his unit, mentioned above. Thus the standard ohm is defined as the resistance at 0°C. of a column of pure mercury 1 sq. mm. in section, and of a length which is determined by absolute measures. There have been many attempts to obtain this length, and the nearest approximation to the true ohm which we have at present is obtained when this length is 106·3cm. Hence the international ohm, as it is called, which was agreed on last summer at the Chicago Congress, is defined as the resistance of a column of mercury 1 sq. mm. in section, whose length is 106·3cm.

Mercury standards of resistance, though accurately reproducible from the previous definition, are obviously very inconvenient to preserve or use; for this reason secondary standards, in which the resistance material is in the form of wire, are used.

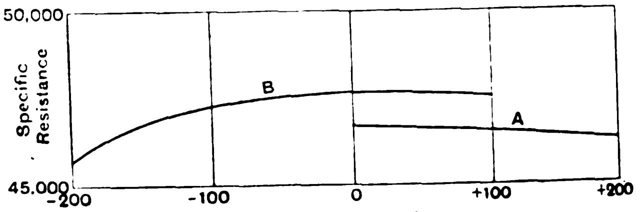

FIG. 2.—A, Manganin after Annealing. B, Manganin before Annealing at 100 C.

Such standards should not alter their value with lapse of time; they should be capable of assuming a certain specified temperature with rapidity, and their temperature coefficients of resistance change should be small, so as to minimise the error due to an inaccurate estimate of their temperatures.

German silver, which was used in the earlier resistance standards, is liable to become rotten in course of time, owing to the crystallisation of the zinc which it contains.

Manganin, which commends itself at once for such a purpose owing to its negligible temperature coefficient, is unfortunately liable to change in consequence of the oxidation of the manganese. And, practically, so far as we know, an alloy of one of platinum to two of silver is the only available substance for the construction of a really permanent standard of resistance.

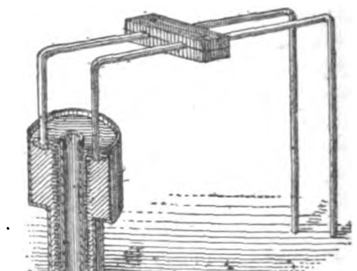

FIG. 3.

The form of standard which was introduced by the British Association is made as follows: The actual coil, the wire of which is doubled back on itself to avoid self-induction effects, is wound on a brass tube having ebonite cheeks; to the upper cheek, two long bent copper rods, kept separate by an ebonite distance piece, are attached, Fig. 3. The coil is then placed in an annular brass vessel, which is then filled up with paraffin wax.

It is, however, very difficult to get a large mass of substance, such as paraffin, which insulates heat as well as electricity, to assume a given surrounding temperature, as that of ice and water. It is also much more easy to determine the temperature of a given layer than it is to determine the mean temperature in a deep vessel. Hence the modification of the design by Dr. Fleming:—

The case or shell which contains the coil is in the form of a ring, Figs. 4 and 5, this ring consists of a pair of shallow circular

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troughs of brass, provided with flanges, which can be screwed together so as to form a square-sectioned annular space.

From this ring proceed upwards two brass tubes through which, though carefully insulated from them, pass two stout copper leads, as in the B.A. standard. The actual resistance coil is formed of a length of three-fold silk-covered platinum-silver wire, which is first baked above 100° C to dry it completely, and then immersed in melted paraffin wax. The wire is then cut the proper length, folded once on itself, and wound

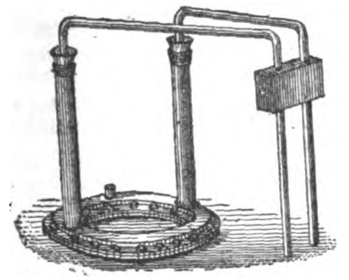

Fig. 4.

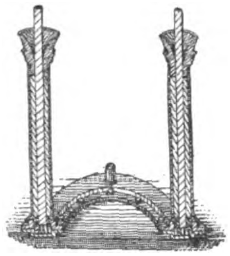

Fig. 5.

on a wooden mandrel of such a shape that the coil, when wound, will drop loosely into the hollow of the brass ring. After further insulation, it is packed into the upper circular groove, the resistance is accurately adjusted, and the bottom half of the ring is screwed on, the joint being made good by a thin indiarubber washer. Such a standard coil not only is capable of assuming the surrounding temperature conditions rapidly, but any heat produced by the current used in comparing its resistance, is quickly got rid of.

(To be continued.)

THE CANDLE-POWER OF GLOW LAMPS.*

In order to possess a full knowledge of the behaviour of the lamp as an energy-translating device, it is necessary to know four things about it. First, we must know the current, in amperes, which is taken by the lamp when a certain electric pressure is produced between the ends of the carbon filament. Generally speaking, lamps are denominated by the pressure at which they must be worked to give satisfactory results as to duration. This pressure measured in volts is called the *marked volts* or *maker's volts*, and lamps may be distinguished as 100-volt lamps, 50-volt lamps, 10-volt lamps, &c. The current taken by a lamp can be measured by many kinds of instruments, which are called *ampere-meters* or ammeters. The pressure between the terminals of the lamp can be measured by suitable *voltmeters*. Approximately speaking, a lamp intended to work at 100 volts and to give 16 candles light has a carbon filament about 5in. long and about $\frac{1}{100}$th of an inch in diameter, and when worked at a pressure of 100 volts it takes from $\frac{3}{5}$ths to $\frac{2}{3}$rds of an ampere. If we divide the number representing the electrical power in watts taken by the lamp by the number representing the candle-power of the lamps, the quotient gives us the number representing the *watts per candle-power*. In most modern lamps this last number varies from $2\frac{1}{2}$ to $3\frac{1}{2}$, when the lamp is being used at the marked volts. There are therefore four quantities in connection with every lamp which it is important to know. First, the *marked volts* or voltage of the lamps; second, the *ampere current* taken by the lamp at the marked volts; third, the *candle-power* of the lamp; and, fourth, the *watts per candle-power*.

It is important that, in making thus a determination of the constants of a lamp—viz., the current passing through the lamp, the pressure difference at the terminals of the lamp, and the candle-power of the lamp by comparison with a suitable standard of light—these quantities should all be measured at the same instant. By varying the current through the lamp, as we can do by using pressures of different values, we can obtain a series of observations by which the candle-power, current, and volts on the terminals of the lamp are all measured simultaneously for different values of the pressure on the lamp terminals, and these values can be set out in a series of curves which are called the characteristic curves of the lamp. In Fig. 1 is shown a curve illustrating the manner in which the light of a 16-c.p. lamp varies as the current changes. It

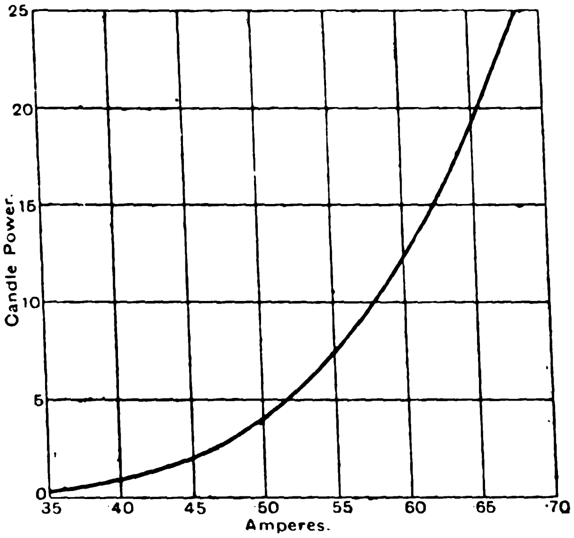

Fig. 1.—Curve showing Variation of Candle-power with Current in a Glow Lamp.

will be seen that a very small increase in the current is accompanied by a large increase in the light of the lamp, and it can be shown that the candle-power varies very nearly as the sixth power of the current. That is to say, if a lamp gives 1 candle light when a current of one ampere is passing through it, then it would give $2 \times 2 \times 2 \times 2 \times 2 \times 2 = 64$ candle-power if two amperes were passed through it. For a reason to be explained later, however, no lamp would bear such a relative increase in current. But the above-mentioned law

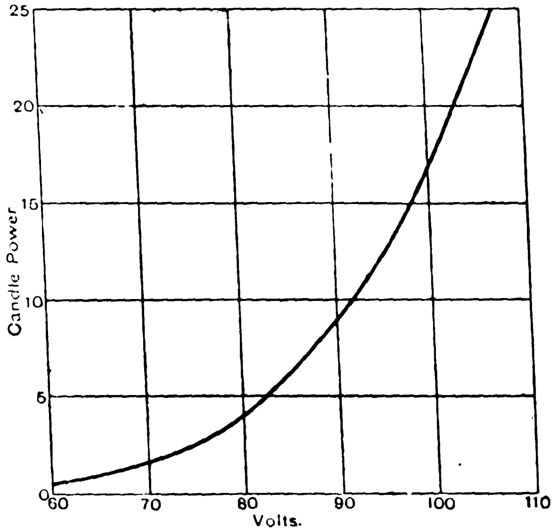

Fig. 2.—Curve showing Variation of Candle-power with Voltage in a Glow Lamp.

holds good proportionately for all glow lamps; viz., that the candle-power varies approximately as the fifth or sixth power of the current. In Fig. 2 is shown another curve, illustrating the manner in which the candle-power varies with the volts, and in Figs. 3 and 4 curves showing the manner in which the candle-power varies with the watts and with the watts per candle-power. From the curve in Fig. 3 it will be seen that the candle-power of the lamp varies very nearly as the cube of the total power in watts supplied to it. In other words, if we supply the lamp with twice the electrical power, the

* From a forthcoming work on "Electric Lamps and Electric Lighting," by Dr. J. A. Fleming, to be published by *The Electrician* Printing and Publishing Company. All rights reserved.

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candle-power is increased eight times. If we supply it with three times the electrical power, it is increased twenty-seven times. These curves will show, amongst other things, the great importance of preserving the pressure at the terminals of a lamp quite constant when that lamp is used as an illuminating agent. Any variation of the pressure, however small, produces a very serious variation in the candle-power of the lamp. It is convenient to bear in mind the following figures for the 16-c.p. lamp as generally made. Such a lamp

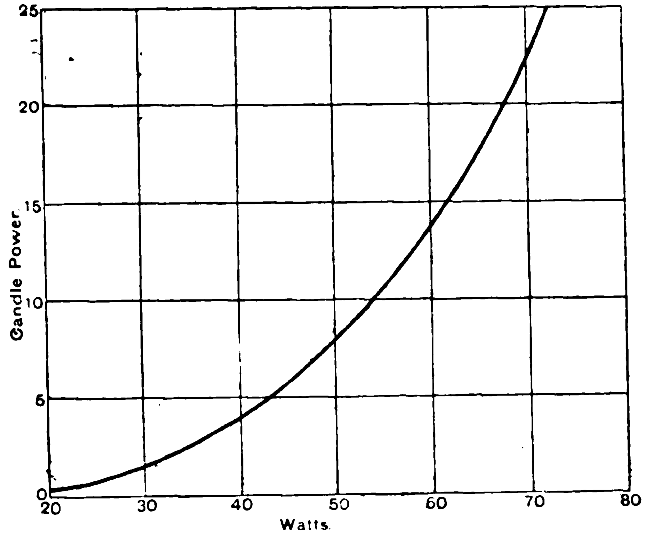


Fig. 3.—Curve showing Variation of Candle-power with Wattage in a Glow Lamp.

takes, when worked at a pressure of 100 volts, 0·6 or $\frac{3}{5}$ of an ampere, absorbs 60 watts of power, and therefore in $16\frac{2}{3}$ hours consumes an amount of energy which is $16\frac{2}{3}$ times $60 = 1{,}000$ watt-hours. This amount of energy is called one Board of Trade Unit, and is generally sold by the Electric Supply Companies in England at prices varying from 3d. to 8d.

As soon as we begin to use incandescent lamps in practice, even although the pressure at the terminals may be kept exceedingly constant, we find that lamps are like human

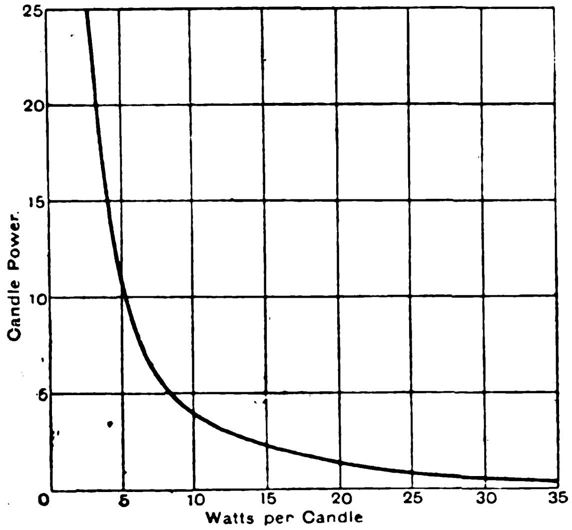
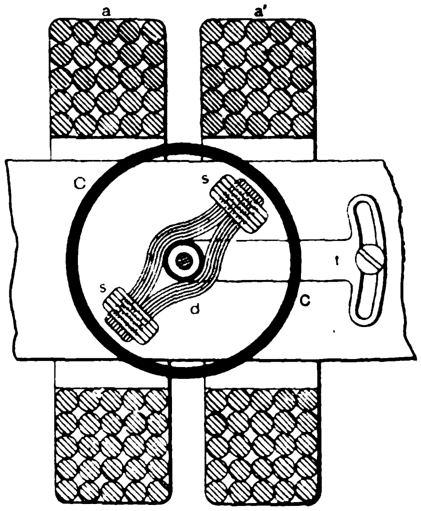


Fig. 4.—Curve showing the Variation of Candle-power with Watts per Candle-power in a Glow Lamp.

beings—they have a certain life or duration, and, moreover, most of them undergo a process of deterioration in light-giving power. After a certain time the filament of the lamp is destroyed, and the lamp ceases to work. The duration of any lamp when worked under certain conditions as to pressure and supply is called its *life*, and from a large number of observations of similarly constructed lamps when worked in a particular manner we can deduce the *average life* of a lamp. We cannot predict from observations of one or two lamps what the average duration will be, any more than we can tell from observations on one or two human lives what is the average duration of human life in any place. The life of any particular individual lamp may be only a few hours, or it may be many thousands of hours. This average duration is only one factor in determining the real value of the lamp as a translating device. Apart from accidental circumstances, the factors that determine the life of the lamp are the temperature at which the carbon filament is kept, and the nature of the surrounding gas. Assuming, however, that an incandescent lamp is supplied with electric current at a constant electric pressure: it is always found that two marked changes occur in the lamp in the process of time; first, the lamp begins to blacken by a deposit of carbon which is made upon the interior of the bulb; and, second, the carbon filament undergoes a change by which its electrical resistance becomes increased and its surface altered, so that, whatever its initial condition, its surface finally assumes a much darker and more sooty appearance than when first manufactured.

THE DUNCAN ALTERNATE-CURRENT METER.

One of the problems which has confronted electrical engineers has been the invention of a commercial alternating current recording meter which will record "all" loads correctly. In the early days of electric lighting it was customary to charge so much per lamp per week, month, or year, because there were no practical recording meters. This was, of course, most unsatisfactory both to supply companies and to consumers.



Before long various types of recording meters appeared, which recorded, it is true, but gave no satisfaction; for the greater part of them made electric light very cheap for the small consumers and very expensive for the large, on account of the slow speed on a small number of lights.

A meter which, it is claimed, solves the problem, and which is dependent on the principle of the repulsion of a closed secondary from its primary, and is a practical development of Prof. Elihu Thomson's experiments, has now been brought out by Mr. Thomas Duncan, of Fort Wayne, Indiana. The essential parts of the meter are the primary or field coils *a*, *a'*, which are connected in series with the lamp circuit, the secondary or armature C consisting of an aluminium cylinder, a magnetic path-diverter, *d*, made of laminated iron, and carrying a closed secondary, *s*, which consists of several copper punchings; the aluminium fans, the registering train, and the spindle which carries said armature and fans. The armature has no electrical connection with the circuit. It is claimed that the speed on one light is a few per cent. slow, on some as low as 2 per cent., but that on all other loads the meter is correct.

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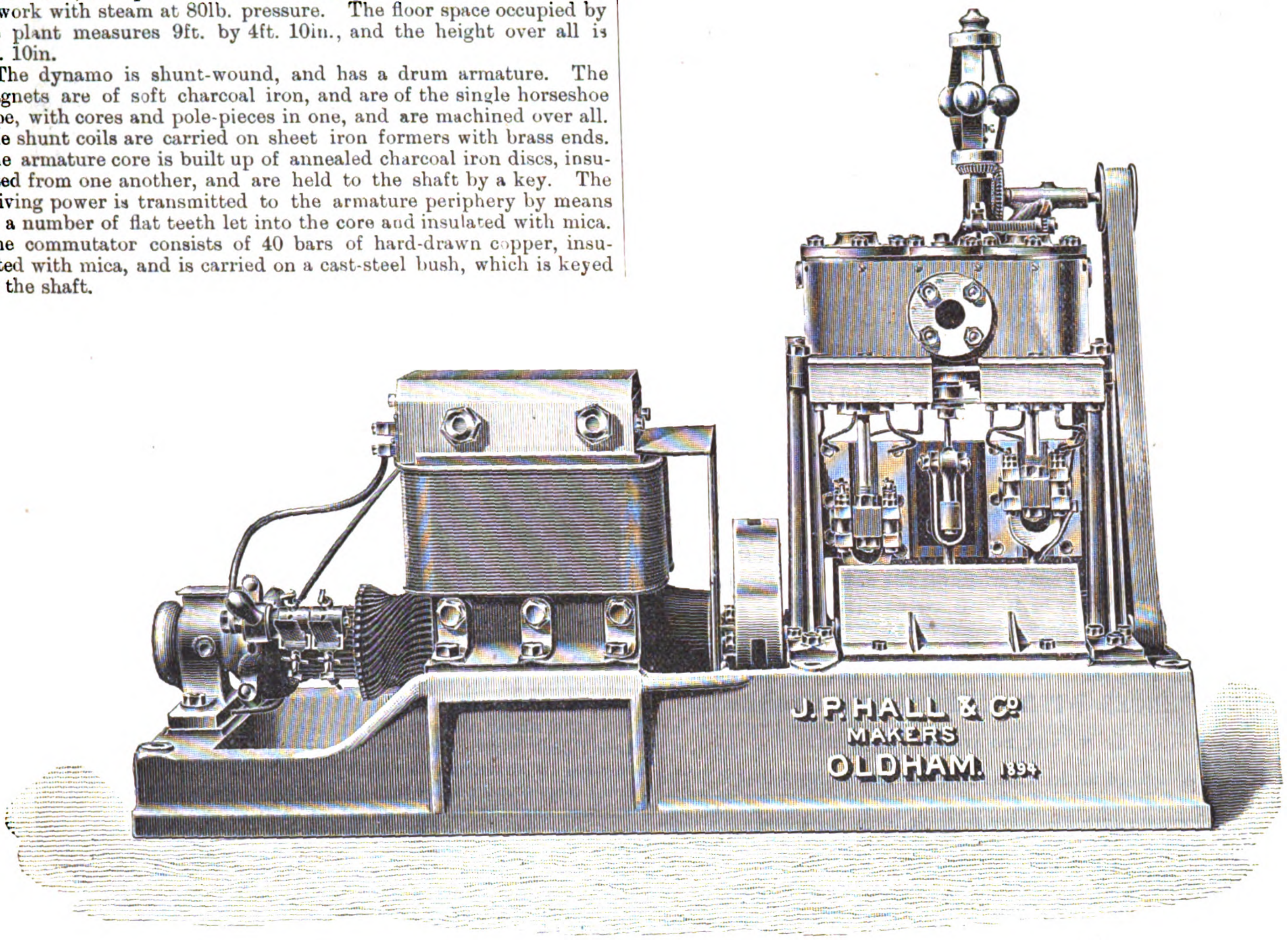
COMBINED ENGINE AND DYNAMO.

The accompanying illustration shows a combined steam engine and dynamo, manufactured by Messrs. J. P. Hall and Co., of Oldham. The plant is designed to give an output of 40 amperes at 100 volts, at a speed of 500 revolutions per minute, and is intended to work with steam at 80lb. pressure. The floor space occupied by the plant measures 9ft. by 4ft. 10in., and the height over all is 3ft. 10in.

The dynamo is shunt-wound, and has a drum armature. The magnets are of soft charcoal iron, and are of the single horseshoe type, with cores and pole-pieces in one, and are machined over all. The shunt coils are carried on sheet iron formers with brass ends. The armature core is built up of annealed charcoal iron discs, insulated from one another, and are held to the shaft by a key. The driving power is transmitted to the armature periphery by means of a number of flat teeth let into the core and insulated with mica. The commutator consists of 40 bars of hard-drawn copper, insulated with mica, and is carried on a cast-steel bush, which is keyed to the shaft.

3in. The bearing surfaces are of phosphor-bronze, and are made very large; that at the dynamo end is designed as a thrust bearing, to take up the end thrust of the armature. The engine is controlled



The steam engine is a twin-cylinder high-pressure engine, the diameter of each cylinder being 4½in., and the stroke of the pistons

by a Pickering high-speed governor, driven by a strap. The lubrication is effected from one main oil box.

HIGH-FREQUENCY CURRENTS.

Mr. F. Himstedt publishes in *Wiedemann's Annalen*, Vol. LII., p. 473, some methods of repeating Tesla's experiments which are of some interest. As he did not possess Tesla's elaborate apparatus, he first resorted to electric oscillations produced by the Lecher arrangement, and later on, plain Leyden jars. He connected the poles of a strong Ruhmkorff's coil, 50cm. long, 20cm. in diameter, and worked by five or six accumulator cells to the inner coatings of two Leyden jars of moderate size, insulated from one another on blocks of paraffin wax, and also to a spark micrometer. The outer coatings of the jars were connected by a copper wire 4mm. thick, and 150cm. long, bent into U-shape. A 16-volt glow lamp, put in parallel with this wire, soon became white hot when the micrometer was suitably adjusted. Using jars of 16cm. diameter and 42cm. height as many as three lamps could be made to glow simultaneously one over another; namely, a 65-volt lamp below, a 16-volt lamp in the middle, and a 2-volt lamp at the top. If the point of the glass globe be filed off, the lamp ceases almost entirely to glow. Tesla ascribes this to the different manner of the bombardment of the gas molecules in the globe, the author thinks it due to convection. If the incandescent body be a platinum wire of from 0·05 to 0·1mm. diameter, it oscillates violently during incandescence, and showed as a zigzag line; but it does not swing in a plane like a string, but in all possible planes, appearing like a beam of light.

It is necessary for the success of the experiment to have an interruptor working regularly, and a suitable spark micrometer. The former should be a Foucault interruptor with tough zinc amalgam under oil replacing the mercury, and the micrometer balls should be of zinc. A Tesla transformer was made as follows: a wire 4mm. in diameter was wound on a glass tube 4cm. thick, in ten turns 1cm. apart, over this an ebonite tube was pushed, on which was wound 200 turns of wire 1mm. thick, about 1mm. apart. This was placed in a suitable earthenware bath containing machine oil, and its secondary connected to two metallic spheres supported on ebonite pillars. The primary was connected to the Leyden jars in the place of the U-wire. When the interruptor is working, brush discharges take place from the knobs, sparks take place to a conductor held near. If two parallel wires go out from the knobs a broad band of light shines out brightly up to three or four metres away. If one pole be connected to earth, and a fine wire 15-20cm. long be hung on the other, the wire begins to move and describes the surface of a cone, easily seen in the dark, by the brush discharge all along the wire.

If anyone touch one pole, rays of light go out from any part of his body to a conductor held near. If he stand on a metal plate, he feels a pricking sensation in the feet, and brush discharges are seen coming out of the soles of his shoes. If several persons form a chain, and the first touch one pole of the transformer, while the

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last holds a Geissler tube, with or without electrodes, in his hand the tube glows brightly, and none of the persons feel anything whatever.

If one pole of the transformer be earthed, while the other is connected to a large metallic sphere 60cm. in diameter, Geissler tubes three or four metres away glow brightly. A glow lamp connected o he unearthed terminal glows only with the phosphorescent light o ia Geissler tube, but it glows brightly if covered with a tin-plate shade. The filament oscillates so violently that it soon breaks. If a conductor be brought near the point of the lamp, the globe is broken and a continuous stream of sparks passes through the opening, and the carbon filament continues to glow till it is all burnt away.

In the second portion of his Paper the author informs us of some curious facts. The transformer differs from an ordinary induction coil in a curious way. A vacuum tube connected to it gives cathode light at both ends, and anode light in the middle. Reversing the current, or connecting to the other pole makes no difference. An electroscope is always positively charged when put near a point connected with either pole, and only positive Lichtenberg figures can be produced with it.

Experiments with different gases showed that the predominance of positive electricity in the transformer had its cause in the surrounding medium. Air and oxygen give positive discharges; while hydrogen, coal-gas, nitrogen, carbon dioxide, and ammonia give negative. If one pole be made with two points of discharge, one in hydrogen, and one in air, positive and negative electricity come out of the same pole in accordance with the nature of the medium; and a gradual alteration from positive to negative can be obtained by diluting oxygen with more and more nitrogen; the maximum positive effect being produced when the mixture is in the proportion of the constituents of the atmosphere.

On the other hand, when an induction coil is used instead of the transformer, the reversal of the current always reverses the charge of an electroscope held near, whatever the nature of the surrounding medium.

AN INSTRUMENT FOR DETERMINATION OF PHASE DIFFERENCES WITH ALTERNATING CURRENTS.*

BY M. VON DOLIVO-DOBROWOLSKY.

It may be said of modern alternate current working that it is the utilisation of differences of phase, for most of the newer applications of alternate currents have as their basis the phase difference of two currents, or of current and pressure; while the resolution of the alternating current into its idle and working components is now all important.

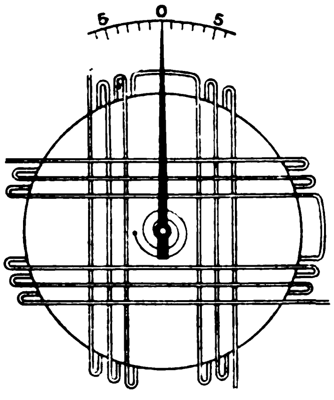

Fig. 1.

The resultant current may be measured directly by an ammeter or dynamometer, and the working current may be found by wattmeter and voltmeter, or at given volts from a wattmeter reading directly, and from the ratio of the working to the resultant current, the idle current, and the phase-displacement may be graphically determined; but there are cases in which a direct measurement of the idle current is most valuable, not to say indispensable, and the phasemeter here described is essentially an ampere meter measuring the idle current.

The apparatus resembles in its arrangement a three-phase motor; it is shown in its simplest form in Fig. 1. Two coils at right angles to one another surround an iron disc, arranged to rotate on points. If the two alternating currents which traverse the coils differ in phase, then, as is well known, there is a torque on the iron disc. This torque has the value $D = a\, i_1 i_2 \sin O$, where $i_1 i_2$ are the two currents and O the angle of lag. The rotation of the iron disc is opposed by a spring, the amount of deflection from zero being then a measure of the torque, and therefore of the difference of phase.

If one of the coils be wound for voltmeter current, Fig. 2, with a large induction less resistance in series with it, the current in this portion will be approximately in step with the volts; and if the other coil be used as a current coil, carrying the main current, then the deflection measures any difference there may be between current and volts, $D = a\, i\, e \sin O$, while the direction of deflection shows whether the current has a lead or a lag.

If the instrument is always to be used at the same voltage, or if allowances can be made by adjustment of the voltmeter-coil resistance to suit any small variation, then the formulæ above becomes $D = b\, i \sin O$; but $i \sin O$ is the idle current, and thus in this case the deflection is directly proportional to the idle current. The Allgemeine Elektricitäts Gesellschaft will shortly place the instrument on the market. (Fig. 3.)

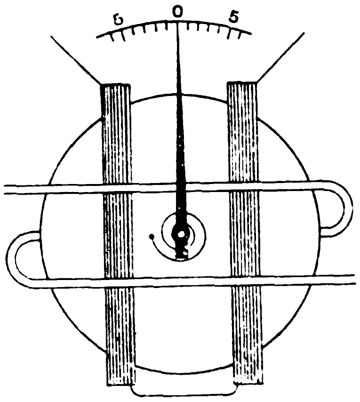

Fig. 2.

The scale is so graduated that at the given volts and frequency the phasemeter reads directly in amperes the value of the idle current; and small differences of pressure and frequency affect the reading by an amount directly proportional to the alteration. The most important application of the new instrument is to central stations running their alternators in parallel, and also to transmissions using so-called synchronous motors. It ought to-day, since the epoch-making work of Mordey and Swinburne, to be a matter of common knowledge that it is useless to try and govern alternators running in parallel by alteration of the excitement, since this only produces an armature reaction tending to neutralise its effect; the current so produced is an idle current, and is generally known as the synchronising current. It may lead or lag behind the E.M.F., strengthening or weakening the field. It is obviously best to reduce this current as much as possible, owing to the power needlessly wasted by it in the armatures; but one must be careful that the machines do not get out of step, and for the purpose of the regulation the present instrument is very valuable, as the sign and magnitude of the synchronising current can be determined, and the excitement of the machines adjusted to the best value. If there is no phase displacement due to the external circuits, the phasemeter should indicate 0; and if a displacement, due to motors for instance, exists, each phasemeter should indicate in the same direction and about the same amount, this being the most advantageous arrangement. With the phasemeter, therefore, it is possible to utilise the alternate-current station to its full capacity; to bring the machine to zero of current when switching off, thus avoiding flickering of the light, and to judge of the output of the machines into the mains. The annexed figure (Fig. 4) shows the

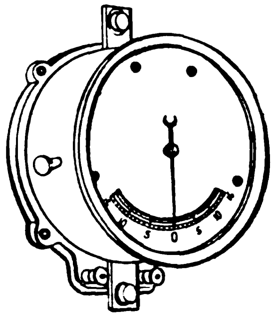

Fig. 3.

* Abstract from the *Elektrotechnische Zeitschrift*, June 21, 1894.

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arrangement and connections of an alternate-current station fitted with phasemeters ; M M are the machines, fitted the omnibus bars $L_1 L_2$. H H are the switches, with the synchronisers *i i* ; and in the circuit of each machine is an amperemeter and a phasemeter. The ammeters can be advantageously replaced by wattmeters, the phasemeters having their current coil in circuit with the dynamos, and their pressure coil on the omnibus bars ; this latter arrangement being capable of simplification as shown, by using the common series resistance S, which may have adjustable self-induction to bring the phasemeter readings to O when motors are on the mains. The machines have in addition each a voltmeter and a field regulator ; while a main regulator, R, enables the voltage on the mains to be adjusted as required. If during the running the phasemeters have all the same deflection while one machine is doing too little work, the only remedy is to regulate the steam (or water) supply, and thus alter the power given to it.

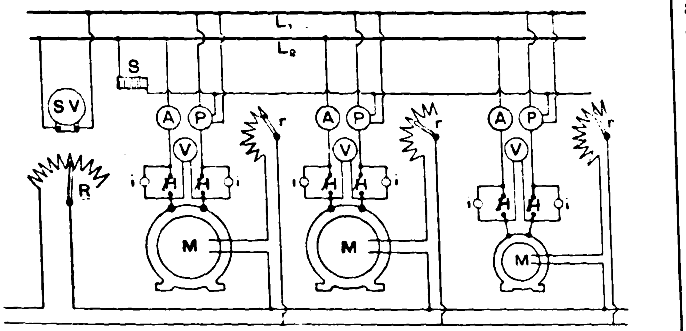

FIG. 4.

When a dynamo is to be switched out, steam should be gradually cut off, keeping the phasemeter on O by means of the field regulator, until the ammeter shows no current, when the main switch H is opened. In a similar manner the most favourable excitement for a synchronous motor at any given load may be found, and thus the $C^2 R$ losses reduced to a minimum ; and the phasemeter in general may be said to add considerably to the simplification and safety of the station.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *September* 1, 1894.

Electric Locomotives.—The General Electric Company has just completed a forty-ton electric locomotive, designed for speeds not exceeding thirty miles per hour. The draw-bar pull is 14,000lb., the wheel-base 6ft., and the diameter of drivers 40in. The two trucks are similar to those of ordinary passenger cars, and the motors, one on each axle, are of the single-reduction spur-geared type, mounted as in ordinary street-car practice. The Baltimore and Ohio Railroad Company will soon have several large electric locomotives in use for transferring its trains through Baltimore, its lines there passing through a series of tunnels under the city. A locomotive, designed by Sprague, Duncan and Hutchinson for the Chicago terminal of the Northern Pacific Railroad, will be ready for use in about a month. This is the largest electric locomotive yet designed in this country, weighing 65 tons, and developing 1,000 H.P. The frame of the locomotive is similar to that of the ordinary standard steam type, but with a four-pole motor built directly to each of the four axles. The drivers are 52in. in diameter, and the speed is to be 35 miles per hour.

Canadian Electrical Transmission Plant.—The Stanley-Kelley Company will instal a large two-phased plant at Montmorency Falls, near Quebec, the generators to be three in number, of 675 H.P. each. The current will be generated at 5,500 volts, and conveyed to Quebec, 8 miles distant, by four wires for each machine, with a line drop of 6 per cent. At a sub-station in the city step-down transformers will reduce to 2,000 volts, which will be the voltage of the distributing system. The transformers will be cooled by an air draught. The current will be used for both lighting and power service.

The Tariff Bill, recently passed, though drastic in some of its provisions, will have little or no effect in increasing American electrical importations. The reduction of the duty on incandescent lamps from 60 to 35 per cent. might place this branch of trade within reach of foreign competition at present prices, but it is probable that such competition would be met by a cut in domestic prices. The new rates may, however, lead to importations of armature plates and field forgings, as well as of porcelains for electrical insulation and electrolier glass shades.

NEW YORK, *September* 7, 1894.

Accumulator Litigation.—A decision has been handed down by a United States Court denying the motion of the holders of the Brush accumulator patents for a preliminary injunction against the manufacturers of the chloride accumulator. The Court holds that the testimony submitted by the complainant to maintain the claim of infringement is based upon too broad a construction of the claims of the Brush patent, and upon a yet broader construction of the decisions of the Courts which have sustained these patents. While the real merits of a case are but slightly examined into on a motion for a preliminary injunction, yet the language of the Court in this case is regarded by those interested as decidedly favourable to the chloride accumulator.

The Commercial Cable.—On September 1st, the laying of the last four miles of the in-shore end of the Commercial Cable Company's cable was completed, and on Sunday morning the harbour section was laid and connection made with the Company's shore lines at Pier A, North River. This is the first direct cable connection with New York City.

The New York Electrical Society.—This Society during the past year, instead of listening to the reading of Papers at all of the regular monthly meetings, has adopted the policy of making occasional visits to inspect features of electrical interest. This new departure is much appreciated, and has resulted in a large increase of membership. The Society as a body, for instance, attended a performance of "Sinbad," in which electricity plays a large part, and at the opening of the new Postal Telegraph building made an official visit of inspection to its large electrical plant and examined its equipment. Several days ago, upon the invitation of the proprietors, the members visited the Wild West show during a night performance, and after it were shown the very complete electrical installation of this show, which gives night performances. This plant consists of four 80-kilowatt dynamos, which supply current to 800 incandescent lamps, 77 2,000-c.p. arc lights, 46 2,000-c.p. arcs with corrugated glass diffusion reflectors, and several search lights. The distribution of light is such, notwithstanding the immense area of the grounds, that the night performances are as satisfactory to the audiences as day ones.

CORRESPONDENCE.

THE GOVERNMENT AND THE TELEPHONES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR : From time to time you have criticised the action of the National Telephone Company and the Government, with respect to an agreement between them on the question of telephonic communication throughout the United Kingdom.

The following letter may be interesting to yourself and readers at the present juncture :—

[COPY]. General Post Office, London. September 7, 1894.

SIR,—I am directed by the Postmaster-General to acknowledge the receipt of your letter of 3rd inst., on the subject of the proposed establishment of a local telephone exchange in —— and to acquaint you, in reply, that it is not competent for any person or company without the license of the Postmaster-General, to transact telephonic exchange business within the United Kingdom. The question of the grant of a licence for such business is, however, solely one for the consideration of the Postmaster-General ; and under the proposed new agreement between the Postmaster-General and the National Telephone Company, to which you refer, the rights of the Postmaster-General in this respect are expressly reserved.

I am, however, to say that, as the whole question of telephonic communication is still open to discussion when Parliament meets next year, the Postmaster-General does not see his way to entertain applications for fresh licences.

Mr. Arnold Morley thinks it right, at the same time, that you should be informed that, as will be seen on reference to paragraphs 51, 52, and 53 on page 438 of the "Post Office Guide" for the present quarter, the Post-

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master-General's exclusive right of transmitting telegrams extends, not only to the transaction of telephonic exchange business, but also, with a few specified exceptions, to the establishment of any telephonic communication whatever within the United Kingdom.—Yours, &c.,

T. Vaughan Hughes, Esq. (Signed) SAM ARDRON.

It seems strange that local telephonic business in the country is to be blocked for some months because certain agreements between the Postmaster-General and a limited liability company are not yet ratified. The National Telephone Company have surely been masters of an unenviable situation while their patents were in force quite long enough for those who have had experience of the telephonic service of other countries.—Yours, &c.,

T. VAUGHAN HUGHES.

A PROPOSED INTEGRATOR.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In connection with your report of Prof. Henrici's Paper on planimeters, read before the British Association, the following description of a possible integrator, to be used in the same way as Amsler's, may be interesting. (Fig. 1).

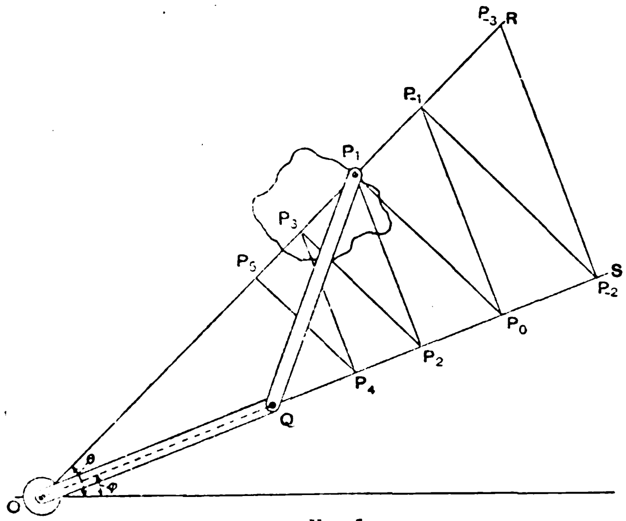

FIG. 1.

O Q . Q P_1 . are equal links of fixed length, pivotted together at Q, and turning about a fixed point, O.

P_1 is the tracing point.

Points ..... P_4, P_3, P_2, P_0, P_{-1}, P_{-2}, P_{-3} .... are found by drawing perpendiculars alternately on O P_1 R, O Q S.

If wheels placed at those points turn on the axes O P R, O Q S, the rotations will measure the values of the integrals

.... $\int \frac{r^4}{a^3} d\theta$, $\int \frac{r^3}{a^2} d\theta$, $\int \frac{r^2}{a} d\theta$, $\int r\, d\theta$, $\int a\, d\theta$, $\int \frac{a^2}{r} d\theta$, $\int \frac{a^3}{r^2} d\theta$ ....., where $r\,\theta$ are the polar co-ordinates of P_1, a is twice the length of O Q, and P_1 is moved round a closed curve.

$$O P_0 = a \,.\, O P_1 = r \,.\, O P_2 = \frac{r^2}{a} \,.\, O P_3 = \frac{r^3}{a^2} \ldots O P_n = \frac{r^n}{a^{n-1}},$$

and $$O P_{-1} = \frac{a^2}{r} . O P_{-2} = \frac{a^3}{r^2} \,.\, O P_{-3} = \frac{a^4}{r^3} \ldots O P_{-n} = \frac{a^{n+1}}{r^n}.$$

For a wheel on the axis O P_1 R, say the wheel at P_n, where n is odd, it is clear that the rotation measures $\int \frac{r^n}{a^{n-1}} d\theta$.

For a wheel on O Q S, say the wheel at P where n is even, the rotation measures

$$\int \frac{r^n}{a^{n-1}} d\phi, \text{ where } \phi = \theta - \cos^{-1}\frac{r}{a}$$

$$d\phi = d\theta + \frac{dr}{\sqrt{a^2 - r^2}},$$

and $$\int \frac{r^n}{a^{n-1}} d\phi = \int \frac{r^n}{a^{n-1}} d\theta + \int \frac{r^n\, dr}{a^{n-1}\sqrt{a^2 - r^2}},$$

the latter integral vanishes round a close curve.

This machine, if it could be constructed, might be applied to the evaluation of any quantity of the form $\int f(r)\, d\theta$, where $f(r)$ can be expanded in powers of r. The well-known extended form of Amsler's planimeter gives the values of $\int \sin\theta\, dx$, $\int \sin 2\theta\, dx$, &c., &c., where x is the distance O Q from a fixed

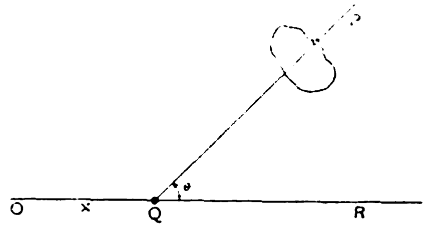

FIG. 2

point O along the straight line, which is the locus of Q, and where θ is the angle P Q R (Fig. 2). Amsler's machine will evaluate any quantity of the form $\int f(\theta)\, dx$, where $f(\theta)$ can be expanded as a series of sines of multiples of θ, the integration being effected round a closed curve.—Yours, &c.,

September 17, 1894. WM. ARTHUR PRICE.

TURNING DOWN THE ELECTRIC LIGHT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As you have devoted over a column to "slating" my patents in connection with the "turning down" of glow lamps, I presume you will allow me to reply in a somewhat smaller space.

In the first place, your paragraphs are to my mind somewhat unfair, as they mainly deal with the cutting-off principle, which the *Birmingham Gazette* article expressly states is not suitable for householders, and, generally speaking, your remarks and extracts remind me of the American editor, who, in giving an "extract" from a contemporary merely omitted the word "not."

Now, the commercial value of my patents lies in the switches which switch from parallel to series, and from one series to another series, and require no resistances and no "dead" lamps.

In a bedroom or railway carriage lighted by two 16-c.p. lamps the current passing when full on is (according to your figures, which I will take throughout to save argument) 1·28 amperes; but, when I throw the switch over and alter the current from parallel to series, the current passing is, as near as I can measure, 0·25 ampere, or between one-fifth and one-sixth the current, and between one-fifth and one-sixth the cost, quite exclusive of the extra life given to the lamp.

In cases where one 16-candle-power lamp is considered enough I place two 8-candle-power lamps. Then take the varied series principle. In my cluster of six 16-c.p. lamps I run them when full on in three lots of two series, but when I want a subdued light I turn my switch over, and the following change takes place—all in one movement of the switch and instantaneously—two lamps momentarily go out, and one of them is transferred to one of the remaining pairs, and the other to the other pair; as a result, I get two lots of three series. When full on the ammeter registers 3½ amperes, and when subdued to a pleasant mellow light it registers 1½ amperes, thus showing a saving of four-sevenths in current and money.

Now professors may make what elaborate calculations they like on their blackboards, but practical men will look at this question of £ s. d.

The essence of the invention is this: The power ordinarily consumed by the resistance is reproduced as light instead of being dissipated in heat, and this without altering the number of lamps aglow. Something intended to serve a like purpose has been tried in a clumsy way before by having a lamp not in use when full light is required, but which is switched into series to increase the resistance and reduce the light; but this plan, in addition to its unsightliness, does not reduce the light as much as mine, and uses 100 per cent. more current.

To my mind the ordinary resistance reminds me of a man slowing down his engine by having a blow-off cock on his cylinder.—Yours, &c., THOMAS BUDWORTH SHARP.

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THE ALTERNATE ARC.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In some experiments which I undertook a few months back I found that the band of violet light of the usual alternating-current arc lamp could be got rid of, and the efficiency considerably increased, by using a solid carbon for the top and a cored one for the bottom, in place of the two cored ones commonly used. Carboned in this way the arc struck is shortened to a normal length, with the result of an increase of temperature at the points of the carbons, and naturally a whiter light comparing very favourably with the direct-current arc, supposing the current supplied to each is equal.—Yours, &c.,

Bournemouth, September 12, 1894. S. G. BROWN.

THE GLASGOW MUNICIPAL ELECTRIC SUPPLY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your "editorial note" this week you concluded by saying: "We observe the units unaccounted for still amount to 16 per cent. of the total number generated, the figure of the previous year having been no less than 26 per cent. This is probably as much a matter of meters as of mains."

The statement accompanying the report was sent out by the Treasurer, and from the quantity not accounted for has to be deducted the quantity expended on the feeders 73,703 units, on the batteries 12,775 units, and on meter shunts, say, 2,000 units, leaving about 50,000 unaccounted for.

The figures for the previous year relate entirely to the supply from John-street Station. This station supplied an alternating current at 2,400 volts, transforming through Ferranti's 1882 transformers. The current measured through the day averaged about 4 amperes, which was read from an instrument graded to read from 10 amperes. The output of the station was not calculated from this office, so that I do not think comparisons can be made between the two years. Might I call your attention to an error in your statement on page 583. The headings of columns seven and eight are transposed. They ought to read: Number of public lamps, 71 and 102; the per cent., 25·15 and 16·2.—Yours, &c, W. ARNOT.

Glasgow Corporation Electric Lighting Station,
September 15, 1894.

LEGAL INTELLIGENCE.

Thames Electric and Steam Launch Company v. Ernest Scott and Mountain (Limited).

At the Brentford County Court, on Saturday last, before Judge Bagshawe, Mr. W. S. Sargeant, manager of the above Company, sued Messrs. Ernest Scott and Mountain, of Newcastle-on-Tyne, to recover £11. 11s. for work done. The defendants claimed as a set-off £37. 3s. 6d. for work done by them to an engine which had been in care of plaintiff.

Mr. LAMBERT (for the plaintiff) said in November, 1891, the plaintiff received instructions from Mr. Bolton, one of the defendants' agents, to remove an engine from Kew Bridge to his own house, with the object of disposing of it by sale. The engine was consequently removed by Messrs. Woodhouse and Rawson, and by a further order from Mr. Bolton was subsequently removed to Eel Pie Island, where it was found the engine required certain repairs, which were also carried out by an order from Mr. Bolton. The cost of removing and repairing constituted the present claim.

Mr. GROSSER (for defendants) said that the claim was disputed as a whole. As to the counter-claim, the defendants held that the plaintiff had put every obstacle in the way of defendants obtaining the engine, which was not finally returned till July, 1894. The counter-claim was formed of Mr. Winterbourne's account in removing the engine from Eel Pie Island, which was swelled by the obstacles put in the way by defendant, and of repairs necessary to the engine.

Correspondence which was put in contained a letter from the defendant Mountain, who repudiated any liability for the action of Mr. Bolton, which was written, as explained by Mr. Grosser, in ignorance that Mr. Bolton had given any instruction for work to the plaintiff. The defendants were under the impression that the Thames Electric Launch Company were submitting a claim independently of that made by Mr. Sargeant, but Mr. Lambert said that for all purposes Mr. Sargeant was the Company.

Mr. SARGEANT said he sold Messrs. Woodhouse and Rawson his business at Chiswick in 1892; he was their manager when the engine was removed, but he was away at the time. Messrs. Woodhouse and Rawson went into liquidation in 1892 or 1893, after he left them. He did business on his own account while with Messrs. Woodhouse and Rawson. Bolton was asking £225 for the engine, which had never been consigned to Messrs. Woodhouse and Rawson. The demand for the return of the engine in 1893 was made through Bolton. When he left Messrs. Woodhouse and Rawson's he started boat building at Twickenham; that was before the removal of the engine from that firm's premises. He never began to sue Messrs. Woodhouse and Rawson for the delivery of the engine.

After £1. 1s. had been withdrawn from the plaintiff's claim, a verdict was given for the plaintiff on the claim for £2. 10s. 3d. and costs, and for the plaintiff also on the counter claim, without costs.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

TENDERS INVITED.—The St. Pancras Vestry require tenders for works in connection with their new central station at King's-road, Camden Town, of which particulars will be found in our advertisement columns. Specifications, &c., can be obtained at the offices of Prof. H. Robinson, 13, Victoria-street, S.W.; and tenders must be sent in to Mr. Albert E. Pycraft, the Chief Clerk, Electricity and Public Lighting Department, Vestry Hall, Pancras-road, N.W., by 12 o'clock on October 11th.

TENDERS ACCEPTED.—The tender of Messrs. Crompton and Co. has been accepted by the Mersey Docks and Harbour Board for an electric light installation at the new coaling jetty, Duke-street Bridge, East Float, Birkenhead; and the Board have given the Liverpool Electric Supply Company (Limited) an order to instal the electric light in the Albert Dock warehouses.

——— The following tenders have been received by the Electric Lighting Department of the St. Pancras Vestry for the supply and laying of armoured cables:—

Reid Bros.	£2,428	17	2
W. T. Glover and Co.	2,339	2	2
W. T. Henley's Telegraph Works Company	2,084	6	6
India Rubber Company	2,084	1	4
British Insulated Wire Company	2,073	6	3
Callender Company	1,872	11	0
Siemens Bros. and Co.	1,812	11	1
Fowler-Waring Cables Company (accepted)	1,750	14	6

——— The Worcestershire County Council have accepted the tender of the New British Installation Contractors (Limited) for the wiring of the County Hall, the Crown-court, the Council Chamber, the offices, and grounds, for the sum of £273. 15s. 4d.

——— The Electric Light Committee of the Town Council have accepted the tender of Messrs. Mackenzie Bros., of Edinburgh, for the supply of 175 arc lamp posts.

——— The Bury Town Council have accepted the tender of Messrs. W. Storrs, Sons and Co., of Stalybridge, for the erection of an electric lighting station.

——— The tender of Messrs. Edwards and Yirrell has been accepted for the erection of buildings for the electric light supply to "The Gables," Linslade, Bucks.

LIQUIDATIONS.—The Official Receiver (Mr. S. Wheeler) has just issued his observations in the matter of the Steam Loop Company (Limited), which was formed in December, 1890, to acquire and work patents for the steam loop designed to secure for steam users economy of fuel and water, and to carry on the business of engineers and tool makers. Liabilities are returned at £1,146, with assets estimated to produce £139, in addition to patent rights which cost £47,900. The Directors of the Company state that they are unable to estimate the value of these patents, and accordingly tenders have been invited for the same from a selected number of engineering firms. The Official Receiver states that there are circumstances connected with the promotion of the Company requiring investigation.

——— A general meeting of Roper's Electrical Engineering Company (Limited) is called for October 15th, at 3 o'clock, at the offices of Messrs. Neill and Holland, 35, Hustlergate, Bradford, to receive an account of the winding up, and a general report from the liquidator (Mr. W. M. Gray).

——— At meetings of the shareholders of Field's "M.P." Development Association (Limited), held on 10th and 29th ult., a resolution was passed and confirmed, winding up the Company voluntarily. Mr. B. Newstead, of 3, Church-passage, Guildhall, E.C., is the liquidator.

BANKRUPTCIES.—The adjourned meeting of the creditors of Arthur Shippey was held at Bankruptcy-buildings, Carey-street, W.C., on Monday last. In the absence of a sufficient number of proxy holders no vote could be taken by the Official Receiver. The debtor asked that his affairs should be wound up, and this was agreed to, and the public examination is to take place on October 2nd at 12 o'clock. The principal creditor (for £3,273) not having proved his claim, his debt was not admitted for voting. The debtor explained that after a few ups and downs he started afresh in 1886 with £50 capital borrowed from his

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mother-in-law, and he hoped to pay off all his debts when his patents were put into the right channel for developing. He has a brother in America who, he believes, will float him again when he (the brother) arrives in England. He attributes his failure to unrealised assets, and to his inability to pull through a scheme for the electric lighting of Herne Bay. The debtor was adjudged bankrupt in 1882, and then filed a statement of affairs, showing liabilities £1,852, with assets showing an apparent surplus of £5,917. No dividends have, however, yet been paid, and no discharge obtained under these proceedings. He subsequently started in business as an electrical engineer and afterwards sold his business to a limited company, entitled Shippey Bros. (Limited), for £8,000, of which he was to receive £3,000 in cash in six half-yearly instalments, and the balance in shares. He received no cash, but accepted further shares in lieu thereof. The debtor expects that Shippey Brothers (Limited) will shortly be bought out by a new Company, and that then his shares will be of some value. He is now employed as a traveller on commission. The present liabilities, as estimated by the debtor, are £1,170, against which assets, also estimated by debtor, show a surplus of £4,797. No books of account have been produced. A portion of the estimated surplus is dependent upon the sale of certain patents to a limited company now being formed to work them. The debtor has been asked to file a statement of reasons for anticipating a surplus.

——— The first meeting of creditors of W. D. Gooch (*see* last week's *Electrician*) is to be held on the 24th inst., at 11, and the public examination is fixed for November 8th, at 12:30, both at the Bankruptcy Court, Carey-street, W.C.

Receiver Appointed.—Messrs. H. Ward Leonard and Co., of Electrical Exchange-building, New York, announce that they have voluntarily gone into temporary liquidation. Mr. Leonard has been appointed temporary receiver for the New York State assets. The statement of affairs shows assets estimated about $177,000 and liabilities about $62,000. Of the assets $109,000 are locked up in a suit against the Cayadutta Electric Railway Company. H. Ward Leonard and Co. being, according to the law of the United States, subject to attachment, the Directors have deemed it best for the interest of creditors and stockholders to place the Company's affairs in the hands of a receiver until the settlement of the action with the Railway Company, when it is anticipated ample assets will be forthcoming to settle all claims in full and means provided to enable the Company to continue its business.

Appointments.—Mr. F. F. Bennett, of the firm of Bennett and Druce, Preston, has been appointed by the Radcliffe Local Board as their consulting and electrical engineer.

——— Mr. J. B. Mitchell, of Bradford, has been appointed electrical engineer to the Corporation, at a salary of £180 per annum.

Appointment Vacant.—The Brighton Corporation Electricity Works require an electrician for the meter-testing department. Applications must be sent in at once to Mr. Arthur Wright, the manager, Corporation Electricity Works, Brighton.

Changes of Address.—Messrs. J. C. Fuller and Son, telegraph engineers, &c., have removed from 547, Old Ford-road, Bow, London, E., to Woodland Works, Wick-lane, E.

——— The London offices of Palmer's Shipbuilding and Iron Company have been removed to 17, Billiter-buildings, Billiter-street, E.C., and the registered offices of the Company are now at Newcastle-on-Tyne.

——— Messrs. Jeffery, Taylor and Co., electrical engineers, have removed from Tidal Basin, London, E., to city premises at 11, Queen Victoria-street, E.C., where the firm will continue to carry on the business of electrical engineers. Recent installations carried out include the Royal Albert Music Hall, London, E. (the outside lighting by Jeffery arc lamps), as well as a number of installations in the E.C. district.

Tramways for Sale.—By order of Mr. Justice Chitty, the Hull Street Tramways are to be sold as a going concern by private tender. The tramways consist of 16,797 yards of single and double line. There are over 33 cars, rolling stock, freehold land, fixed machinery, &c. Tenders have to be sent in to the chief clerk of Mr. Justice Chitty, at his chambers, Royal Courts of Justice, Strand, London, W.C., not later than the 24th prox.

A New Safety Connector.—The introduction of electrical heating and cooking apparatus has shown the necessity of improved arrangements for connecting and disconnecting the conducting wires from the utensils while in use. The kettles, saucepans, &c., of course, require frequent cleansing, and the wires become damaged if not detached. The ordinary system of using a plug attached to the wire and inserting it in the socket affixed to the apparatus is by no means a perfect arrangement. Protection to some extent is afforded by a ring of metal or porcelain around the pins, acting as a shield; but there are still "live" ends, and a fork or other piece of metal coming in contact with these would probably result in an alarming flash, besides blowing the fuse. The most serious thing would be the banishing of the electrical cooking apparatus from the household on account of these imaginary dangers. To prevent all possibility of accidental contact Messrs. Crompton and Co. are introducing a patent safety connector in which there are no exposed contacts. The usual arrangements for connection are reversed, as the pins (or other plug forms of contact) are fixed on the utensil itself, and are surrounded with a shield of metal to protect them from mechanical injury. The socket attached to the flexible wire is made with the contact tubes sunk well into the base and connected up in the ordinary manner. In front of the socket, and covering the entrance to the tubes, is a fibre or porcelain disc, pierced with two holes for the admission of the pins, and free

Fig. 1.

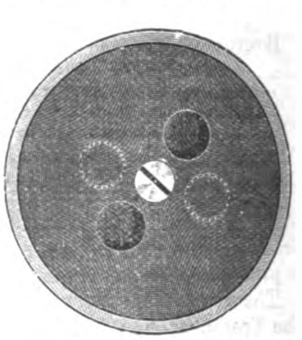

Fig. 2.

to move on a central screw. A spring fixed underneath helps to keep the disc in such a position that the ends of the tubes are always covered. When the pins are inserted in the holes of the disc, contact is not made until a quarter turn is given to the socket, when the pins are allowed to enter the tubes. The action is simple, and is similar to the turning of a key in a lock. Immediately the plug is pulled off the shield springs round, covering the holes and automatically protecting them. The connections are brought to the handle. This prevents the contacts becoming wet and greasy when the utensils are in use, and there is less danger of damage in the cleaning. The working parts of the connector are enclosed in a nickel-plated case, and two milled rings give plenty of grip power. Fig. 1 is a general view of the safety connector; Fig. 2 is a plan of shield, the dotted circles showing the position of the contact tubes below; Fig. 3 shows method of using.

Fig. 3.

The new safety connector can be applied to electric light standards, or, indeed, to any kind of portable fitting, and the necessity of keeping the wire attached is obviated. For floor sockets the safety connector is of service, as loose blocks or plugs are dispensed with when the socket is not in use. The makers are adapting the principle of the safety connector to high tension switches, terminals, and connections, which will be automatically protected, thereby preventing accidental contact.

Portable Ladder Scaffolds.—Messrs. Heathman and Co., of Endell-street, London, W.C., are making a portable ladder scaffold to telescope and adjust at various heights. These ladders are found very convenient for use in cleaning and attending to arc lamps. The ladder is mounted upon wheels, and is thus easily moved about over rough ground, and can be completely managed by one man. The firm have recently made several of these ladders to order, the first being in use at Spitalfields Market, and others have been supplied to the Norwich Castle Museum, the London and North-Western Railway Company, Crewe, and the Great Northern Railway Company. The ladders are certainly a great advance on the old clumsy style of portable ladder.

The Union of Continental Incandescent Lamp Makers.—A list of the members forming this association is, we understand, to be published shortly. The quarterly meeting of the union was held at Frankfort on the 10th, 11th, and 12th inst., when it was announced by the President that communications had been received from several lamp makers who had hitherto kept aloof from the association, intimating that they were prepared to join.

"Architects, Builders, and Contractors' Directory of America."—We have received a copy of "Hendricks' Architects and Builders' Guide and Contractors' Directory of America for 1894-95," which is a complete directory of all the construction industries of that country, and contains over 170,000 names, and is published by the Samuel E. Hendricks Company, of New York,

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The work is very complete, and provides for the architectural, building, and contractors' industries a valuable means of intercommunication, and is indeed what, as time progresses, the publisher of "*The Electrician* Electrical Trades' Directory and Handbook" hopes to provide for the important industries served by this journal. The science of directory compilation is probably better understood in this country than in any other; but, although this may be agreed, such a work as the one under review is, for lack of encouragement, very difficult of achievement here.

Graphic Wiring Table.—A new graphic wire table has been designed by Mr. A. H. Howard, which shows the dimensions of copper wires and cables in both decimals of an inch and in metric measurements, the equivalent sizes in solid and stranded wires, the fall of potential, the rise of temperature with given amounts of current, and other necessary and useful information, enabling the electric light engineer to see at a glance the best form of mains and conductors he can employ for the work he has in hand. The various wires and cables are arranged above one another in vertical columns according to their area, ranging from 0·001in. to 1 sq. in.; so that all equivalent areas are shown in the same horizontal lines; while diagonal lines give the fall of potential per 100 yards upon any sized conductor, with any current from 1 to 1,000 amperes. A series of curves, printed in red, shows approximately the temperature of any conductor with any given current. These curves are based upon Mr. A. E. Kennelly's experiments for ascertaining the rise in temperature of insulated wires enclosed in wooden casing. A feature in the design is that the divisions are drawn at distances proportional to the logarithms of the areas; instead of being directly proportionate to the areas. The diagonal lines showing the fall of potential are thus made parallel instead of radial, with the result that all parts of the table are equally easy to decipher; the resistances of the several conductors are given in separate columns, at per 1,000 yards and per mile. The weight per mile is also shown. The table is drawn upon a fairly large scale, and is so arranged as to admit of additional lines being inserted to embody any data that may be useful in particular cases, such as the resistance, &c., of iron, platinum, or other metals which are used in electrical work. This table, which is the most complete of the kind that we have seen, will shortly be issued by Messrs. W. T. Glover and Co., of Salford and London.

The Epstein Company.—We understand that the application recently made for subscription to Seven per Cent. Mortgage Debenture Stock of this Company met with fair success. A sufficient amount was subscribed, we learn, to justify the Directors in going to allotment, and, pending the completion of arrangements now under consideration Epstein accumulators are made, under the Company's supervision, by a leading firm of electrical engineers.

Ready Reckoners.—We have received a copy of the third issue of "Reid's Patent Indexed Ready Reckoner," and amongst the many books of this kind in the market the handiness of this ready reckoner is noticeable. It is furnished with a fore-edge step-by-step index of all amounts from $\frac{1}{16}$th of a penny to 20s. 3d. A chartered accountant's certificate is given that the book has been thoroughly overhauled and the figures verified, a by no means unnecessary complement to a perfect ready reckoner. The book is well printed on good paper, strongly bound in cloth gilt, and is published at 2s. 6d. A useful office accessory.

Aberdeen.—At a joint meeting, on Friday, of the Watching and Lighting and Gas and Electric Committees of the Town Council, it was reported that the cost of the electric lighting of Union-street, at 7d. per unit, was £262. 2s. 10d. per annum. The expenditure for gas light over the same area was stated to be £70. 5s. 10d. It was decided that the gas department should supply the current for street lighting at 2½d. per lamp per hour, the Lighting Committee to bear the cost of the carbons and maintenance.——Steam power has hitherto been employed for generating the electric current used in lighting the Monastery at Fort Augustus, but a 45-h.p. turbine has recently been substituted for the steam engine. The water is obtained from the river Tariff, about three-quarters of a mile distant. It is intended to utilise electricity in the Monastery for motor purposes as well as for lighting.

Aberystwyth.—Considerable dissatisfaction was expressed at the last meeting of the Town Council at the delay which it was stated had occurred in the lighting of the town by electricity; but a message was received from Mr. Grant, the contractor, before the Council separated that the works would be ready for testing in three or four days.

Alleged Theft of Telegraph Materials.—On Monday, James Bailey and Charles Sowden, labourers, were brought up on remand at the Plymouth Petty Sessions charged with stealing a quantity of telegraph materials, the property of Her Majesty's Postmaster-General. The material included Leclanché zincs, copper wire, and old Daniell plates. After hearing some evidence the prisoners were again remanded.

Ayr.—The Secretary of State for Scotland has approved the loan of £15,000 proposed to be raised by the Local Authority for the execution of works under their Electric Lighting Order. The Board of Trade have been informed of the system proposed to be adopted for the electric lighting of the town, and as soon as they have approved it the necessary works will be started.

Bath.—At the meeting of the Surveying Committee of the Corporation on Monday, Alderman Bright said he thought the Electric Lighting Company ought to switch on the current a little earlier in the evening for the lighting of the streets. Alderman Sturges explained that the agreement with the Company provided for an average lighting throughout the year of 10 hours for each night. It was found impossible, however, so to arrange the lighting as to make this average cover the hours of darkness all the year through, and he suggested that the complaint should be referred to the Lighting Committee, which was done.——A meeting of shareholders of the Bath Electric Lighting and Engineering Company (Limited), held on Thursday last, adopted a special resolution authorising the Directors to apply to the Board of Trade for a Provisional Order for an extension of the Company's area. It was stated that, while the Local Authority had not intimated their consent to the Company's proposed application, it was not anticipated that they would seriously oppose it.

Blackburn.—The sanction of the Local Government Board has been received to the borrowing by the Town Council of £32,000 for electric lighting purposes, and the Board have also approved of the Corporation using No. 1 gasworks as the site for an electric lighting station.

Blockley (Worcester).—The streets of Blockley have been lighted by petroleum or electricity for 31 years, the cost being raised by voluntary contributions. The committee which have had the matter in charge have now wound up their proceedings, and a public meeting is to be called to arrange for the future lighting of the streets.

Bootle.—The Town Council have resolved to apply for an electric lighting Provisional Order.

The British Museum.—A Parliamentary return just issued says that the artificial lighting of the reading-room has been greatly improved by the installation of incandescent electric lights fitted to the reading desks. The old system of arc lamps is, however, still retained for the general lighting of the room, but at a lower candle-power.

Bromsgrove.—The Local Board have decided to consent to the application of Messrs. Hemming and Co., of Birmingham, for permission to introduce the electric light into Bromsgrove, the Board reserving all legal rights and powers.

Cardiff.—A petition is being signed at Cardiff with a view to inducing the National Telephone Company to place that town in direct telephonic communication with the metropolis. A similar movement in connection with the post-office telephone system has been initiated by the Cardiff Chamber of Commerce.——Dr. Arthur, of London, last week explained to a meeting of the Cardiff Health and Port Sanitary Committee a scheme for dealing with house refuse, by which a large portion of the refuse would be utilised for lighting the town by electricity. The Committee are awaiting further information.——At a meeting of the Lighting Committee of the Corporation on Tuesday last, the question was introduced of the provision of small motors, which would probably be used by tradesmen if they could be rented at a moderate outlay. The Borough Engineer agreed that the question was a practicable one, as it was to the interest of the Corporation to have as much electricity used during the day as possible, but the subject was eventually deferred for further consideration.

Carlisle.—The Gas Committee of the Corporation have instructed the manager to make inquiries in reference to the notice given by the Brush Provincial Company that they would apply for a Provisional Order.

Chapel Lighting.—The electric light has been installed in the Waltham-street Wesleyan Chapel, Hull, the work having been done by Mr. Blanchard, of Whitefriargate. There are 18 electroliers of wrought iron, specially designed to suit the building, and carrying from three to twelve lamps. The three-wire system has been adopted.

Chester.—Complaint was made at the last meeting of the Town Council of the dilatoriness of the Electric Lighting Committee, but it was stated that the Committee were still engaged in seeking a suitable site for a generating station.——A special meeting of the Town Council was held on Wednesday, when, after some discussion, the recommendation of the Electric Lighting Committee that the Water Tower Gardens, belonging to the Corporation, be the site for the proposed electric light station, and that the Committee be authorised to proceed with the establishment of the installation, was adopted.

Colliery Managers' Association.—The annual gathering of the members of the National Association of Colliery Managers was

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recently held in the Forest of Dean at the invitation of the south-western branch of the Association. Mr. F. W. T. Brain, general manager and secretary of the Trafalgar Collieries, who is the president for the ensuing year, and who occupied the chair, delivered an interesting address, in which he referred with satisfaction to the financially sound condition of the Association. A considerable portion of the Chairman's address was devoted to the subject of the wages disputes in the coal trade, and to the probable effect of an Eight Hours Bill on the mining industry. Reference was then made to the recent explosions attributable to the accumulation of coal dust, and the effect of shot firing thereon. The cost of the electric fuses, which were now so generally used for shot-firing purposes, and were so emphatically recommended by H.M. Inspector of Mines and also by the Prussian Commission for the safe and efficient firing of all explosives, would be found to be somewhat higher than that of gunpowder. This extra cost was very largely due to the limited number of fuses used, but he looked forward to a much increased consumption which would bring about a reduction in the cost. With regard to the employment of electricity in mining he (the president) had but a short time left him for dealing with this important subject. That electricity would be largely applied to mining work in the near future he was convinced. With three electric pumps working underground in the collieries with which he was connected, the first one of which had been running since 1882 (and this was, he believed, the first known application of electricity to mining work), he could speak with confidence as to its utility. So satisfied were the proprietors of the Trafalgar collieries as to the advantages afforded by electricity that they were now putting down an extensive system of underground main and tail rope haulage of about 150 H.P., costing several thousand pounds, and he hoped at some future time to be able to place before the south-western branch of the Association a description of the plant. Electricity, applied to pumping, hauling, and coal cutting, was now in constant work in several parts of the country. With the improvements now being introduced its use would become much more general, and even now scarcely a week passed without particulars being published of new electric plant in connection with mining. So far as mining was concerned, the application of electricity had passed from the experimental to the practical stage, notwithstanding considerable initial difficulties, and he regarded its future use as assured. Mr. Brain's remarks on this subject met with the hearty endorsement of the members of the Association. The members subsequently visited Mr. Simmonds' limestone quarries at Edge Hills, to witness one of the largest blasts on record, in which four tons of gunpowder were exploded. Everything passed off satisfactorily. These operations were carried out under the management of the Electric Blasting Apparatus Company, of Cinderford, in presence of between 6,000 and 8,000 persons, who lined the hills in the neighbourhood. By this explosion it was calculated that about 36,000 tons of rock had been displaced. A banquet was subsequently held under the presidency of Mr. Brain, at which the toast of "Success to the National Association of Colliery Managers" was proposed by Mr. T. Forster Brown, who stated that in his 30 years' residence in the district of the Forest of Dean he had frequently been brought into contact with the Chairman and his brothers, the former of whom had done yeoman service as one of the earliest pioneers in the application of electricity to practical purposes, and they were proud of his success in that direction. Subsequently the members visited the Trafalgar Collieries to inspect the new electrical machinery and appliances recently erected, and referred to in the president's address. The machinery for this important work was put down by Messrs. Easton, Anderson and Goolden (Limited), and the installation is so thoroughly complete that it even includes a telephone service. The electrical operations are worked from the top, and the telephone system connects up the engine house, the haulage engine room, and the extreme point on the roadway. A visit was afterwards made to the Electric Blasting Apparatus Company's fuse factory, in the inspection of which the members were much interested; and, finally, the members were invited to a public reception at Coleford, which brought the function to a pleasant conclusion.

Country House Lighting.—Lord Burton is extending the electric light at Rangemore Hall, near Burton-on-Trent, and new machinery for 1,000 lights is being put down under the direction of Messrs. Massey and Allpress. The same firm are also rearranging a very large electrical plant for Lord Windsor, at Hewell Grange, near Bromsgrove.——Messrs. Drake and Gorham have been entrusted with the lighting of Mr. J. T. Smithe's house at Eveley. There will be about 100 lights, and the power will be derived from a water turbine driving a 5-unit E.C.C. dynamo. Fifty-three D.P. cells will be fixed, capable of supplying current to 58 16-c.p. 60-watt lamps for nine hours or over 90 for four hours.

Dublin.—Messrs. W. Curtis and Sons, of Abbey-street, have secured the contract for the electric lighting of the new Parcels Post Depôt. Concentric wiring has been adopted, and the work is to be carried out under the direction of Mr. J. Howard Pentland. The total effective candle-power to be provided for is about 7,000.

Derry.—An adjourned special meeting of the Lighting Committee of the Town Council was held on Tuesday, at which the animated discussion on the subject of the electric lighting cables was resumed. A letter was read from Dr. J. Hopkinson, dated February, 1893, in which approval was given to the specifications and drawings prepared by Mr. Blake, the Corporation's electrical engineer, for the cables. From the remarks made at the meeting it would appear that litigation is, unfortunately, about to be entered upon, and many of the comments made at the meeting were, therefore, better left unreported until the parties concerned have an opportunity of explaining the position. Mr. Crawford M'Cay, the solicitor, pointed out that it was unwise for the members of the Council to step in between Mr. Blake, their engineer, and the contractors.

——— At the meeting, on Friday last, of the Londonderry Port and Harbour Board, a letter was read from Dublin Castle intimating that the veterinary department would agree to the inspection of cattle previous to shipment being carried on at the port, if the Commissioners provided suitable electric light. The light should be of a certain intensity, and the lamps should be so fixed as to obviate the casting of a shadow, and they should be 11ft. from the ground. After some discussion, the secretary was directed to write to the Corporation inquiring whether that body would be able to supply the electric light at the cattle pens and, if so, upon what terms.

Electricity in the Dairy.—At Blythwood, Stanstead, on Wednesday, Mr. and Mrs. James Blythe entertained the British Dairy Farmers' Association to an exhibition of their "electric dairy." This is a picturesque building, and was opened by the then Lady Mayoress of London in 1892. It is lighted throughout by electricity, and the creamers and separators, churns and other dairy machinery are driven by electric motive power. The exhibition afforded much interest to a distinguished body of visitors, including the Lord Mayor of London and the Agents-General for South Australia and British Columbia.

Fermoy.—The Fermoy Town Commissioners at their last meeting expressed great dissatisfaction with the gas lighting of the town, and decided to take immediate steps to ascertain the practicability and probable cost of introducing electric lighting.

Factory Inspection.—At the concluding meeting of the Associated Chambers of Commerce last week, the following resolution was passed:—"That where factory inspectors propose to inflict new special rules for any manufacturing trade, such rules should be submitted to the local Chambers of Commerce, and copies also sent to the London and other chambers, in order that concerted action may be taken to prevent undue interference with trade." It is in the power of the Chamber of Commerce to effect considerable improvements in the present method of factory inspection. One of the most serious complaints made against the Factory Department of the Home Office is that its inspectors appear to discharge their duties in a haphazard way. So soon as a change of inspectors takes place the new man considers it his duty to at once undo the work of his predecessor, and in many cases calls upon factory and workshop owners to effect radical changes at considerable expense. This is particularly noticeable in the fencing of moving machinery. What is deemed sufficient by one inspector fails to impress his successor, who immediately sets to work and suggests considerable modifications at the expense of the owner. It is not at all an uncommon experience to find that the rules carried out in a factory for years have, on the advent of a new official, to be set aside and fresh rules adopted.

Fareham.—A special meeting of the Local Board was held on Thursday last week to receive the arbitrators' award in connection with the purchase by the Board of the undertaking of the Fareham Electric Light Company (Limited). The arbitrators, Dr. J. A. Fleming and Mr. A. H. Preece, reported that they had carefully examined the building and plant belonging to the Company, and they estimated the value of the undertaking as a going concern, comprising the whole of the plant, machinery, electric cables and stock as scheduled in the inventory of the property of the Company, to which reference is made in the draft agreement between the Board and the Company, at £4,866. 3s. This sum does not include the value of the Browett-Lindley vertical engine and of the self-exciting alternator, which are in the electric light station, but not included in the above valuation. The Chairman, after reading the report, submitted an estimate of the expenditure which would be necessary for the purchase of the undertaking, as follows:—Purchase money to be paid to the Company, £4,886. 3s.; purchase of the site of the station and additional adjoining land, £700; for laying the wires underground and supplying an additional engine, £1,000; cost of electrical adviser and arbitrator, £175; purchase of 7/18th wire, instead of 3/18th, as recommended in the specification, £120. A proposition was then made that application be made to the Local Government Board for sanction

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to borrow £7,000 for the purpose of purchasing the Company's undertaking, and, after a lengthy discussion, it was carried by 4 votes to 3.

FELIXSTOWE.—The Felixstowe and Walton Local Board have decided to open negotiations for the purchase of the local gas and water undertakings. It was stated at the meeting that if the offer of the Gas Company were not satisfactory, sufficient surplus power could be obtained from the two engines used in the sewage works to light the town by electricity.

FREE LABOUR.—A report of the executive of the National Free Labour Association states that of the 9,786,073 male persons of 20 years of age or over who are working for their living in the United Kingdom, only 1,109,014 are members of trade unions. Referring to the result of the attitude assumed by the leaders of the various seamen's associations, the report states that the result of the aggressive attitude taken up by the men's leaders has been that Southampton, Plymouth, Cardiff, Dublin and Hull have been converted into free labour ports. A manifesto accompanies the report, in which reference is made to the feather-brained resolutions passed at the recent Trade Union Congress at Norwich.

FULHAM (LONDON, S.W.).—The Vestry have instructed the Town Hall Committee to at once consider the advisability of installing the electric light in the Town Hall, in order to prevent the new decorations being spoilt by gas.

GERMAN TRADE MARK LAW.—The new German trade mark law comes into operation on the 1st prox. Under this law all previously recorded marks must be entered on the Imperial register at Berlin, and the first applicant secures priority. Marks which have previously been registered at Leipzig, unless re-registered, will be disregarded by the Berlin officials when dealing with new applications. Infringers of registered trade marks are liable to fine and imprisonment, and to pay an indemnity to the duly registered proprietors. The British Trade Protection Office, Monument-chambers, London, E.C., will give any further information required on the subject.

GOVERNMENT OFFICES.—The electric light is to be installed in the Cabinet Chamber, at 10, Downing-street, the residence of the First Lord of the Treasury, by the time the next Council is held there next month.

GRANGE (LANCASHIRE).—The Local Board have appointed a subcommittee to act with those appointed by other local authorities in the district, with the view of combining in the opposition to the proposed application for a Provisional Order of the Windermere and District Electric Supply Company (Limited).

HAMMERSMITH.—The Vestry have instructed the Town Hall Committee to report on the cost of lighting the Town Hall by electricity.

HERTFORD.—In 1891 the Corporation obtained a Provisional Order for supplying electricity within their district. An electrical engineer was appointed, who prepared plans and estimates for a suitable installation, which was at the beginning of last year reported favourably upon by Prof. Forbes. The Lighting and General Committee of the Council have circularised the inhabitants with a view to ascertaining the probable extent to which the current would be taken, and a special meeting of the Corporation was called for the 24th ult., for the purpose of carrying out the scheme, but was adjourned for a fortnight in order that the ratepayers might have an opportunity of acquainting themselves with the details. Previous to the adjourned Council meeting a public meeting was held, as was reported in our last issue, when a resolution adverse to the scheme was carried; but, at the special meeting of the Council held on the 7th inst., a resolution proposed by Alderman Shelly, "that the electric lighting scheme proposed by the engineer, extended so as to supply the Hertford General Infirmary, be carried out as speedily as possible," was carried, after an adverse amendment had been lost, by the casting vote of the Mayor. The Council then further instructed the engineer to prepare, with the assistance of the surveyor, the detailed plans for carrying out the scheme and the requisite forms of tender for the several sections of the same, and it was also decided to apply to the Local Government Board for their sanction to a loan of £6,000 for electric lighting purposes.

HOVE.—The new baths and laundry, which were opened last week are lighted throughout by electricity, and each bath is fitted with an electric bell.

LEEDS.—For some time past the noise and vibration caused by the electrical plant in the basement of the Municipal Buildings has been a source of discomfort to those engaged on clerical work in the building, and in February last the city engineer was instructed to prepare a report upon the question of the removal of the plant to one of the refuse destructor buildings, it being thought that the waste energy of one of these places could be utilised. The city engineer submitted his report to a meeting of a special sub-committee of the Corporation on Thursday last. He thought that the cheaper and better course to be adopted would be to do away with the generating plant, and to take the current from the mains of the Yorkshire House-to-House Company. After a lengthy discussion the committee resolved to recommend the Council to adopt this suggestion.

LLANDUDNO.—The Llandudno Improvement Commissioners have resolved to apply for a Provisional Order to light the town electrically.

MILL LIGHTING.—The new roller mills at Barton Mills, near Mildenhall, and Messrs. J. Smith and Co's. new roller mills at March have been lighted throughout by electricity; the work having been executed by Messrs. W. J. Crampton and Co., of Cambridge and Yarmouth.——Messrs. Baxendale and Co., of Manchester, are installing the electric light in the Hillsteads and Cinderhill Mill, belonging to Messrs. Bancroft and Co., of Todmorden.

MOSS SIDE.—At the meeting of the Moss Side School Board on Tuesday, a report was presented showing the comparative cost of lighting the new schools by gas and electricity, and, on the recommendation of the Sites and Buildings Committee, it was decided to adopt electric lighting, and the Clerk was instructed to advertise for tenders for the work.

RADCLIFFE (LANCS.).—At the last meeting of the Local Board, a recommendation of the Electric Lighting Committee was adopted that Mr. Bennett be instructed to prepare plans for an electric light installation, in the first instance of not more than 6,000 8-c.p. lamps, and that the works be laid out in such a manner as to enable the Board to make future extensions. If it be decided to proceed with the electric lighting after a Provisional Order has been obtained, Mr. Bennett will be appointed to carry out the works in accordance with terms submitted.

RAILWAY STATION LIGHTING.—A magnificent pile of buildings has just been completed for the Terminal Railroad Association of St. Louis, Mo., U.S.A., for which, with the exception of heating, electricity has been utilised throughout. The building sheds and tracks are lighted, the elevators are run, the station is ventilated, the temperature, time, and watchmen's clocks are regulated, and the signals are throughout governed, by electricity. The electrical plant is considered one of the most complete in the States.

SHOREDITCH (LONDON, E.C.).—The scheme for combining an electric light installation, refuse destructor works, and public baths suffered a practical defeat on Tuesday, when the Vestry, by a majority of seven, postponed for six months the appointment of an electrical engineer.

SOUTHPORT.—At the last meeting of the Town Council, Councillor Holland asked if it was the intention of the Gas and Electricity Committee to have the Promenade illuminated with the electric light. He said that other towns, notably Blackpool, were before them in this respect. Alderman Haeking, the chairman of the Committee, said, however, that there was no present intention of having the Promenade so illuminated.

STIRLING.—A special meeting of the Town Council, at which the question of applying this year for a Provisional Order for lighting the borough by electricity was discussed, and it was agreed to proceed with the application to the Board of Trade.

TAUNTON.—At the monthly meeting of the Town Council, held last week, the report of the Electric Lighting Committee was presented, and, after some discussion, was carried by 18 votes to 1. The Committee reported that they had carefully considered the subject of various extensions to the electric lighting system, and that these extensions have been approved by Dr. Fleming, the consulting electrical engineer. The Committee therefore recommend that the following extensions be carried out, and that application be made to the Local Goverment Board for sanction to borrow £5,000 for the necessary works, this sum to be repaid within a period of 30 years:—

	Estimated cost.
At Sub-station No. 2 (St. James-street)	£1,450
Sub-station No. 3 (to be constructed under the road at Eastgate)	1,500
Coal shed, weighing machinery, and other works at the generating station	300
A new boiler, large engine, dynamo, and other works	1,750
Total	£5,000

VICTORIA STATION (MANCHESTER).—The Lancashire and Yorkshire Railway Company are making important alterations at this station, on both the western and eastern sides, which are estimated to cost about £200,000, irrespective of the cost of land acquired for the extensions. When completed the whole of the offices, which cover a large area, are to be lighted throughout by electricity.

WEMBLEY TOWER.—It is expected that this tower will be completed up to the first platform within three months. The platform is at a height of 155ft., and this portion of the tower is upwards of an acre in extent. The extent of country over which the beauty of the landscape is destroyed is upwards of fifty square miles.

WIGAN.—At a meeting, last week, of the Gas Committee of the Corporation the report of the Electric Lighting Sub-Committee was

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share	Last Dividend.	Name.	Previous Week's Price, Sept. 12.		Price Wednesday, Sept. 19.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Sept. 19.	
			TELEGRAPHS.					£ s. d.		Highest	Lowest
£1,012,880	Stock	10 0	Anglo-American	40	43	40	43	5 4 3	Jan., Apr., July, Oct.	..	..
£2,933,560	Stock	20 0	Do. Preferred	76	78	74	76	5 18 5	,, ,,	76½	74½
£2,933,560	Stock	5/0	Do. Deferred	7	7½	6¾	7½	..	.. ..	7½	7
£184,500	100	4%	*African Direct Teleg. 4% Deb. (Reg. & Bearer)	102	105	103	106	3 16 2	January and July	103½	102½
130,000	£10	3/0	Brazilian Submarine	12½	13	12¾	13¼	4 18 1	Mar., June, Oct., Dec.	13	12½
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1906)	109	113	109	113	4 9 6	June and December	..	..
10,000,000	$100	$1¾	Commercial Cable Capital Stock	140	145	140	145	4 17 9	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	12	13	12	13	6 3 1	February and August	..	..
6,000	10	10%	Do. Preference 10 per Cent.	19	20	19	20	5 0 0	,, ,,	..	..
12,931	5	1/7½	Direct Spanish (£4 paid)	4½	5	4½	4¾	4 4 3	April and October	4½	..
6,000	5	10%	Do. Preference 10 per Cent.	9½	10	9½	10	5 0 0	,, ,,	..	..
£30,000	Stock	4½%	* Do. 4½% Debentures of £50 each	105%	108%	105%	108%	..	.. ..	..	..
60,710	20	2/0	Direct United States Cable, 1877	9	9½	8½	9	5 11 1	Jan., Apr., July, Oct.	9 3/16	8¾
400,000	10	5/6	Eastern	15¾	16	15¾	16	4 1 3	,, ,,	16	15¾
70,000	10	6%	Do. 6 per Cent. Preference	16½	17	16½	17	3 10 7	,, ,,	16 13/16	..
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	117	120	118	121	3 6 2	May and November	119½	119
£102,100	100	5%	* Do. 5 per Cent. Debentures, 1899	106	110	106	110	4 11 6	February & August	..	..
250,000	10	2/6	Eastern Extension	15¾	16	15¾	16	4 7 6	Jan., Apr., July, Oct.	16	15¾
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	115	118	116	120	3 6 8	February & August	..	..
£32,700	100	5%	* Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103	106	103	106	4 15 6	January and July	..	..
£95,100	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb., 1900	103	106	103	106	4 15 6	,, ,,	..	..
£300,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.)	103	106	103	106	3 16 0	February & August	104	..
£200,000	£25	4%	* Do. 4% Mauritius Sub. Debs.	108%	111%	108%	111%	3 13 3	May and November	..	..
180,227	10	8 9	Globe Telegraph and Trust	8¾	9½	8¾	9	5 0 0	Jan., Apr., July, Oct.	9½	8¾
180,042	10	6%	Do. 6 per Cent. Preference	15¾	16½	15¾	16½	3 13 10	,, ,,	16½	15¾
150,000	10	5 0	Great Northern	20½	21½	20½	21½	3 19 1	Jan., April, and July	21¾	21½
£190,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	103	106	103	106	4 14 4	March & September	..	..
17,000	25	37/6	Indo-European	46	48	46	48	5 4 2	May and November	46¾	..
37,548	10	5/0	London Platino-Brazilian	5	7	5	7	..	,, ,,	..	..
£100,000	100	6%	* Do. 6 per Cent. Debentures	106	109	106	109	5 10 7	March & September	..	..
£100,000	£100	4%	*Pacific European Tel. 4% Guar. Debs. "Red" 1942	104	107	104	107	3 15 6	..	..	..
11,839	8	4/0	Reuter's	3	5	3	5	..	April and October	..	..
3,381	£100 Cert.	25/0	*Submarine Cables Trust 6 per Cent.	107	112	107	112	5 8 1	,, ,,	108½	108
15,000	10	5/0	West African Telegraph	3	5	3	5	..	January and July	..	..
£249,900	100	5%	* Do. 5 per Cent. Debentures	100	103	100	103	4 17 7	March & September	..	..
30,000	10	2/0	West Coast of America	2	3	2	3	..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	100	105	101	106	7 10 11	June and December	101½	..
88,321	10	9d.	West India and Panama	1¼	1¾	1¼	1¾	..	..	..	..
31,563	10	6%	Do. 6 per Cent. 1st Preference	10½	11	10½	11	5 9 1	May and November	10¾	..
4,669	10	6%	Do. 6 per Cent. 2nd Preference	9	10	9	10	6 0 0	,, ,,	..	..
£80,000	100	5%	* Do. 5 per Cent. Debentures, 1917	108	111	108	111	4 11 1	June and December	..	..
64,242	15	7/6	Western and Brazilian	7½	8½	8½	9½	..	May and November	9½	8
33,129	7½	7/6	Do. 5 per Cent. Cumulative Preferred	6	6½	6¾	7½	..	..	7½	6½
33,129	7½	4/6	Do. 5 per Cent. Deferred	2½	2¾	3	3½	..	..	3 3/16	2½
£171,900	100	6%	* Do. 6 per Cent. Debs., Series "A" 1910	106	109	106	109	5 11 1	February & August	..	..
£214,800	100	6%	* Do. 6% Mort. Debs., Series "B" 1910	106	109	106	109	5 11 1	,, ,,	..	..
$1,211,000	$1,000	7%	*Western Union 7% 1st Mort. (Building) Bonds	115	120	115	120	5 19 8	May and November	..	..
£166,900	£100	6%	* Do. 6 per Cent. Sterling Bonds	100	103	100	103	5 17 1	March & September	..	..
			TELEPHONES.								
41,000	5	10/0	Chili Telephone (fully paid)	1	2	1	2	..	..	..	..
224,850	10/0	2¾d.	Consolidated Telephone Const. & Maintenance	⅛	¼	⅛	¼	..	May and November	..	..
171,504	£1	6d.	Oriental Telephone and Electric (fully paid)	¼	⅝	¼	⅝	..	Yearly	..	..
484,597	5	3/4	National	4¾	5¼	4¾	5¼	4 17 7	June and December	5 1/16	4¾
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	14½	15½	14½	15½	3 17 5	,, ,,	15½	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	14	15	14	15	4 0 0	,, ,,	..	..
119,234	5	3/4	Do. 5% Non-Cumulative 3rd Pref.	5½	5¾	5½	5¾	4 6 11	..	5¾	5½
1,000,000	Stock	4½%	* Do. Debenture Stock, 4½%	109	112	109	112	4 0 11	January and July	109¾	..
58,000	5	1/0	United River Plate	1½	2½	1½	2½	..	,, ,,	..	..
£146,733	Stock	5%	Do. 5 per Cent. Debenture Stock	88	94	88	94	5 6 5	,, ,,	..	..
			ELECTRICITY SUPPLY COMPANIES.								
40,000	£10	..	City of London Electric Lighting (fully paid)	12½	13½	12½	13½	..	..	13½	3½
40,000	10	6,0	Do. 6% Cumulative Pref. (fully paid)	14½	14¾	14½	14¾	4 1 4	..	14¾	14½
19,900	£5	..	Electricity Supply Co. for Spain	..				..	..	..	..
£30,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	4½	5½	4½	5½	3 12 7	..	..	..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	..		..		..	..	..	..
8,322	£5	..	House-to-House Electric	..		..		..	..	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	..		..		..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..		..		..	January and July	..	..
45,000	£5	2/6	Liverpool Electric Supply (fully paid)	6¾	7	6¾	7	..	..	..	..
111,000	5	..	London Electric Supply	¼	½	¼	½	..	..	..	..
49,900	£10	5/0	Metropolitan Electric Supply (fully paid)	9½	9¾	9½	10	2 10 0	..	9¾	9 1/16
£150,000	Stock	4½%	* Do. 4½% Debs. (Bonds of £10, £20, and £10)	7	8 pm	7	8 pm	..	June and December	..	..
6,452	£10	..	Notting Hill Electric	4½	5½	4½	5½	..	..	..	..
19,930	£5	2/0	St. James and Pall Mall	6¾	7½	6¾	7½	..	..	7½	..
20,000	£5	7%	Do. 7 per Cent. Preference	8½	9	8½	9	3 17 9	..	8¾	8¾
59,900	5	2/0	Westminster Electric Supply (fully paid)	6¼	6¾	6¼	6¾	3 6 8	..	6¾	6 1/16
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
90,000	3	1/6	Brush Electrical Engineering	2¾	3⅛	2⅝	2⅞	7 9 6	..	2¾	2 11/16
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	2¾	2⅞	2¾	2⅞	4 11 5	..	2¾	2¾
£125,000	Stock	4½%	* Do. 4½ per Cent. Debentures	109	112	109	112	4 0 4	March & September	..	..
20,000	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref.	1¾	2½	1¾	2½	..	January and July	..	..
12,139	5	..	Edison and Swan United	..		..		..	..	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	..		..		..	..	..	..
120,000	2	..	Electric Construction	¼	¾	¼	¾	..	..	..	..
12,845	2	..	Do. 7 per Cent. Cumulative Pref.	1¾	2½	2	2½	..	..	2½	..
91,195	2	10/0	Elmore's Patent Copper Depositing	1½	1¾	1⅝	1⅝	..	..	1⅝	1 1/16
20,000	5	..	Fowler-Waring Cables (fully paid)	¼	1¼	½	1½	..	..	..	..
50,000	10	10/0	India Rubber, Gutta Percha, &c., Works	23½	24½	23½	24½	5 2 6	February & August	24½	23¾
£200,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	104	106	104	105	4 6 9	March & September	..	..
15,995	£10	6/4	International Okonite Ordinary	..		..		..	..	..	..
16,000	£10	..	Do. 8 per Cent. Preference	..		..		..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid)	..	½	..	½	..	..	..	..
78,949	5	3/6	Swan United (£3 10s. paid)	..		..		..	May and November	..	..
37,350	12	12/0	Telegraph Construction and Maintenance	40	42	41	43	4 3 9	March and July	42	40¾
£150,000	100	5%	Do. 5 per Cent. Bonds	102	105	102	105	4 13 6	January and July	..	..
37,514	£5	..	Woodhouse and Rawson Ordinary (£3 15s. paid)	..		..		..	..	..	..
41,098	£5	..	Do. Preference (fully paid)	..		..		..	..	..	..
£63,570	10	10/0	W. T. Henley's Telegraph Works Ordinary	7½	8½	7½	8½	5 17 8	..	..	..
£30,000	10	..	Do. Preference	..		..		..	..	..	..
			RAILWAYS AND TRAMWAYS.								
£630,000	Stock	1%	City and South London Railway	36	38	33	38	1 16 2	May and November	..	..
7,000	10	5%	Do. 5% Perpetual Preference	12½	13½	12½	13½	3 14 1	May and November	..	..
£67,130	Stock	4%	Do. 4% Perpetual Debenture	121	123	121	123	3 5 1	..	122½	..
37,500	£10	1%	Liverpool Overhead Railway	7¾	8½	7¾	8	1 5 0	..	..	..
6,295	10	5%	Do. 5% Preference	12¾	13	12¾	13	3 16 11	..	..	..
£125,000	Stock	4%	Do. 4% Debenture	111	113	111	113	3 10 10	January and July	..	..

* In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption.

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NOTES.

MUCH interesting and useful information in regard to car and train brakes in general, and electric brakes in particular, is to be derived from the Paper by Mr. E. A. SPERRY, an abstract of which we publish this week. Accurate data respecting the best practice in the design of brake blocks and of brake levers is by no means as plentiful as might be desired, and Mr. SPERRY's researches form a material addition to our stock of knowledge on the subject. Engineers, as a rule, have had to design brakes on the rough-and-ready principle of providing a large allowance for unknown coefficients wherewith to meet unforeseen contingencies. Hitherto the chief difficulty has laid in the limited amount of retarding force which has been available before the wheels commence to skid, a difficulty which, as far as purely mechanical remedies are concerned, can only be surmounted by putting brakes on a sufficiently large number of wheels. The moment skidding commences the rail friction diminishes, and the train slides on against a reduced retarding force. A bad result is flats on the tyre. Mr. SPERRY shows that, with the electric brake, the consequences of skidding can be avoided, and even skidding itself need take place only momentarily. For the force of the electric brake depends on the fact of the wheel rotating, and is proportional to the speed of rotation. The moment there is any tendency to skid, the brake relaxes its grip and allows the wheel to roll. Of course, what really happens is that the brake adjusts its force so as always to keep the wheel rolling. The effect might even be enhanced, and the retarding force of the brake be considerably raised above the value of the normal adhesion, if the rail friction itself were magnetically increased. Another valuable feature in Mr. SPERRY's system of electric brakes is the operation of all the machinery by means of one handle. The act of throwing off the trolley current applies the brakes, and the act of releasing the brakes applies the trolley. This cannot fail to ensure efficient service, by minimising the number of duties of the motorman.

BUT Mr. SPERRY, although careful of the nerves of the motorman and of the lives of pedestrians who may stroll on to the track, appears to be less anxious to please the passengers inside the car. "It may not be known," he says, "that under proper and standard conditions any car or train may be brought from a speed of 10 miles an hour to absolute rest inside of 10ft." We hope we may never be inside any car or train at the moment such an extraordinary feat is attempted. The retardation under these conditions is no less than 11·5ft. per second per second; ten times greater than is usual in practice, and exceeding one-third of the value of *g*. It could not fail to give the passengers a very bad jolt indeed. Nor is it any more comforting to the passenger to be told that the intensity of application of the brake force "should be greatest when the speed is greatest, and decrease as the speed drops off." This, again, is the very way to produce a nasty jolt; and, though it may be quite correct from the point of view of the man who is on the verge of being knocked down by the car, it is likely to raise more than a mild protest from the passengers.

IT was recently observed in one of our Notes that a year or two ago there were a number of attempts at making "dry cells, a misleading name for a rather untrustworthy battery." It is hardly necessary to add that these attempts were prompted by actual success in this direction, and it was to the ineffectual imitations rather than to the satisfactory batteries that we alluded. Among the valuable and original features of Mr. J. T. SPRAGUE's "Electricity" was a table of "The Suitability of Cells." Eleven cells and thirteen uses were enumerated, and a classification was made of the suitability. To draw up a complete table of this kind, well up to date, would be a difficult task; but we are disposed to think that the secret of a thoroughly successful cell would be a clear statement of the purposes for, and conditions under, which it should be used. If these purposes, are numerous, and the conditions liberal, the success should be wide; if, on the other hand, they are limited, the success of the cell, though complete in its way, would be restricted. Many a cell has been condemned because the purchaser has used it for work for which it ought not to have been employed.

BESIDES the conditions under the control of the purchaser, the effect of storage of a stock of dry cells, either under the maker's supervision in his warehouse, or by a, perhaps, ignorant and careless agent, must be considered. A wet cell is dry enough before it is sold, and is liable to no deterioration; but a dry cell, paradoxically, contains a certain initial amount of moisture, and both the storage before sale and the use after sale may alter it. If this moisture is under the observation and control of the user, and can be restored by him when necessary, as in the Leclanché-Barbier cell, alteration in the dryness, by which, of course, we mean the wetness, need not lead to the

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throwing away of a cell as useless, when there is really plenty more work left in it. The last new dry cell is the Obach, and is manufactured by Messrs. Siemens Brothers and Co., who have already had some experience of this kind of battery. Further particulars will be found in another column. Tests of dry cells, like tests of secondary batteries, do not give very much information unless they extend over a considerable period and under varying conditions. A cell may work a telegraph line for a couple of years with perfect success and without attention, but if left standing on a shelf for half that time it may be apparently or actually worthless. A dry battery is more or less a pig in a poke, and if, after use, abuse, or no use, it appears to be useless, it would be convenient to be able to ascertain whether the poke contains any more pig.

A writer in an American contemporary calls attention to the fact, which is evident to anyone who thinks carefully about the matter, that in scientific measurement the directly observed quantity is often altogether different from the quantity to be measured. Indeed, there are very few physical quantities the magnitudes of which are capable of direct measurement, for the number of physical quantities which can be directly observed is very limited. It would be an interesting study to analyse all physical measurements into their ultimately observed factors, analogous to resolving physical quantities themselves into length, mass, and time. Temperature, for example, is a function of matter which can never be directly observed, and which is always measured in an indirect and roundabout fashion. The common thermometer indicates temperature in terms of a length; other thermometric instruments measure it in terms of observed variation in the volume or pressure of a gas, in the rate of flow of heat energy, or in the change in the electrical properties of a conductor. Temperature in itself is probably as impossible of direct measurement as it is of direct observation; except, perhaps, in the phenomena of ultra-gaseous matter, where the direct observation of molecular velocity would, of course, be identical with the direct measurement of the square root of the temperature. This fact by no means tends to clear away the mist which enshrouds, not the idea of temperature itself, but the conception of it in terms of the fundamental physical ideas. Hitherto, all attempts to define the "dimensions" of temperature have proved futile, based as they always have been upon artificial and strained conceptions of the phenomenon. There is ever some quantity which has to be suppressed, but whose suppression cannot be defined in terms of the already suppressed quantities.

In the matter of the atomic weight of carbon, inductive science is poised on the horns of an instructive dilemma. The instruction is not merely to chemical science alone, but may be assimilated by all branches of physical science and research. On the one hand, chemists have been accustomed to argue the atomic weight of an element from the series of compounds which it forms with other elements, on the principle that there can be no half atoms. The lowest integer is taken as indicating the atomic weight. Prof. Wanklyn has recently applied this method to a series of hydrocarbons, and has found that the atomic weight of carbon cannot be 12, but is only half that value. On the other hand, Mendelejef classified the elements into associated groups, on the principle of the periodic law, and a wonderful harmony was the result. Carbon fell at the extreme tip of one of the harmonic curves —as will be seen by reference to Prof. Crooke's diagram, in the *Proceedings* of the Institution of Electrical Engineers, Vol. XX., p. 46—this element being tetratomic and paramagnetic, and standing at the juncture of the electro-positive and electro negative elements in the first half-cycle. This is what happens if the atomic weight of carbon is 12. But if it is 6, the position of this element is shifted, not only out of the first harmonic cycle, but out of every possible cycle; and the periodic law tumbles to pieces like a castle of cards. The dilemma is all the more interesting and instructive from its having been reached by the inductive method. Which is the way out of it? At all events, it teaches us to walk warily, and it reminds us that the "logic of facts" is only unanswerable when all the facts are known and rightly interpreted.

Cable Interruption and Repair:—

	Date of Interruption.	Date of Repair.
Benguela-Mossamedes ...	September 16th. ...	September 26.
Zanzibar-Mombasa	September 4th. ..	--
Macao-Hong Kong	September 25th. ...	—

University College, Nottingham.—The next session of this College begins October 8th.

Gas and Electricity at Biarritz.—A central electric lighting station is being established at Biarritz by the local gas company.

Books.—Messrs. Whittaker and Co. will, in a day or two, publish a new issue, in one volume, of "Electric Lighting and Power Distribution," by W. Perren Maycock, M.I.E.E.

Charges for Electric Power in Berlin.—The Berliner Elektricitätswerke have lowered the price of power for industrial purposes to twopence per kilowatt-hour, from October 1st.

Durham College of Science.—The calendar for the session 1894-95 is now ready, and contains a full syllabus of the subjects to be taken during the session. The day classes include electrical engineering, and the evening classes telegraphy and telephony.

Traction Current in a Telephone Network.—An alarming accident is reported to have happened in Havre on August 15th. The workmen engaged in putting up the telephone wires let a roll of wire fall. All the telephone wires in the quarter of the town were promptly burned up; the wire had tumbled across an electric tramway cable.

The Telegraphists' School of Science.—We have received the list of successes and prizes secured by students in the Telegraphists' School of Science during the last session. The progress in this respect is well marked, the number of successes on this occasion being 159, as against 99 and 66 on the two previous occasions. This institution, under the able direction of Mr. Slingo, aims at the instruction of telegraphists and telephonists in all that is essential to the proper performance of their duties.

The Proposed Berlin Elevated Railway.—The Berlin Municipal Council have agreed to the proposal for the construction of an elevated electric railway. There is little reason to believe, says *The Times* correspondent, that any further obstacles, financial or otherwise, will hinder the execution of this scheme, which those who are fitted to judge have declared to be necessary in consideration of the enormously-increased traffic in the capital. The work will be entrusted to the well-known firm of Siemens and Halske.

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Electric Locomotives in France.—According to the *Engineer*, the Paris, Lyons, and Mediterranean Railway Company is now building three types of locomotives—the first series comprising 40 compound engines; the second, 60 electric locomotives, each capable of drawing 800 tons at a speed of 24 kilometres = 15 miles per hour; and the third, electric locomotives, the motor for which is mounted on the rolling stock.

Compressed (?) Air Cars.—An accident has occurred on the tramway, worked by compressed air, which runs between the Church of St. Augustin on the Malesherbes and the Cours de Vincennes. The reservoir in the under part of one of the cars burst. The passengers, who were naturally in a state of great alarm, escaped uninjured. This new line, which is one of the longest in Paris, traverses the city from west to east, and has been working for nearly a month.

The Electrical Resistance of Manganese Steel at High Temperatures.—At a recent meeting of the Académie des Sciences a Paper was read on "Manganese Steel," by M. H. Le Chatelier. The anomalous results found previously by the author in studying the electric resistance of—13 per cent.—ferro-manganese were explained by the formation of two allotropic varieties of the metal. The temperature of transformation is 740deg., that temperature at which soft iron passes from the magnetic to the non-magnetic state.

New Cable between Cuba and the Bahamas.—The Cuban journals announce that the commission appointed to consider the project of connecting Cuba with the Bahamas by submarine cable have recommended the Government to grant a concession to Don Jose Declaux to lay a cable from Havana either to the Andros Islands, Eleuthera Island or Abaco Island, in the Bahamas, or to the Turk Islands, whichever should prove the better suited for putting Cuba in telegraphic communication with the United States, the Bermudas and the Azores.

A Course of Military Electro-Technology.—An Imperial decree has recently been published in Russia ordering the formation of a military electro-technical school, for the purpose of preparing officers of the Engineers to carry out any military electrical work that may be necessary, to train the privates of the Engineers in electrical duties, and to investigate electrical discoveries and inventions likely to be of use for military purposes. The officers' course will take two years, and the maximum number of officers being instructed at the school at any one time is to be 70.

Briquettes.—The bind used in the recent experiments at a Cumberland colliery with a view of making coal briquettes without admixture of pitch or lime is, says the *Engineer*, partly a waste product, the remainder costing on an average from 20s. to 28s. per ton, according to yield and demand. From 4½ per cent. to 5 per cent. of the bind is added to the coal, and a briquette is obtained which neither cracks or crumbles, but which burns freely in an ordinary fire, or under steam boilers, either with or without forced draught, leaving no slag or clinker. The tenacity of the bind is stated to be such that it permits the moulding of briquettes 4in. by 2½in. by 1½in.

Chicago Exhibition.—The Chicago Exhibition awards have been a fruitful source of controversy from the beginning. The latest dilemma is somewhat amusing. According to a Dalziel telegram from Rome, a difficulty has arisen concerning the publication of the official list of prizes obtained at the Chicago Exhibition by Italian exhibitors. The grand jury having awarded two prizes to the Pope, the Italian Government is placed in the dilemma of either comprising them in their list, in which case Leo. XIII. would appear to be treated as an Italian subject, or leaving the name of his Holiness out of it, thus ignoring the distinction conferred on his two exhibits, and making the publication incomplete.

A Short-Circuited Trolley Car.—The passengers in a Baltimore trolley car had, says the *Western Electrician*, an exciting experience on a trip through South Baltimore a few days ago. It appears that the car was proceeding at a rapid rate, when the trolley wire broke, and before the speed of the car could be checked the wire became badly entangled about it. The car, still on the rails of course, thus became a portion of the short-circuit on the line. The woodwork of the car caught fire in several places and sparks could be seen in all directions. After a time the motorman succeeded in stopping the car, but not before the thirty passengers had been thrown into the wildest state of excitement. After it was all over, however, it was found that no one was seriously hurt, although there were bruises and torn garments in abundance.

French Telegraph Rules and Regulations.—There is a general and justifiable outcry against the Posts and Telegraphs Department and its manager, M. de Selves, says the Paris correspondent of *The Times*. The Department recently gave notice that any telegram not fully addressed would be displayed at the telegraph office instead of being delivered, unless the recipients paid 40fr. a year for registering their addresses. Hitherto telegrams to newspapers have been addressed simply "*Débats*, Paris," and so on, for the whereabouts of their offices could not but be well known. If, however, every telegram had to be addressed, say, "*Times*, 35, Boulevard des Capucines, Paris," the extra four words would cost from 20 to 80 centimes extra, and the registration fee of 40fr. was therefore practically obligatory. The object of this vexatious rule was evidently to increase the receipts of the Department; but the outcry is such that it will doubtless have to be rescinded.

Finsbury Technical College.—At the Finsbury Technical College the autumn courses of lectures and laboratory work begin next week. On Mondays Prof. Silvanus Thompson will deal with alternate currents through the month of October, and in November will give four special lectures upon modern alternate-current motors. The Wednesday evening lectures (elementary course), after the introductory discourse by Prof. Thompson, will be taken by Mr. Eustace Thomas until November, when Prof. Thompson will take up measuring instruments. The laboratory courses remain, as heretofore, under the charge of Mr. E. A. O'Keeffe. The electro-plating laboratory class, under Mr. Rousseau, will meet later in the session. Prof. Thompson's special course of lectures on central stations for electric lighting are to be given on Thursdays at 7.30 p.m., commencing October 4th. Particulars of these courses are to be obtained from the College Registrar.

Physical Society.—The meetings of this society will henceforth be held on the same day and at the same hour as heretofore (Fridays, 5 p m.), in the rooms of the Chemical Society in Burlington House. All communications to the secretaries or other officers of the society may in future be addressed to Burlington House, or to the secretaries at their respective addresses as given in the list of members of the society. The Council have also decided to initiate the publication of a series of abstracts of Papers on Physics. The slender resources at their command make it necessary to begin cautiously. At first abstracts will only be given of Papers which appear in a certain number of the more important foreign magazines. They will be published regularly at the beginning of each month in the form of a supplement to the *Proceedings* of the Society. The first number will be issued in January, 1895. Should the scheme prove successful it is intended to enlarge its scope. The abstracts will for a time be edited by Mr. Swinburne.

Coast Communication.—The Hamburg-American Steamship Company's steamer "Steinhöft," Captain Busch, bound from Hamburg for Montreal, went ashore on the coast of Devon early on Saturday morning on a sandy beach half a mile eastward of Torcross. The coastguard promptly sighted her and signalled, and as the tide was falling, with little sea running, they were able to communicate with the ship. There being no immediate danger, no one landed, but the rocket apparatus was got ready for instant use. Unfortunately the Torcross and other coastguard stations are not connected by wire with Plymouth or any other telegraph station which is always open, and thus a horse had to be procured and a messenger despatched to gallop ten miles in the darkness to Dartmouth, whence a steam-tug was despatched. The tide having risen, the "Steinhöft" was, with the aid of the tug, got off about ten o'clock, having been fast about seven hours. She did not appear to have suffered material damage and proceeded westward. Had an ordinary sea been running, the delay of assistance, owing to the absence of the long-promised telegraphic communication, would probably have had very serious consequences.

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Displacement Currents.—Two methods for the study of currents in open circuits and of displacement currents in dielectrics and electrolytes, were recently described by M. de Nicolaïeff before the Académie des Sciences. Discs or rings of dielectrics are, in the first method, supported by bifilar suspension between the two poles of an electro-magnet, so that the plane of the ring is at 45deg. to the axis of the electro-magnet, and centrally situated between the poles. The difference in the displacements caused in constant and alternating fields of the same strength is due to a secondary field set up by displacement currents caused in alternating fields. Paraffin shows an increase of 12 per cent. for a period of 930 per minute, and 9 per cent. for 770 per minute. In the second method, displacement currents in the rings are caused by the iron in the magnet cores. The ring is suspended perpendicular to the axis of the cores; the polar faces can be brought nearer to or removed farther from the parallel faces of the ring. By this method, augmentations have been obtained of 15 per cent. for yellow wax, and 8·3 per cent. for paraffin. Electrolytes in annular glass tubes behave just like perfect dielectrics, sulphuric acid giving an augmentation of deviation of 15 per cent.

"British" Electricians.—"In attempting to avert German prejudice against his book, 'Modern Views of Electricity,' which appears to have been aroused, in some measure, by the idea that electrical investigators of that nationality had been slighted, Prof. O. J. Lodge, the British physicist, is," says the *Western Electrician*, "in danger of running full tilt against the American electricians. In a letter to *Nature*, intended to sooth the wounded pride of the Germans, Prof. Lodge says: 'When I said that the four great names in connection with our partial knowledge of the nature of electricity were (excluding living persons) Franklin, Cavendish, Faraday, and Maxwell, I ought to have interpolated the adjective British before the word "names" in order to avoid entering upon much larger questions than were at all appropriate to the expository course of lectures on which the book "Modern Views" was based.' This will naturally excite the question on this side of the Atlantic: When, pray, did Franklin become a 'British' name? Benjamin Franklin was, of course, a native of Massachusetts, and a devoted American patriot, as well as a distinguished philosopher. It is rather cool, to say the least, to claim him as 'British' at this late day. Prof. Lodge should qualify his list a second time."

Searchlights and Torpedoes.—A dispatch from Newport, dated September 7th, says that the torpedo boat "Cushing" left her dock at the torpedo station the previous evening for practice in searchlight work. There were three objects in view when the boat left the torpedo station. The first was to give the class of seamen gunners at the station practice in keeping the searchlight on rapidly moving objects; second, it was desired to determine at what distance it was possible to distinguish the "Cushing" in her present colour, with the searchlight in its present position, and the boat in its direct rays. The torpedo boat steamed up under the shore and then ran into the full rays of the light, which was pointed directly out through the channel to sea. At a distance of a thousand yards it was light enough to read on board the "Cushing," but she was not discernible from shore by those who had kept their eyes upon her from the time they were within hailing distance. When she disappeared from view rockets were discharged from the station as a signal for those on board the "Cushing" to make plottings of their position. The third object was to determine at what distance, without the aid of the light, the torpedo boat could be located by the noise of her engines, swash of water from her propellers, or other necessary conditions in the running of the ship. There was not a ripple on the waters of the bay, but the bright moonlight was somewhat against the boat. In this test the observers first discerned a few sparks in the vicinity of Rose Island. Then more sparks were seen, and it did not take long to determine that they were from the "Cushing's" funnels. Soon the swash of water was heard; but it was several seconds before, with the aid of the search-light, whose rays were at once turned in the direction where the sparks were seen, the boat herself could be sighted. Plottings were again taken upon signal, and it was found that she was about 800 yards away when first sighted by the electric searchlight.

Earth Charging by Leaky High-Pressure Mains.—On January 8th last a grey mare was killed at Bournemouth by an electric shock. A full report of how this mishap came about was sent in to the Board of Trade by Major Cardew, and published on p. 412 of our issue of February 16th. Briefly this is what happened. A defect existed in the insulation of one of the high-pressure service lines of the local Company, from which sparking had taken place, to the enclosing wrought-iron pipe. This pipe was 32ft. long, laid at a depth of about 18in. and terminated at a brick junction box. The ends were thus fairly insulated, while the rest of the pipe was in contact with the earth, which became charged. The accident took place during the progress of a thaw, after a very severe frost. The accident was caused by leakage from the short length of charged pipe, affecting the potential of the surface of the ground to such an extent that between the fore and hind feet of the horse a sufficient difference of potential was established to give rise to the current which proved fatal. In a Paper entitled "On the Difference of Potential that may be Established at the Surface of the Ground immediately above and at various distances from a buried mass of Metal charged from a High Pressure Electric Light Supply," recently presented to the Royal Society by Major Cardew, R.E., and Major Bagnold, R.E., it is remarked that "the fact of such a result following from a simple contact with ordinary road material was a new experience of the possible dangers attending the commercial supply of electrical energy, and that it was thought desirable to repeat the conditions as nearly as possible, and measure the results obtained. Experiments were accordingly carried out at Chatham on January 26th, March 16th, and May 22nd. A length of 33ft. 3in. of 2in. iron pipe was buried to a depth of 18in. A piece of well-insulated 37/16 cable was inserted in this pipe so that the ends of the conductors made good contact with the inside of the pipe at its centre point. Over the centre of the pipe two 56lb. weights were placed on the surface of the ground, and at a distance of 4ft. laterally another pair of 56lb. weights were similarly placed. A 16-kilowatt alternator was connected by means of an underground cable laid in stoneware pipes to the piece of cable in the 2in. pipe. The other pole of the alternator was connected efficiently to earth at a distance of 140ft. from the piece of buried pipe. An 800-volt Thomson static voltmeter was connected across the terminals of the alternator, and a pair of leads, well insulated, were attached by means of screws to the two pairs of weights situated over the buried pipe. These leads were run back together to the experiment room, and were connected alternately to a 140-volt static voltmeter and a Cardew voltmeter. The voltage of the alternator was varied by means of the exciting current. With regard to the experiment of March 16th, the following note was made: "The soil in which the pipe was buried was loamy, and when digging the trench no worms were noticed; but towards the conclusion of the experiment it was observed that hundreds of worms came to the surface between 3ft. and 9ft. on either side of the pipe; no worms appeared, however, immediately over the pipe." On May 22nd the authors of the Paper observe: "The disturbance of the worms was again very distinct, and they appeared, on reaching the surface, to set their bodies parallel to the pipe, or along an equi-potential line." The alternator never gave more than about 600 volts. The authors conclude: "The experiments, as a whole, show conclusively that, under very different conditions of weather and amount of moisture in the soil, it is possible to produce a fall of potential amounting to 25 per cent. of the whole pressure in the supply between points on the surface of the ground 4ft. apart, a distance which most horses stand over, and, further, that, although the connection of such points by a conducting body naturally reduces this potential difference, yet, when this conductor has about the resistance of a horse (say 400 ohms), sufficient current will pass to give a severe shock. It is hoped that, when opportunity serves, these experiments may be extended to the case of pipes buried to greater depths, and to observe whether any difference is produced by the use of a steady, in place of an alternating pressure."

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THE CHEMICAL THEORY OF ACCUMULATORS.—II.

BY E. J. WADE.

Electrical energy does not exist as such in any galvanic cell, whether primary or secondary, but can only be absorbed or given out through the agency of corresponding chemical changes taking place in the cell itself, and its whole electrical behaviour as regards E.M.F., resistance, capacity, and so on, could be predicted and explained were the nature of these changes exactly known. During the last twelve years a great deal of work has been done on lead storage cells in this direction, and many valuable facts have been ascertained; yet at the present day very little is decisively settled as regards the precise chemical reactions that occur, and, consequently, many important characteristics, both good and otherwise, still remain to be satisfactorily accounted for. Probably many consider that time devoted to the elucidation of obscure chemical problems might be utilised to far greater advantage in attempting to construct better and more practical cells, and they are quite indifferent to questions of normal and basic sulphates, sub-oxides, peroxides, and so forth; but this is a mistake. It is true that in very few cases have the chemical theorists pointed the way to any improvements not already embodied in the best practice of the time, but rather have had to formulate their theories so as to account for electrical facts already ascertained; but probably it is for this very reason that storage cells are still so far from practical perfection, and have progressed so slowly as compared with dynamo-electric machinery and other apparatus in whose development theory and practice have gone hand in hand. A good deal has been said at one time and another about storage battery engineers and manufacturers not being chemists; but neither have the chemists who have gone into the subject been electrical engineers, and practical experience with storage cells on a large scale affords much information that could not possibly be obtained from laboratory experiments alone. In justice to the chemists, however, it must be remembered that the problems they have to face, even on their own ground, are by no means easy. Dr. Frankland called attention to this in some remarks he made during the discussion on the Paper by Prof. Ayrton and others on "The Chemistry of Secondary Cells," read before the Institution of Electrical Engineers in 1890.*

"The physical qualities of the cell are capable of very accurate estimation and investigation. But when you come to attempt to ascertain the chemical changes that occur in the charging and discharging of a storage cell you encounter formidable difficulties. The outsider has no idea of these difficulties. Nothing seems more simple than to determine the chemical changes that take place in either the negative or the positive plate of a storage battery. It is not so in reality. The substances used as active materials are, in the first place, mixtures, and the materials obtained at the end of the reaction are also mixtures; and these mixtures are insoluble in any re-agent which does not decompose them. They cannot be volatilised, they cannot be subjected to any process of solution and crystallisation in order to separate and purify their constituents."

Haphazard experimenting on accumulators, however careful and painstaking, seems to have done all that it can do for them, and it now awaits for theory to point out more clearly the causes of the imperfections that still exist, and to indicate the conditions necessary for their elimination; or, at the worst, to show that the limits of advance in any given direction have already been practically attained.

Before attempting to decide what are the actual chemical reactions taking place in a lead storage cell, it will be as well to first see what theories have already been advanced, and how they have been evolved. Planté did not pretend to go at all deeply into the chemical causes of the physical effects that he obtained. He observed the formation of lead peroxide at the positive electrode, and that the local action set up between it and the metallic lead in immediate contact resulted in the formation of lead sulphate, and, as he thought, the liberation of oxygen, but later research has shown that this is due to other causes. He also noticed the reduction of the peroxide to monoxide or litharge at the positive electrode; the oxidation of the lead at the negative electrode and the formation of films of sulphate on both; but on the whole he seems to have been inclined to ascribe the activity of the cell chiefly to occluded oxygen and hydrogen. During the period immediately following Faure's introduction of plates pasted with oxides, this view seems to have been held almost exclusively. Water, it was argued, was the real electrolyte, sulphuric acid merely being added to increase its conductivity, and on charging was decomposed into its constituent gases, which were liberated and absorbed at their respective electrodes. It was, of course, known that the first action of the oxygen was to convert all the active material at the positive electrode into peroxide, but this oxide itself was supposed to take up more gas by occlusion. The well-known property possessed by palladium, platinum, and in a lesser degree by a few other metals, of absorbing oxygen and hydrogen, especially when in a spongy or porous state; Grove's gas battery; Siemens' experiments on gas batteries built up of carbon plates saturated with salts of lead, these were the chief facts on which the theory was based, and the large capacity of a Faure cell was ascribed to the enormous surface offered by the porous mass of reduced oxides.

On discharging the cell the occluded gases recombined to form water, but it was soon perceived that the active material at the electrodes underwent some change as well, and it was thought probable that metallic lead was oxidised to monoxide at the negative, and peroxide reduced to the same substance at the positive

$$PbO^2 + H^2O + Pb = PbO + H^2O + PbO.$$

Dr. O. Lodge, in an able series of articles entitled "Electric Accumulators or Secondary Batteries," which commenced in the *Engineer* in May, 1882,* propounded what appears to have been the most advanced theory held up to that time. He still assumed that water was the essential electrolyte, and that the activity of the negative electrode was solely due to occluded hydrogen, and of the positive electrode during the earlier stages of discharge to occluded oxygen. The reduction of peroxide to monoxide is, however, recognised as an essential reaction, and its subsequent secondary reaction with sulphuric acid to partially form lead sulphate is also noted. A number of interesting experiments are described on the formation of "scums" or films of non-conducting sulphate at the negative plate, but this, as well as its oxidation, are supposed to only occur as its hydrogen becomes exhausted, taking the form of a crust of non-conducting materials that first appears at the surface in free contact with the liquid, and gradually increases in thickness as it spreads inwards. In fact, the formation of sulphate under any circumstances is regarded as an unmitigated evil, so much so that it is expressly stated that the presence of an excess of acid in the cell must be avoided as conducing to the too easy production of this compound at both electrodes.

Almost contemporaneously with Dr. Lodge's articles, some others by Messrs. Gladstone and Tribe, dealing only with the chemistry of the cells, appeared in the columns of *Nature*,† and these, afterwards collected and published in book form,‡ contained the first data obtained by actual analyses, and still constitute the most important contribution to the subject that has yet been made; for, with some comparatively unimportant exceptions, and as far as they go, their conclusions remain equally valid at the present date. They assumed that sulphuric acid, and not water, is the electrolyte, and showed by chemical analyses of exhausted plates that lead sulphate, formed by direct combination with "sulphion" (SO^4), is the normal and only product during discharge at the negative electrode, and they demonstrated that only the merest traces of the hydrogen liberated while charging are absorbed in the reduced material. Their analyses of the positive electrode proved that the peroxide was also converted into lead sulphate, most probably in two stages. In the first place, the hydrogen of the acid would reduce it to monoxide with the formation of water.

$$PbO^2 + H^2SO^4 + Pb = PbO + H^2O + PbSO^4.$$

* *Journal* Inst. Elec. Engineers, Vol. XIX., page 699.

* The *Engineer*, May 16, 1882, and *seq.* Reproduced in *The Electrician*, June 10, 1882, and *seq.*

† *Nature*, January 5, 1882, and *seq.*

‡ "The Chemistry of Secondary Batteries." (1883).

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Then this monoxide would re-act with the sulphuric acid with the formation of lead sulphate and another molecule of water.

$$PbO + H^2SO^4 = PbSO^4 + H^2O.$$

The ultimate result would, therefore, be the formation of a molecule of lead sulphate at each electrode at the expense of two molecules of sulphuric acid, which would be replaced by two molecules of water.

$$PbO^2 + 2H^2SO^4 + Pb = PbSO^4 + 2H^2O + PbSO^4.$$

In addition to this it was shown that the local action between the peroxide and the metallic support was of exactly the same nature, and might be expressed by the same equation, both being converted into lead sulphate.

This new theory gave rise to considerable controversy at the time between Messrs. Gladstone and Tribe and Dr. Lodge, and very well illustrate the different points of view from which a chemist and physicist may regard the same phenomena.

To the latter it naturally seemed highly improbable that any explanation of the cell's action, which involved the production of large quantities of non-conducting insoluble lead sulphate could be correct, however strong the evidence by which it was supported. Lord Kelvin and Dr. Lodge had both failed in their attempts to reduce pure lead sulphate by electrolysis, with platinum electrodes in dilute sulphuric acid, although it peroxidised fairly easily; and even the best of Messrs. Gladstone and Tribe's own experiments showed that this reduction only took place after the action of the current had been prolonged for some days and then not completely. How, then, was it possible for the same result to be obtained in a cell in a few hours, and with a complete absorption of the current until only a very small percentage of sulphate still remained to be acted upon? Messrs. Gladstone and Tribe, although they had undoubtedly proved their case, do not seem to have recognised that in putting the chemistry of the cell on a better basis they had rendered its physics proportionately difficult to understand. Later experience has shown that the conception of the distribution of the sulphate formed was largely at fault. Instead of the portion of the active material first acted upon being wholly converted into sulphate, and producing a solid crust at the surface in free contact with the liquid, the action takes place, more or less uniformly, throughout the whole mass, owing to its extreme porosity, and leaves a nucleus of conductive material underneath, by which the current in charging is distributed to every portion of the plate. Mr. Swinburne and others have also shown that lead sulphate, when mixed with litharge, reduces easily enough, so no doubt it is very largely a matter of conductivity; but this is not a complete solution of the difficulty, and a perfectly satisfactory explanation has never yet been propounded.

Early in 1883* Dr. Frankland also showed that lead sulphate was the ultimate product at both electrodes, although he expressed his equations in terms of hexabasic sulphuric acid ($H^2SO^4 + 2\ H^2O$ or SH^6O^6), which he considers to be the real electrolyte. He demonstrated that neither oxygen nor hydrogen is occluded in the fully-charged plates, and drew attention to the fact that the changes in the specific gravity of the acid afforded a means of determining the amount of sulphate formed, and might be utilised in practice to indicate the degree to which a cell was discharged.

From this time onwards the double sulphating theory rapidly gained ground, although even in 1886 the late Mr. A. Reckenzaun, who was exceptionally well acquainted with all matters pertaining to storage cells, seems to have still adhered to the occluded gases theory. It is now almost universally accepted as representing the final results of discharge; but considerable differences of opinion still exist, especially with regard to the positive electrode, as to how far it is a primary electrolytic action which contributes towards the E.M.F. of the cell, and how far a secondary local reaction which is dissipated in the form of heat. The chief practical outcome was a recognition of the necessity for supplying cells with stronger acid and more of it, so that the normal sulphating could easily take place without the electrolyte becoming too weak.

The corrosion or rotting of the positive grids and plates, by reason of local action with the lead peroxide, seems to have

* *Proc.* Royal Society, Vol. XXXV. (1883), page 67.

been considerably over-estimated by the early manufacturers, and Messrs. Gladstone and Tribe's researches tended in the same direction. The users of cells were warned never to overcharge them, as this was supposed to reduce the skin of lead sulphate that otherwise protected the positive support, and thus promote local action.

Messrs. Drake and Gorham, however, in 1886* showed that the real protective coating was the dense film of peroxide into which the sulphate was gradually converted, and that some overcharging was decidedly beneficial, as it hastened the formation of this film, besides reducing any residue of sulphate that was present elsewhere. On the other hand, they found that the over-discharging then generally practised was the real cause of the excessive sulphating, buckling and local action to which the cells were so liable. These views entirely revolutionised the methods of treatment formerly adopted, and put them on the basis on which they have since remained.

Very few additions were now made to the chemistry of the cells for some little time. The excess of sulphate formed under certain conditions, and the extreme difficulty with which it was again reduced still continued to puzzle investigators, and seemed to point to the existence of two different kinds, one reducible and one not. Various theories of double sulphates, basic sulphates and so on, were developed to meet the occasion, but had very little evidence to support them. In 1889† Dr. Frankland made some experiments which seemed to indicate the existence of two basic sulphates obtainable by the action of sulphuric acid on litharge and minium respectively, but both Messrs. Gladstone and Hibbert‡ and Mr. Robertson§ consider they are only mixtures of normal lead sulphate with more or less oxide.

The Paper by Prof. Ayrton and others on "The Chemistry of Secondary Cells," read before the Institute of Electrical Engineers at the end of 1890,‖ did not propound any new theory of their action, but supplied some very interesting data, both qualitative and quantitative, as to the composition of the plates at various stages of charge and discharge. Their investigations also included an examination of the temperature changes of a cell during charge and discharge, and these, together with some experiments made by Messrs. Duncan and Wiegand about the same time, and communicated to the American Institute of Electrical Engineers in May, 1889,¶ form the first definite contributions to this branch of the subject. In both Papers attention is called to the remarkable fact that a cell actually cools during discharge.

So far, almost all the investigations into the chemistry of the cells had been confined to an examination of the changes taking place at the electrodes, and very little attention had been paid to any reactions occurring in the electrolyte; but the researches of the last three or four years seem to indicate that there really lies the explanation of many obscure points.

Planté had, indeed, observed the formation of some unstable compound containing "active oxygen," which he thought to be hydrogen peroxide (H^2O^2), and he ascribed the high initial E.M.F. of a freshly-charged cell to its presence; but, to suit the needs of the "occluded gas" theory, it was assumed that the real agent was oxygen, liberated at the positive electrode in the form of ozone, and this idea has prevailed more or less generally to the present day.

In 1878 Berthelot discovered the highly-oxidised compound persulphuric acid, and showed that it was a direct product of the electrolysis of dilute sulphuric acid; while hydrogen peroxide, whose presence under similar conditions had long been known, was chiefly a secondary product resulting from its subsequent reversion to normal sulphuric acid.

$$H^2(SO^4)^2 + 2H^2O = H^2O^2 + 2H^2SO^4.$$

In 1883** Messrs. Gladstone and Tribe noticed persulphuric acid in some solution that had been subjected to electrolysis;

* British Association, 1886. *Electrician*, September 19, 1886.
† *Proc.* Royal Society, Vol. XLVI. (1889) page 304.
‡ *Proc.* Physical Society, Vol. X. (1890), page 448, and Vol. XI. (1890), page 44.
§ *Proc.* Royal Society, Vol. L. (1891), page 105.
‖ *Journal* Inst. Elec. Engineers, Vol. XIX., page 660.
¶ *Electrical World* (New York), June 15, 1889.
** *Journal* Chemical Society, 1883, page 345.

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but Prof. Armstrong and Mr. G. H. Robertson, in 1891,* were the first to call attention to the probability of this compound being the cause of the variations of E.M.F. and other phenomena observed in the cells, and the latter gentleman discussed the matter in more detail in a Paper read before the Society of Arts in the same year.† He showed that persulphuric acid and hydrogen peroxide were formed in considerable quantities at the positive electrodes of a cell during charging, their relative proportions depending on the strength of acid that was used; and, further, that the latter compound was capable of causing local action and ultimate sulphating at both electrodes. He also considered that a cell's E.M.F. was in some way dependent on the amount of these compounds present, but his experiments on this point were not very definite or conclusive.

Meanwhile, Messrs. Gladstone and Hibbert had commenced an investigation of the relations of the electrolyte to the E M.F., from the point of view of the strength of acid. Their first results were communicated to the Physical Society in 1890;‡ but in a very interesting Paper "On the Cause of the Changes of Electromotive Force in Secondary Batteries," read before the Institute of Electrical Engineers in 1892,§ they go much more fully into the matter. Messrs. Duncan and Wiegand, in their communication referred to above, had already shown that during discharge the strength of the solution contained in the pores of the active material might be very greatly reduced by the abstraction of sulphuric acid to form sulphate with the production of water far faster than it could be equalised by diffusion from the surrounding liquid; and, following up this line of argument, Messrs. Gladstone and Hibbert endeavoured to prove that the loss of capacity and E.M.F. with heavy discharges, and subsequent recovery on standing; the high E.M.F. observed immediately on the cessation of charging; and the normal variations of E.M.F. during charge and discharge would all be accounted for in a similar way. Although in some points, perhaps, the deductions drawn from their experiments are stretched to cover rather more than can be explained by their aid alone; yet, on the whole, they supply a thoroughly well-connected chain of evidence and reasoning, from whose main conclusions it seems difficult to dissent. During the discussion that followed their Paper, Mr. Robertson advanced some further arguments in favour of the persulphuric in the electrolyte being the real cause of the variations of the E.M.F., and Messrs. Gladstone and Hibbert again returned to the subject from their point of view in a communication to the Physical Society shortly afterwards;‖ but since that time no further direct evidence bearing on the point in dispute has been adduced.

The last contribution to the chemistry of lead storage cells worth noticing is that of M. M. G. Darrieus read before the Société Internationale des Electriciens in May, 1892. The author advances some theories of their action, so widely at variance with those generally accepted and the results obtained by other experiments that they would require a considerable amount of confirmatory evidence to sustain them, especially as the details given regarding the apparatus used, and the methods of electrical measurement employed are very meagre. He is strongly of opinion that the formation of lead sulphate at the positive electrode is purely a secondary reaction, the reduction to litharge being the essential one. Further, in order to account for the high E.M.F. of the cell, he maintains—and it is here that the originality of his views is most apparent—that the porous lead of the negative electrode, prepared by electrolytic reduction, is in a highly energised allotropic condition, something similar to "explosive antimony"; and that consequently it furnishes far more energy and E.M.F. by its conversion into lead sulphate than lead in its normal metallic state. Besides this, he considers that the sulphating takes place in two stages; first an oxidation of lead to sub-oxide (Pb^2O), and then a conversion into lead sulphate with the elimination of water; half the lead, however, returning to the metallic state, and being protected from further action by the surrounding sulphate.

$$Pb^2O + H^2SO^4 = Pb + PbSO^4 + H^2O.$$

Although it may be impossible to agree with the whole of the conclusions drawn by M. Darrieus from his researches, yet at the same time his paper is well worth study both for its originality and suggestiveness, and some of his experiments might well repay repetition. With the exception, however, of a passing allusion to it by Dr. Gladstone, the paper does not appear to have attracted much notice in England.

(To be continued.)

* *Proc.* Royal Society, Vol. L. (1891), page 105.
† *Journal* Society of Arts, Vol. XL. (1892), page 44.
‡ *Proc.* Physical Society, Vol. X. (1890), page 448.
§ *Journal* Inst. Elec. Engineers, Vol. XXI., page 12.
‖ *Journal* Physical Society, Vol. XII. (1892).

THE CONSTRUCTION OF RESISTANCES.*

BY D. K. MORRIS

(Continued from page 607.)

While on the subject of coils designed to assume temperature conditions rapidly, it may be of interest to describe a type of coil in which this point is almost the sole object of design, namely, a coil suitable for the determination of specific resistance over wide ranges of temperature. Such coils should be small, have very little mass, and be at all points accessible to the insulating medium in which they are intended to be measured.

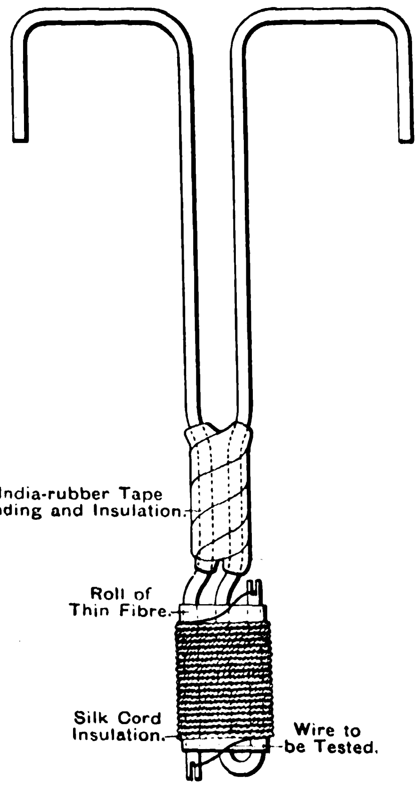

FIG. 6
Coil used for Determination of Specific Resistance at Low Temperatures (Dewar and Fleming). Rather l ss than half actual size.

Measurements of resistance can be easily carried out with a high degree of accuracy; but this refinement of measurement is very apt to be worthless if the substance under test has a large temperature coefficient, for the possible error in the measurement of temperature may correspond to a large error in the resistance.

The coils used in the research previously referred to were constructed as in Fig. 6. Two pieces of stout copper wire were taken and bent thus, and bound together at the middle with insulating tape, and the four ends were tinned. A piece of very thin vulcanised fibre sheet (like thin card) was then fastened to one leg and wound round, a turn and a half, and fixed at the other.

* A Paper read at a Student's Meeting of the Institution of Electrical Engineers, March 16, 1894.)

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Two lengths of silk cord were wound side by side from top to bottom of the fibre cylinder, one was fastened at both its ends, and, after immersion for some time in melted paraffin wax, the other was unwound, thus leaving a spiral channel into which the wire of known length and cross section could be wound, and its ends soldered to the ends of the copper leads. In this way a length of wire of as much as three metres could be wound in a single open layer.

Such coil had very little mass, and hence assumed the temperature of its surroundings readily. This was especially neces-

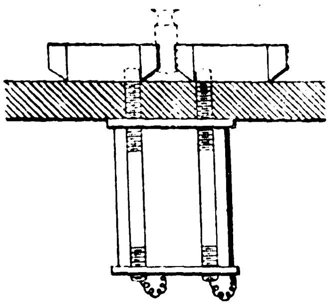

Fig. 7.

sary in the low temperature experiments, for when immersed in, say, liquid oxygen, they did not boil away any very large quantity before they were cooled down.

Resistance Boxes.—The principles which determine the making of a good standard of resistance have been given at some length, because these are the points which should be aimed at, though in a lesser degree, in the construction of ordinary resistance coils. Resistance boxes contain sets of coils which are definite multiples or sub-multiples of the ohm. The arrangement of these coils depends on the purpose for which the box is required.

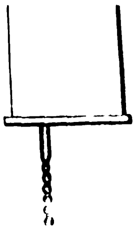

Fig. 8.

Each coil has a separate core, which ought to be a brass or copper cylinder covered with thin rubber or varnished paper, the cheeks being of thin ebonite. When a coil of given resistance is to be wound, a length of well-insulated wire of slightly greater resistance is cut—doubled on itself at its middle point, and wound thus double on its core. This method of winding is important for two reasons: Not only do we in this way avoid induction effects while the current is varying, but we prevent

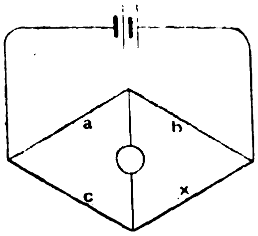

Fig. 9.

the direct magnetic action of the coils which would render any ordinary galvanometer practically useless. After each layer of the coil is wound, it is dipped into melted paraffin, so as to fix the turns relatively to one another, preserve them from damp, and insure better insulation.

When the coil is wound, it is fixed in position by two long brass or copper screws passing through the cheeks and ebonite cover to two brass pieces at the top, which are arranged so that the coil can be short-circuited by the insertion of a brass plug (Fig. 7) which must be accurately fitted.

The ends of the wires are then soldered to these long screws, care being taken to use no corrosive flux (resin being the right thing).

The coil is now brought to the temperature at which it is to be accurate, and is finally adjusted.

There are several ways of adjusting; the simplest is to slide the wire into or out of the drop of melted solder at the point, allowing it to cool completely before re-measuring. Another way is to leave the middle point of the wire, where it is doubled, projecting out of a hole in the cheek; to strip the insulation from this part, and to go on twisting the loop together until the resistance is *very* nearly down to its proper value, and then to touch it with solder (Fig. 8).

The coils of lower resistance are made with thicker wire to render accurate adjustment easier.

The cutting away of the brass blocks underneath, is to increase insulation and to allow the removal of dust which may collect there on the ebonite, as this might seriously diminish, by its shunting action, the effective resistance of a coil of several thousand ohms.

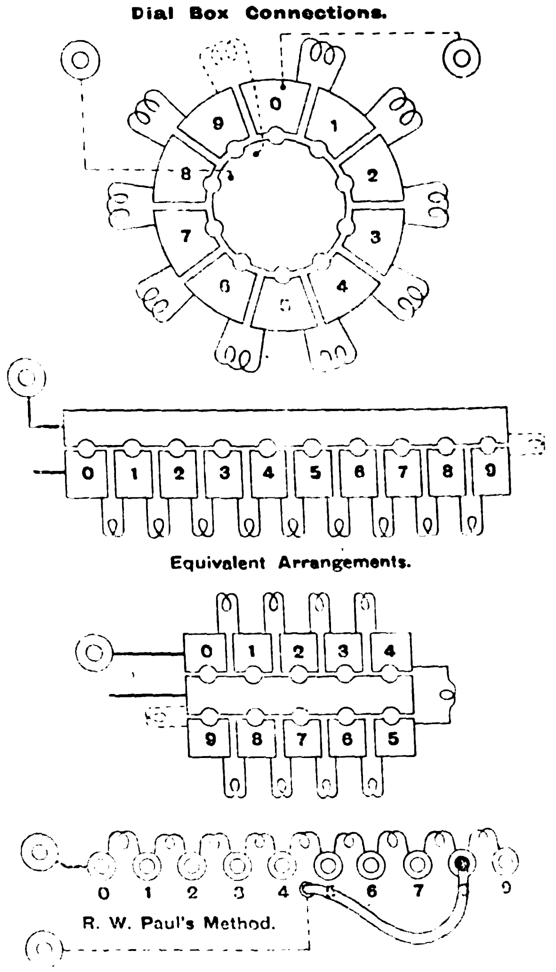

Fig. 10.

For instance, to take a bad case, suppose the insulation resistance to fall to about 10 megohms, while the coil itself was one of 10,000 ohms.

The effective resistance would be $\dfrac{1}{\dfrac{1}{10{,}000}+\dfrac{1}{10{,}000{,}000}}$ $=\dfrac{10{,}000{,}000}{1{,}001}=\dfrac{10{,}000}{1{\cdot}001}$; so an error of 1 in a thousand would arise, which would in many cases be serious.

Arrangement of Coils in a Resistance Box.—The commonest way of measuring an ordinary resistance is to compare it with known ones by the Wheatstone's bridge method, Fig. 9. We all know the diagram of connections—three of the arms must be known, the fourth can then be calculated.

You see from the diagram that these three arms will be wanted all in series, and it is usual to arrange them perma-

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nently so. And since $\frac{a}{b}=\frac{c}{x}$, therefore $x=\frac{b}{a}c$; so if $\frac{b}{a}$ is made an even power or root of 10, we get x by simply shifting the decimal point of c. Hence the common disposition of coils in Wheatstone's bridge sets. Thus, in the best boxes, the ratio arms each contain 10, 100, 1,000, and 10,000 ohm coils, placed at the back of the box, and the rest of it is occupied by a set of coils, such that we can get any unit between 0 and 20,000 ohms. This is done by providing coils of 1, 2, 2, 5, 10, 10, 20, 50, 100, 100, 200, 500, 1,000, 1,000, 2,000, and 5,000 ohms.

An excellent arrangement of coils for a series resistance box is that used in dial boxes, Fig. 10. They contain three, four, and sometimes more sets of 10 equal resistance coils, 10 units, 10 tens, 10 hundreds, and so on. The connections are as shown on the diagram.

It is obvious that only one plug for each digit in the result is needed, and that the number at the position of the plug represents the number of ohms (or tens of ohms, or whatever

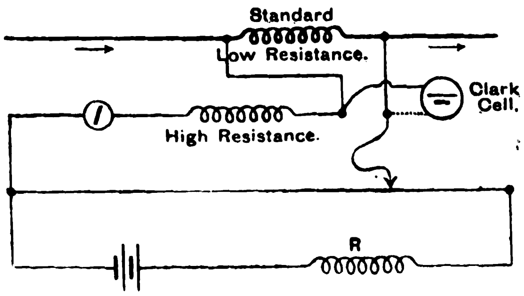

Fig. 11.

it may be) in circuit due to that part of the box. So that one reads such a dial box exactly in the way that one reads a gas meter or a speed counter, arranging the decimal point according to the ratio coils in use.

Two equivalent arrangements are shown below on the diagram, and a modification in the arrangement by R. W. Paul, in which a flexible cord is used, and the plugs can be inserted into complete sockets, which, therefore, cannot get out of shape owing to warping of the cover.

Resistance boxes of the Post-Office pattern have the battery and galvanometer keys permanently connected up; while "testing sets" usually contain the galvanometer in the box, the only terminals supplied being one pair for the battery and one pair for the resistance to be measured.

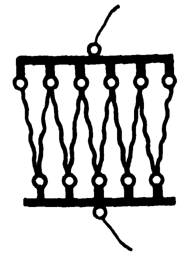

Fig. 12.

Conductivity boxes, or boxes in which the coils are arranged in parallel, are sometimes used, though comparatively rarely. The conductance of the circuit is obtained by adding the conductances of the coils.

Very high resistances are sometimes made of a strip of graphite in an ebonite case; but this method of construction is of little use in accurate work.

We now come to the consideration of accurate resistances designed to carry considerable currents. Such resistances are necessary for making measurements by the potentiometer or Poggendorff's bridge method. This method, which has been brought into practical use quite lately, is one of the best methods of measuring large currents and small resistances (Fig. 11). We have a wire, down which there is a uniform fall of potential of two or three volts, kept up by a couple of small accumulators, and after adjusting R so that on calibrating by a Clark cell there is a fall of exactly one volt per metre of the slide wire, we can read small differences of potential with considerable accuracy by finding how many centimetres of the wire will neutralise the unknown E.M.F., as indicated by the zero galvanometer.

Thus, to measure a small resistance, we pass a considerable current through both the known and the unknown resistance, and compare the fall of potential down each, which gives the ratios of resistance. While, to measure a large current, we simply pass it through a known resistance capable of carrying it, and measure the drop.

If, as would usually be the case in setting up a potentiometer, apparatus is not at hand to measure the low resistance as it stands accurately, the best way of proceeding is as follows:—

Let the required resistance be $\frac{1}{100}$th of an ohm. Take ten German silver wires, each having accurately the *same* resistance and about $\frac{1}{10}$th of an ohm. Join them in a zigzag way between two rows of mercury cups (Fig. 12), and measure them on a Wheatstone's bridge thus in series, when they will be about one ohm.

Their resistance, when joined in parallel by stout copper connections, will be accurately $\frac{1}{100}$th of the value in series. If, however, one is able to measure low resistances accurately, then it is more convenient to solder all the wires side by side to two massive end pieces to which are attached terminals.

Messrs. Crompton's form of low resistance for this kind of work is made in a different way. The following is a description of a $\frac{1}{100}$th of an ohm resistance made by that firm.

A wide strip of manganin, 6¼in. wide, 20in. long, and $\frac{1}{16}$in. thick is divided into four by three slots $\frac{1}{10}$in. wide (Fig. 13). Stout terminals are fixed to the ends; two blocks of ebonite are fastened on it near these two terminals; and screws, passing through the manganin and the ebonite blocks up to two small terminals, serve as connections for the potential wires. The resistance is measured between these two screws, which should not be placed too near the large terminals.

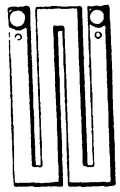

Fig. 13.

If it is desired to measure 100 volts (continuous) with accuracy, a resistance is required which will stand that pressure without any appreciable heating, and which is divided exactly in the ratio of 1 : 99; so that if, by the potentiometer, we measure the fall of pressure down the section, which is $\frac{1}{100}$th of the total, and multiply by 100, we get the total pressure.

To do this conveniently, two horizontal bars of ebonite about a foot long, and as much apart, each having a hundred deep notches, are supported in a wooden frame. Then 200ft. of fine platinoid wire (No. 38) is wound up and down till the notches are full.

The resistance of the whole will be about 1,400 ohms, and that of the first turn can then be accurately adjusted to be $\frac{1}{100}$th part of this. The measurement of 100 volts by the potentiometer then becomes quite easy.

(*To be concluded.*)

THE MANUFACTURE OF ALKALI AND BLEACH BY ELECTROLYSIS.

The latest attempt of importance to manufacture caustic soda and chlorine by means of electrolysis is that which is being made by the Aluminium Company, under the guidance of Mr. H. Y. Castner. From such statements as have been published it appears that the process belongs to the type in which mercury is used, both as a cathode and as a means of transferring sodium from the decomposing cell to a compartment in which the sodium amalgam is acted upon by water with the formation of caustic soda. In this instance the mercury forms the bottom layer in a cell divided into three com-

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partments, the middle member of which contains an iron cathode immersed in caustic soda solution, while the remaining pair are provided with carbon electrodes dipping in brine. The mercury at the bottom of the composite cell serves as the cathode of the two outer compartments and as the anode of the middle compartment, receiving sodium in the former and giving it up in the latter. Bodily transmission of the mercury charged with sodium from the outer to the middle compartment is effected by communicating a rocking motion to the whole apparatus. It is claimed that by this arrangement the usual difficulty arising from the need of a suitable diaphragm of low resistance is overcome, and that the voltage required is correspondingly small as the electrodes are brought almost into contact with each other. It is evident that the fact that sodium is obtained as an intermediate product is not a cause of any increase in the voltage necessary for each cell, as the sodium does not appear as an end-product of the reaction, but generates in the cathode compartment the same voltage as that which its liberation absorbs in the anode compartment. The critical voltage of the cell is, therefore, that proper to the electrolysis of a solution of sodium chloride. Any extra voltage that may be required in practice is due to the internal resistance of the electrolytic cell

The apparatus, which is said to have been in regular use at Oldbury for about six weeks, consists of 30 cells 6ft. in length, 3ft. in width, and 6in. in depth, jointly capable of an output of 1,200lb. of caustic soda and 1,000lb. of chlorine per day of 24 hours, with an expenditure of 110 I.H.P.; each cell, therefore, yielding 38½lb. of caustic soda and 34½lb. of chlorine per 24 hours, and absorbing about 3½ I.H.P. The caustic soda is obtained as a 20 per cent. solution (presumably fairly free from salt) from the cathode compartment, and when evaporated yields solid caustic soda, containing as much as 99 per cent. NaOH. The chlorine is of a purity of 95-97 per cent., the balance being alleged to be hydrogen, doubtless derived from the premature action of the sodium dissolved in mercury in the anode compartment upon the brine with which it is in contact. The simultaneous presence of free chlorine and hydrogen is only possible while the conditions necessary for inducing their combination to form HCl (*e.g.*, exposure to strong light) are not operative. Should such conditions obtain, loss of chlorine will, of course, occur, with a corresponding deterioration of the bleaching powder ultimately produced. The remaining hydrogen appears in the cathode compartment, but its utilisation does not appear to have been attempted. An electrical efficiency of 88·9 per cent. is claimed for the process.

It is with this last statement that we are more particularly concerned, as it is one of those illusory allegations which are especially mischievous, tending to injure legitimate electrolytic enterprise. Adopting the moderate estimate that 3½ I.H.P. per tank corresponds with 2,100 watts at the electrodes, and taking the figures given above—viz., that the resulting production of chlorine is 34½lb. per 24 hours—it follows that the voltage for each cell is 4·3 volts. Seeing that the critical voltage for the decomposition of sodium chloride in aqueous solution is a trifle over two volts, it is obvious that an efficiency of barely 50 per cent. is obtained, instead of the 88·9 per cent. which is claimed. In short, the process in this respect is neither better nor worse than a dozen others which have been brought forward within the last few years. In all cases a voltage of 4·5 to 5 volts is necessary when everything is working smoothly, and a good deal more becomes requisite when the apparatus is not quite at its best. It must not be supposed that this huge waste is inevitably fatal to a process; but it is futile to ignore its existence, and claim an efficiency contradicted by the very figures put forward by the inventor himself. In this particular case the cost of energy necessary to produce one ton of caustic soda and about 2½ tons of chloride of lime would be approximately £4.2, assuming that a large plant was employed and the process worked continuously. Any estimate of this kind only touches the fringe of the matter, however, as the cost of the plant and its up-keep are apt to be heavy in all electrolytic processes. Thus it comes about that in spite of the enormous apparent saving which the adoption of electrolysis would effect in the manufacture of alkali and bleach, the civilised world is still dependent on purely chemical processes for the supply of these commodities. A good deal of progress has been made, and, on the whole, on sound lines; but electrolytic soda and bleach will not have the market to themselves yet awhile. The time when they shall have driven out their rivals will not be hastened by overstating the advantages of processes for their manufacture.

THE CLARET-WUILLEMIER SYSTEM OF ELECTRIC TRACTION.

For some months past an electric tramway on a system possessing some curious features has been working without a hitch at Lyons in connection with the Exhibition now being held there. The line is double track, one-metre gauge, some two miles long, and it runs from the centre of the town to the Exhibition gates. The generating plant is inside the Exhibition grounds, and comprises a 100-H.P. gas-engine, belted to a six-pole 500 volt Thury dynamo; the gas is manufactured on the spot by the Buire-Lancauchez process. The rolling stock comprises 12 motor-cars, each weighing, with its complement of 42 passengers, and its 20-H.P. double-reduction Thury motor, something like nine tons. The speed is regulated by switching resistances into and out of circuit. Carbon brushes are used, the wear of which, it is said, amounts to 0·06 mm. per run of

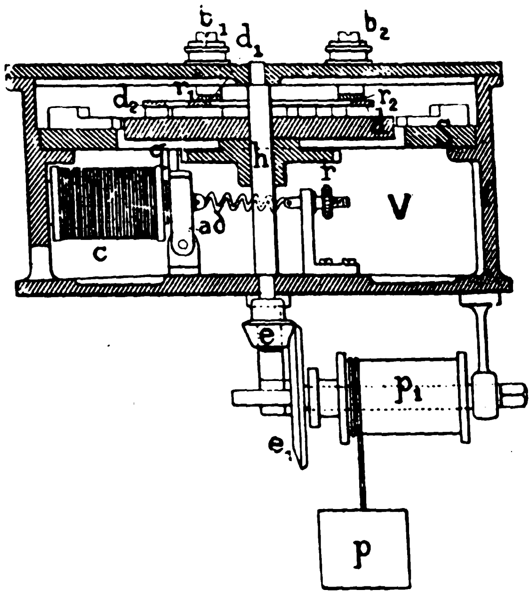

FIG. 1.—Distributor. Elevation.

100 kilometres. During the month of August the line was used by 124,000 passengers; 15,000 being the largest number carried as yet in one day.

The Claret-Wuillemier system is simply a special application of the principle of bringing successively into contact with the "live" conductor sections of an insulated conductor laid between the rails on a level with the roadway, a principle which was first thought out by Profs. Ayrton and Perry, and which met with what was, perhaps, its most practical exposition in the Lineff device (see *The Electrician*, Vol. XXV., p. 205). Compared with the simplicity of Mr. Lineff's plan, that of MM. Claret and Wuillemier appears complicated to a degree; but since it has managed to withstand the test of actual running, it must be easier to make it work well than to describe it clearly.

The sectional conductor consists of reversed rails 2·8 metres long and 3 metres apart; so that the cars, which are 7·6 metres long, almost cover two sections and an intervening gap. The sections are insulated by wood-paving blocks run in bitumen. The main cable, which has a section area of 0·135 sq. in., and is armoured and lead-covered, is run under the pavement, the feeding wires from the distributors being led to the sectional conductor inside a wooden trough impregnated with a preservative and tarred. The return is by the rails.

The distributors, which are laid in pits 100 metres apart, are as follows: In each distributor there is a spindle *h* (*see*

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Fig. 1) carrying a ratchet wheel, r, upon which rests an insulating base, d, which supports two copper rings, d_1 and d_2, insulated from each other. Ring d_1 carries the horizontal arm m_1 (Fig. 2) and ring d_2 the arm m_2; so that as h revolves these two arms come into contact with the contact-pieces t_1, t_2, &c. The arm m_1 is somewhat wider than the interval between two contact pieces, m_2 being narrower than this interval. In Figs. 3 and 4 we see that the arm m_2 presses on the upper edge of the contact pieces, whilst m_1 presses only on the lower part. Each contact piece is, however, all in one part, except in one instance, where the two portions are insulated from each other, as shown in Fig. 4. From each of the contact pieces

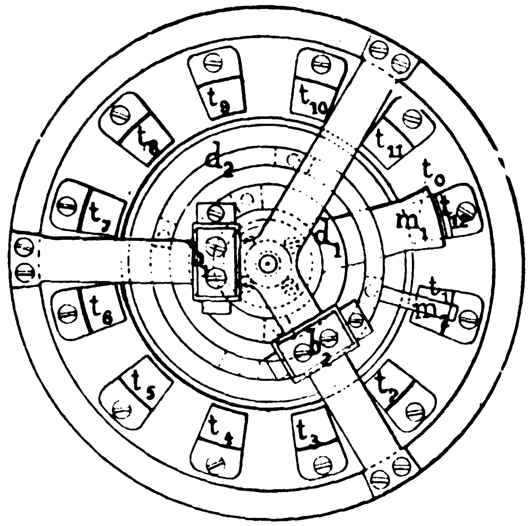

Fig. 2.—Distributor. Plan.

wires run to the corresponding sectional conductor. The rings d_1 and d_2 are placed in connection with the terminals b_1 and b_2 respectively (Fig. 1) by means of brushes, b_1 being in connection with the main conductor, and b_2 with one end of the coil of the electro-magnet c (Fig. 1), the other end of which is to earth. The rotation of the arms m_1 and m_2 is effected by means of a weight (or electric motor) p, which communicates motion by the bevel wheels e and e_1 (Fig. 1) to the spindle h, the ratchet wheel r of which cannot rotate, however, until a stud, q, on the armature of the electro-magnet c releases it.

By aid of the diagrammatic sketch (Fig. 5) we may now possibly be able to see what happens as a given car, X, passes along. As shown, the rear collector y_1 of the car is just leaving the sectional conductor s_1, and the front brush y_2 has just come into contact with the section s_2. The current from the dynamo reaches the distributor by the terminal b_1, passes to the copper ring d_1, along the arm m_1 to the contact-piece t_1, thence to the

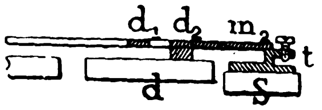

Fig. 3.—Details of Distributor.

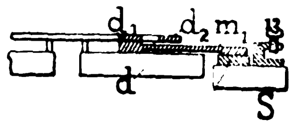

Fig. 4.—Details of Distributor.

sectional conductor s_1, along the collector y_1, to the car-motor, and thence by the wheels to the rails x and back to the dynamo. But a portion of the current finds its way back *viâ* collector y_2, sectional rail s_2, contact piece t_2, arm m_2, ring d_2, terminal b_2, and electro-magnet c. This current causes the electro-magnet to attract its armature and to release the ratchet-wheel r, so that the weight immediately p comes into action, and revolves by the ratchet-wheel amount of one tooth, switching m_1 on to t_2 and m_2 on to t_3, when the whole of the motor current is collected by y_2; and the electro-magnet, being cut out of circuit until y_2 comes into contact with s_3, ceases to attract its armature and allows the stop q to arrest the motion of the ratchet-wheel r, and so on, until the car has passed to the last sectional rail connected to the particular distributor. To this last section is also joined up the first contact-piece of the next distributor, which is thus enabled to take up the running.

On looking at Fig. 4 it will be observed that the lower part of the last contact-piece, on which presses the arm m_1 conveying the main current, is insulated from the rest, so that when the car leaves the last sectional rail connected to the distributor under consideration, it leaves the distributor insulated, and the car has to take all its current from the next distributor, and, no current finding its way home *viâ* the electro-magnet c, the distributor remains at rest until the front collectors of the next car comes on to sectional conductor s_1 when the cycle of operations begins once more.

A distributor of this kind, it is obvious, is only applicable to a double-track line; that is, to one on which the cars are always travelling in the same direction along the same individual track. It will also be obvious that the use of distributors results in a perfect block-system, the cars being perforce kept apart by at least the length of the portion of the sectional conductor served by one distributor. To apply the distributor to a single-track line, with cars running in either direction, several addi-

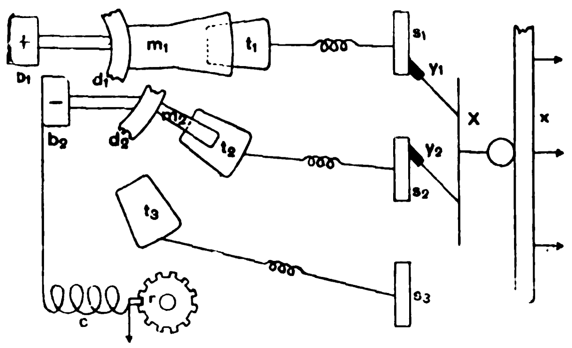

Fig. 5.—Diagram of Connections.

tional complications are needed, for a detailed description of which we must refer our readers to *l'Electricien* for September 22nd, whence these particulars and some of the illustrations are taken.

In Fig. 6 we have a side view of the collectors used at Lyons, each of which is composed of three pairs of shoes, each car having four sets altogether, two being at the rear and two at the front of the car. The part a is a permanent magnet, ff being cast-iron pole-shoes capable of revolving round x, rr

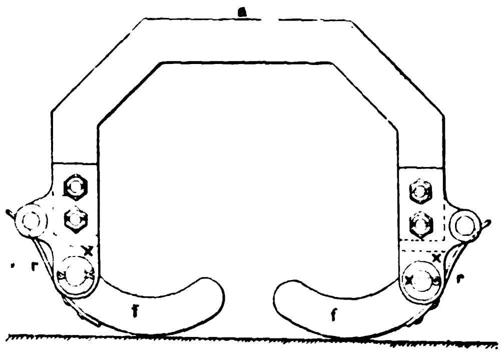

Fig. 6.—Collecting Shoe.

being springs which lift the collecting-shoes off the roadway when they are not pulled down by the attraction of the iron sectional conductor.

The Claret-Wuillemier system is certainly ingenious, and has, it would seem, been successful in practice; but particulars as to first cost and maintenance would be of interest.

Society of Engineers.—Mr. Perry F. Nursey has been unanimously elected honorary secretary and treasurer of this society. The next ordinary meeting of this society will be held at the Town Hall, Westminster, on Monday, October 1st, when a Paper will be read on "The Utilisation of Town Refuse for Generating Steam," by Mr. T. W. Baker, B.A. The annual dinner will be held at the Holborn Restaurant, on Wednesday, December 12th.

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PHOTOMETRIC UNITS AND DIMENSIONS.

The introduction and progress of electric lighting has conduced to the development of photometry, and while the methods and apparatus which are now used differ but little from those which were employed fifteen or twenty years ago, the immature and defective state of the science of photometry as a section of optics has been forced upon the notice of all those who have treated the subject in a scientific manner. The mere comparison of the candle-power of two sources of light of similar colour, a process which is the beginning and the end of the science of photometry to many people who imagine they know all there is to know about the matter, is really a very limited branch of the science. Photometry received much more attention at the end of the last and the beginning of the present century from Continental physicists than from our own, and the names of LAMBERT, BUNSEN, BOUGER, FOUCAULT, WEBER, are familiar in connection with this subject. It is hardly the fault of English physicists, then, that the vocabulary, definitions, and units of photometrical quantities should be in such a state of confusion. Just as in the early days of electrical science the crude hypothesis of electric fluids led to the use of the word "current," and thus wrought immediate and irremediable mischief; so, by some accident, the notion of a flux of light was not clearly recognised, where a real flux exists. To meddle with the nomenclature of photometry is a serious matter, for since the boundary between "electro-magnetics" and optics has disappeared, the geometrical principles of photometry cannot be distinguished from those of radiant energy.

It is well, for several reasons, that a Frenchman has undertaken this task. MASCART, CORNU, PALAZ, VIOLLE, HOSPITALIER, and BLONDEL are among the modern writers on photometry, who have not failed to take advantage of the flexibility of the French language, and its ample vocabulary. But the task of translating M. BLONDEL's article on photometric magnitudes and units, which will be found in our present issue, was no easy one. We have freely quoted the original French,

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since it is not only the meaning which we have to give, but the actual words chosen by the author. For these words we have endeavoured to find close English equivalents. The need for reform is well established by M. Blondel; the incoherent jumble of geometry with photometry, and the illogical suppression of the idea of a flux of light in all directions is clearly pointed out. While we regard this as a most important contribution to physical nomenclature, we must confess that the author goes rather far with his system, sound as it is. But there is no harm in this. On the contrary, it is the meagreness of the phraseology of the past that has led to confusion, and if M. Blondel offers us more than we feel inclined to use, we have but to adopt that which best claims our attention and supplies our wants. The recognition and acceptance of the units and their definitions is the first step; and the naming of them, where naming is necessary, may be left for the present. We are, indeed, inclined to think that the adoption of symbols for these units is of greater importance than the settling of names. We have got on very well with the idea of magnetic induction and the symbol **B**, and the expression "lines" when a numerical magnitude was given, without the name "gauss" or "thom"; it is the minority who clamour for such names. Fortunately, the whole of these photometrical units are based on the fundamental one of luminous intensity, which is practically 1 c.p. It seems highly probable that in this country and in America the "candle-power" will remain, while its magnitude may perhaps be adjusted by a congress or by the Board of Trade. The unit of luminous flux may, perhaps, deserve a name; but it cannot be a "candle." The idea that a light of one candle-power gives the light of 4π, or 12·57 "candles," though technically true, would be too absurd. This flux is often spoken of as "total light" or "quantity of light." This is not quite accurate. We really mean, as it were, a current of light or rate of emission of luminous radiant energy. The product of this by unit time would give a true quantity, Mr. Blondel's last unit is of this kind; but it is not likely to be often required. It is under certain circumstances necessary to employ the notion of a flux of light; and it is wrong to describe the unit as 4π candle-power; hence the need for a name. If some name is not adopted, enterprising lamp makers will advertise lamps of 201 candles, meaning 16 candle-power. The third unit, that of illumination, really needs a name. M. Hospitalier and others have strongly objected to the bougie-metre and to the candle-foot; and, with some sophistry, it has been argued in defence that, although there may be a little ambiguity in speaking of "7·5 candle-feet," there is nothing unsound in "7·5 times a candle-foot." It is a que tion whether M. Blondel's illumination, intrinsic brilliancy, and intrinsic radiation might not be reduced to a single unit. It will be seen that their dimensions are identical. There is a very simple connection between them, and a little examination will show that the same unit will do for each. Suppose a light of k candle-power has an effective luminous area of a square feet. If the light be an opaque incandescent sphere of 1 foot radius it will show in any given direction a projected area of π square feet, or the same as a disc of 1 foot radius. Its brightness or intrinsic brilliancy is its candle-power per unit area, or k/π candle-power per square foot. The total quantity of light, or luminous flux, emitted by the sphere is $4\pi k$ units, and the illumination it can produce at a distance of f feet (this distance being not less than 8 or 10ft.), is k/f^2 candle-feet. If it be desired, then, to know the quantity of light given out per unit area of a luminous body, this is at once obtained from the brightness, by multiplying by π. Now, the total flux of light emitted by the sphere is $4\pi \times k$ units, the total area of luminous surface is $4\pi \times 1^2$ square feet, hence the intrinsic radiation, which might, with some reason, be called the illumination of the luminous surface, is $(4\pi \times k) / (4\pi \times 1^2) = 1$ candle-foot, where $k = 1$. This, as we have already shown, is π times the brightness, a relation which always holds good. The surface of such a self-luminous sphere emitting pure white light cannot be distinguished from a non-self-luminous sphere dead white, reflecting or scattering cent. per cent. of the light falling on it, and illuminated from some external source with the illumination of one candle-foot. As a corollary of some interest in connection with dead white reflectors, it may be remarked that a perfect white reflector of one square foot illuminated with π candle-feet emits one candle-power normally.

In one case we have been obliged to depart from a close verbal translation of Mr. Blondel's nomenclature. He uses *éclairement* for illumination in the ordinary sense of the word; but when he comes to the two time units, he employs the less common French word *l'illumination* to denote the quantity which is, perhaps unscientifically, calle l a "candle-foot-second." Such a unit has been proposed in connection with photography, and it would be of immense practical importance in that art. It is nothing more or less than "exposure" in the photographic sense. It is true that the photographer measures his exposure as a time only, but the degree of illumination is suppressed. He chooses a period which shall, under the circumstances of illumination, give a desired chemical result. For all practical purposes this result is determined by the product of the time into the illumination. We hope that Mr. Blondel's important article will draw attention of physicists to the nomenclature of photometry. It is most unfortunate that π should intrude so often, and give rise to such complications, but owing to a lamentable anomaly of the space in which we live, this embarrassment is unavoidable.

PHOTOMETRIC MAGNITUDES AND UNITS.*

BY ANDRÉ BLONDEL.

Of all branches of Physics, photometry is the one whose system of units has been the least improved. Whilst the vocabulary of Electricity has been daily added to, and the supply of electrical units has become almost in excess of the demand,† some of the units being, indeed, left somewhat out in the cold, the Electrical Congresses which have been successively held since 1881 appear to have thought that photometry only needed a good standard of light. But this was too optimistic a view, and there is to-day a reaction against it. Does this mean, as has been urged, that photometry is a science requiring recasting? Certainly not, since the few physical principles upon which it is based are firmly established, and cannot give rise to any objections. Photometric phraseology is, however, to my mind, open to criticism, and the number of units is insufficient. I propose in this article to briefly justify this apparently subversive assertion, and to put forward a simple system of units and definitions fulfilling the desiderata which I shall point out. I trust my readers will not take exception to the somewhat irreverent manner in which I shall, perhaps without reason, criticise the existing state of things, but that they will only take my good intentions into consideration.

Imperfections of Existing Definitions.

Photometry has retained without much alteration the phraseology which it has received from the eighteenth century. This is doubtless to be explained by its poor theoretical development, and by the forcedly limited field that it offers to investigators. It is not, however, a sufficient reason for perpetuating anachronisms such as the definition of quantity of light and the units in use. Classic phraseology gives the name of "quantity of light" to the *flux* of light, and thus puts itself into contradiction with the termi-

* From *La Lumière Électrique*.

† The few gaps that remained have been filled in advance by the recent proposals of the American Institute of Electrical Engineers, which, on the initiative of Messrs. Houston and Kennelly, has elaborated a system of concrete magnetic units in every way deserving of success.

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nology adopted in the study of Heat, an agent which is nevertheless analagous. It would never enter the mind of anyone to-day to confound quantity of heat Q with the flow Φ; for the first is equal to the product of the second into the time [Q = Φ T]. Why make this confusion in photometry, when no advantage is to be derived from so doing? It is the height of unreason. Indeed, it is in my opinion desirable henceforth to make use of the notions of *flux* and of *quantity* of light in exactly the same way as in Heat.

It would also be a good thing to get rid of the word "brightness" (*clarté*), which each author uses in a different sense, and to definitely allot the word "brilliancy" (*éclat*) to the intrinsic brilliancy of the sources of light.*

On the other hand, it is necessary to protest against the singular idea which people too often appear to have about the part played by units. There are, in fact, no less than six fundamental photometric quantities: intensity (*intensité*), flux (*flux*), illumination (*éclairement*), intrinsic brilliancy (*éclat intrinsèque*), time-illumination (*illumination*), and quantity of light (*quantité de lumière*), the last being connected with energy; and yet it is pretended that a single unit "the candle" will serve for all. To make use of this for all purposes, like Æsop wished to the tongue, is exactly as if we measured the different quantities which intervene in magnetic phenomena in terms of unit pole. Who, for instance, would dream of measuring magnetic induction in terms of "unit pole at a distance of 1cm"? Yet this is what we do every day in photometry when we measure illumination (*éclairement*) in terms of "a bougie at one metre." But this is not all: many people readily excommunicate, in an aggravating and amusing way, those who are not seduced by this strange expression, but prefer to confine themselves to the compound words "bougie-mètre" or "candle-foot," which, at least, do not pretend to define by their etymology the nature of the unit which they express, and which are only conventional terms.

If the notion of flux of light, which ought to be the fundamental one of photometry, is constantly misunderstood, as I have asserted, is it not simply because no special unit has been to express it in? The uninitiated, who instinctively feel that light spreads itself like water in all directions, are naturally bewildered when they see the luminous output measured in candles as well as the intensity. An American contemporary,† which gleefully collects photometric pearls, recently told an amusing story, the truth of which it guaranteed, which is a good example of this way of looking at the matter.

An expert, called in to interpret a clause in a public electric lighting contract between a town near New York and the local electrical company with regard to some 2,000 nominal candle-power arcs, expressed his opinion, it appears, as follows:—The arc lamps are suspended at the cross roads, and each one, therefore, sends out its light in four directions; one cannot, therefore, expect to get 2,000 candles in each direction. The 2,000-candle arc arranged for in the agreement was one sending 500 candles down each road.

We do not wish to make fun of this expert, for in truth he is a very sensible man. The quantity the most needful to be known in this instance was, as he rightly thought, the flux of light, and if photometry does not enable us to define a lamp with that in view, it is photometry which is in the wrong.

Photometry is still more faulty when it conceals the idea of flux of light under artificial names, often extraordinary and well-calculated to deceive the world, such as "volume of illumination" (*volume d'éclairement*), a quantity which is obtained by calculating the illumination of each point of the ground beneath the source of light, and then integrating the products of each illumination into the corresponding area. This volume of illumination is merely the flux of light emitted by the source over the corresponding solid angle, and therefore in no wise depends on the orientation of ground lit up. Why, then, instead of giving the quantity its proper name, compound this strange amalgam of photometry and geometry?

The confusion which exists between flux and intensity of light necessarily results in a corresponding ambiguity in the definition of "intrinsic brilliancy." With some‡ the intrinsic brilliancy of a source of light of uniform luminous intensity is equal to the quotient of the total quantity of light (read "flux of light") by the surface S of the light-giving portion of the source $i = \Phi/S$. With others§ it is the quotient of the luminous intensity measured in a normal direction to the light-giving surface; that is to say, $i = I/S$. These two expressions are evidently anything but equal,|| and, as in both cases the authors whom I have just quoted measure the brilliancy in candles per square centimetre, a fresh source of error arises.

All that has been stated leads to the irrefutable conclusion that a special unit should now be adopted for each different quantity, as is done everywhere else. Even in photometry, as a matter of fact, this step would not be a complete innovation, for some years ago the photographers, more progressive in this respect than the electricians, established under the presidency of eminent *savants* (MM. Abney, Cornu, Janssen, Sébert, Violle, &c.), a unit of time-illumination (*illumination*) specially applicable to photography, the "phot," of which I shall speak later.* The path cut for physicists, and especially for electricians, is to adopt analogous units, capable of forming with this one a coherent system directly applicable to practical cases.

An important question to be decided is what kind of names are to be chosen for the new units? I think the matter is already settled by the previous adoption of the "phot," and the names to be coined should therefore be taken from Greek and Latin roots and not from the names of celebrated *savants*. The pantheon of the units is, moreover, already sufficiently furnished to render it unnecessary to mutilate any more names, as was done in the case of Volta and Faraday, or to perpetrate any more jokes like that to which the "mho" owes its existence. International rivalries will thus be avoided. Moreover, Photometry, like Heat, is an autonomous science, and may be allowed to settle its units on different lines to Electricity, and, assuming that we confine ourselves to Greek or Latin roots, nothing is easier than to build up a manageable system of units such as the one of which I will now briefly explain the uses and definitions.

Units Applicable to the Different Photometric Quantities.

Let us pass successively in review the different photometric quantities enumerated above, and let us see how they are inter-connected.

(1) The *luminous intensity* of a source of light in any given direction is the ratio of the flux emitted over a small solid angle, having this direction as axis, to this solid angle.

The unit of intensity, or "violle," adopted by the Congress of 1881 and the International Conference of 1884, is defined by a concrete standard due to M. Violle, and perfectly satisfactory from the point of view of constancy, the capital point when choosing a standard. The Violle standard is the light, measured at right angles to the source, which is emitted by a sq. cm. of platinum at the moment of solidification.† In practice the "violle," having no success with lamp makers, whose nominal figures it reduced too much, the Congress of 1889 had to adopt a secondary *practical* unit, the "bougie décimale," equal to the twentieth part of the "violle"; this, excellent as a magnitude, is deplorable as a name. In fact, the "bougie décimale" is not the tenth part of any unit; it approximates the tenth of the carcel, but the carcel being current only in France, the qualification of decimal has no meaning abroad; "bougie vigésimale," or "vigésiviolle," or "demi-déciviolle," is what should have been chosen; but it would be so little attractive to talk of a lamp of 16 demi-déciviolles, that we must not be too severe with the Congress for having hesitated to adopt such nomenclature. The expression "bougie décimale" has the additional grave defect that it tends to confusion, since the decimal qualification is very often forgotten, so that if we see "candles," or "kerzen" mentioned, we have first to critically examine the context to find out whether English, German, or decimal candles, &c., are intended, things which are far from being the same. In Germany this confusion has already discredited the "bougie décimale," and for the most part the Hefner (H. L.) unit is employed, contrary to the decisions of the Congress of 1889. The very existence of the Violle unit is thus threatened, and at the recent Congress in Chicago the German *savants* demanded that it should be replaced by another unit. This demand, I think, arises from a mistaken view of the needs of photometry, since, although a good secondary standard may be wanted, that has nothing to do with the theoretical standard. This would not, however, certainly have happened had the same thing been adopted as practical unit, but with a new and unambiguous designation. The word "phot" would have done admirably, but as it is already adopted for time-illumination (*illumination*), as we shall see further on, we are obliged to choose another. Fortunately, the Greek word "pyr" ($\pi\nu\rho$ = fire or source of light) appears equally satisfactory; it has, indeed, been already put forward in England to denote a million candles; but it would be contrary to the now recognised rules to give a special name to a multiple. I propose, therefore,

* The *intrinsic* brilliancy is still often distinguished from the *total* brilliancy by applying this last term to the luminous intensity of the source. This use of the word brilliancy unfortunately gives rise rise to confusion.

† *Electrical World*, June 2, 1894, p. 729.

‡ Palaz: "Photométrie," p. 231.

§ Mascart: "Optique," Vol. III., p. 145; Violle: "Rapport Général de la Commission Permanente du Congrès de Photographie," 1891, p. 119; C. E. Guillaume: "Unités et Etalons," p. 170.

|| We shall see later on that when the source follows Lambert's law of emission, the ratio of the two expressions is π, so that the figures vary in the ratio of 1 to 3, according to the definition chosen.

* Brussels Photographic Congress (*Comptes Rendus*, p. 66).

† The phraseology adopted by the Conference "the unit of light is the *quantity* of light emitted in a normal direction by a sq. cm., &c.," seems to be incorrect, for either they wished to define the unit of *intensity*, which is not a *quantity* of light, or they wished to define the unit of *flux*, and then they should have said over what solid angle this was to be measured.

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now to call the "bougie décimale," or the practical unit of intensity whatever it may be in the future, a *pyr*; using for big lights the *megapyr*, equal to a million *pyrs*. The "violle" would then naturally remain the primitive theoretical unit, and the *pyr* would only constitute the base of the system of practical units.*

2. The *luminous flux* (*flux lumineux*) Φ should have as a practical unit the flux which takes place over a solid angle equal to unity from a point source having the uniform intensity of one *pyr*. I suggest the word "lumen" for this unit. A source of light having a mean spherical intensity of *n pyrs* would thus have a total flux of $4\pi n$ *lumens*.

3. The *illumination* (*éclairement*) *e* at a point of a surface is equal to the ratio of the luminous flux which falls on a small element of surface to the area of this surface $e = d\,\Phi/d\,s$.

It is absolutely necessary to adopt a new name for the unit of illumination, and I am astonished that the Congresses of 1889 and 1893 did not recognise this necessity. The term "bougie-mètre" leads to confusion unless we state it is a question of the "bougie décimale," and the term "bougie-décimale-mètre" is not very handy to make use of when mentioning a unit. Finally, the metre not being yet in common use in England and America, one makes a great mistake if one anticipates that it will nevertheless be admitted in a compound word. As a matter of fact, in no English writings have I met with the expression "candle-metre," whilst on the other hand, the "candle-foot" is generally to be found. To insure uniformity in international terminology, which is the aim of every system of units, we must adopt a simple name in which the unit of length does not figure. A name is ready to hand; it is the "lux" proposed by Mr. Preece at the 1889 Congress, and which we will apply now to the "bougie-mètre." All who are in touch with the wants of practical photometry are in agreement as to the adoption of this word.†

According to the terminology previously indicated, the *lux* must be defined as "the illumination produced by an uniform source of one *pyr* on a surface at right angles to the rays, and situated at a distance of one metre," or, which comes to the same thing, "the illumination produced on a surface of 1 sq. m. by an uniform flux of 1 *lumen*." Inversely, one could define a *lumen* as the luminous flux capable of illuminating a square metre to the extent of *one lux*. The product of a certain number of *lux* into a surface computed in square metres will thus give a number of *lumens* representing the total flux received by this surface.

4. The *intrinsic brilliancy* (*éclat intrinsèque*) *i*, as I have already stated, has hitherto had two different meanings; I will only preserve the more usual one. The intrinsic brilliancy is the quotient of the intensity, measured at right angles by the surface of the emitting source $i = I/S$.

When a luminous body follows Lambert's law of emission, and we place before it a diaphragm pierced with a hole, the luminous intensity produced by the hole in the direction of its axis is independent of the orientation of the emissive surface placed behind; we say then that the intrinsic brilliancy is constant for all incident angles. In the contrary case we shall denote by the term "brilliancy at the angle α" the brilliancy of the hole when its axis makes the angle α with the normal to the incandescent surface. This generalisation of the notion of brilliancy is often very useful.

The practical unit of brilliancy is the intrinsic brilliancy of a source of light giving 1 *pyr* per unit of surface ($\frac{1}{20}$th of the brilliancy of the Violle standard). To be complete we should also define under the name of *intrinsic radiation* (*rayonnement intrinsèque*) ϕ the ratio of the flux of light emitted by the source to the emitting surface $\phi = \Phi/S$. This unit of radiation corresponds to a radiation of 1 *lumen* per unit of surface.

These two units have the same physical dimensions, and one might give them two special names, say the "*phane*," from the Greek root φαν, shining, and the "*lampsis*," from the Greek root λαμψισ, brilliancy; but to do so would be to uselessly complicate nomenclature, since we can simply express these units in *pyrs* per square centimetre or millimetre, and in *lumens* per square centimetre or millimetre; expressions which have no ambiguity, and will not give rise to fresh confusion.

In general there is no simple relation between the intrinsic brilliancy and the intrinsic radiation. But when the light-giving body follows Lambert's law of emission it is easy* to show that $\phi = \pi i$ and consequently that a brilliancy of *n pyrs* per square centimetre, correspond to an intrinsic radiation of πn *lumens* per square centimetre.

5. *Time-illumination* is by definition the product of the illumination (*éclairement*) *e*, to which an object is submitted into the duration of that illumination. The unit is the *lux-second*, that is to say, the time-illumination obtained by an object by an illumination of 1 *lux* prolonged for one second; this unit received at the Brussels Photographic Congress the special name of "phot." The *phot* plays an important part in photography, since chemical reactions appear to depend directly on the product $e\,t$. The same applies to certain physiological phenomena connected with the vision, a certain minimum time-illumination (*illumination*) is necessary before one receives a luminous impression; it is in *phots* that this should be expressed. One may assume that, generally speaking, there must be about 10^{-8} *phot* in the plane of the pupil to enable it to perceive, in ordinary practice, a punctiform source of light.

6. The *quantity of light* should no longer be confounded with the *flux of light*, as was previously pointed out. The *quantity of light* L is, by definition, the product of the flux of light into its duration. It is, therefore, equal to a *lumen-second*, and we might give this unit the name of "rad," which has already been proposed by certain photographers.† The *rad* may also be defined as the quantity of light received by unit surface (1 sq. m.) exposed to an illumination of 1 *phot*. We can thus express in *rads* the quantity of light necessary to produce a luminous impression on the retina. For commercial purposes it might be enough to measure the quantity of light in *lumen-hours* in the same way as we measure the quantity of electricity in ampere-hours instead of in coulombs. The *lumen-hour* could be made the basis of lighting contracts, as we shall see further on.

The quantity of light for a radiation of given wave-length is proportional to the energy of the radiations; one might, therefore, like to denote it in ergs, as with other forms of energy. But when polychrome sources of light are in question, this datum no longer has any simple relation with the photometric effect produced, since each radiation has a different coefficient of physiological action. The total energy of luminous radiations is, therefore, only of indirect interest in this matter, and it is desirable to keep it separate from the idea of quantity of light as just defined. Energy proper only comes in in laboratory researches.

Examples of the Application of the New Units.

The suggestions I have just made would not be complete if I did not show how to make practical use of them. I propose, therefore, with this object in view, to give a few examples of different kinds solely to show how to employ the new units, and without pretending to propound any theory properly speaking on the matters to which I adopt them.

Example 1. Measure of the Luminous Effect of an Arc Lamp.—Generally speaking, it is not too well known what is meant by a lamp of so many candles, and European engineers, discouraged by the continual misunderstandings on this point, have mostly given up designating arc lamps other than by their electrical constants.‡ This solution may be convenient, but it has the grave defect of rendering it unnecessary for the companies to trouble themselves about the quality of the carbons and their efficiency as light givers. Now, the uncertainty that arises is due, as a rule, to the fact that the makers do not state whether they mean horizontal intensity, maximum intensity, or mean spherical intensity. The uncertainty would, consequently, disappear if they would agree to designate lamps by their total flux expressed in *lumens*, which is equal to their mean spherical intensity multiplied by 4π; a lamp of 30 spherical carcels would thus become a lamp of 3,770 *lumens*. This new system would have the advantage, so far as lamp makers are concerned, of resulting in bigger figures than the present system, and, so far as the public is concerned, of leading to no confusion whatever. Since in these days the average shape of the curve giving the distribution of candle-power of arc lamps is well known, the information as to the *lumens* would alone be quite enough. This might, however, be usefully supplemented by stating how many *lumens* are emitted above and below the horizontal; this last

* There would be another advantage in adopting a new name such as the *pyr*, namely, that it would henceforth give a scientific stamp to light measurements; the common word "candle" leads one to suppose that one is dealing with an empirical unit without scientific value. At present everyone who knows what a stearine candle is thinks he has mastered photometry, much in the same way as every man who knows how to read and write thinks he understands philosophy. When he is talked to about *pyrs*, he will more readily admit that a certain apprenticeship is requisite before one can usefully discuss questions of lighting.

† *See* especially Palaz: *Traité de Photometrie.* This question was raised at the Société des Electriciens in connection with the Chicago Congress programme. But the French Committee, which seems to have endeavoured before all things to avoid every innovation, did not admit this matter into its list.

* If we call I_a the luminous intensity produced at an angle α by an infinitely small element of incandescent surface, we have by Lambert's law, $I_a = I_0 \cos\alpha = i_0\,d\,S\cos\alpha$, i_0 being the intrinsic brilliancy along the normal; consequently the total flux

$$d\,\Phi = \int_0^{\frac{\pi}{2}} i_0\,d\,S\cos\alpha \times 2\pi\sin\alpha\,d\,\alpha = i_0\,d\,S \times \pi,$$

whence $$d\,\Phi/d\,S = \pi\,i_0.\text{—Q. E. D.}$$

† Abel Buguet. *Journal des Sociétés Photographiques*, May, 1892.

‡ American engineers have recently come to a singular decision on this subject. By them every 10-ampere lamp will in future be called "a lamp of 2,000 candles" even if it only gives 500 or 600. This is a sad precedent, and an example to avoid.

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figure is, in fact, the only one of any use in public lighting, as we shall see further on.*

Example 2. *Effect of a Projector.*—I propose to define the electric arc, and beam of a projector. Let us assume an arc having 1 sq. cm. of crater placed at the focus of a projector having a cross section, S, of 1 sq. m. at the base of the beam, an absorption of 20 per cent., and a mean coefficient of optical utilisation of $\lambda = 0{\cdot}5$. Let us assume that the crater is sensibly plane and has an intrinsic brilliancy of 160 *pyrs* per square millimetre. The intensity of the arc in a direction normal to the crater will be $100 \times 160 = 1{,}600$ *pyrs*. Again, the emission following sensibly Lambert's law, the intrinsic radiation is, as we have seen, $\phi = \pi i$, and the flux produced by the crater $\Phi = \pi \times 16{,}000 = 50{,}000$ *lumens*. The total flux, taking into account the light of the arc and of the negative, will be about 20 per cent. greater. Only a portion of this flux will fall on the active surface of the apparatus. The flux can in each particular case be measured by means of direct photometric measurements: for instance, if it is a case of a horizontal lamp, the useful portion of the curve of distribution can be planimetered. Supposing the corresponding flux equals 30,000 *lumens*, since the projector absorbs 20 per cent., the *emergent beam* would finally be one of about 24,000 *lumens*.

The *luminous power* (*puissance lumineuse*) of the projector, according to the definition of this quantity usual in the case of optical apparatus, that is to say, the luminous intensity of a naked light giving the same illumination at a great distance along the projecting optic axis,† is approximately expressed, as I have recently shown,‡ by the equation $P = \lambda\ S\ i$; that is to say, in this case $P = 0{\cdot}5 \times 1{,}000{,}000$ sq. mm. $\times\ 160$ *pyrs* = 80 *megapyrs*.

The *maximum* illumination on a surface normal to the axis of the beam may be calculated from this figure from infinity to a certain critical distance by the law of the square of the distance. If the distance l is expressed in metres we get $e = 80{,}000{,}000 / l^2$ *lux*: at one kilometre, for example, $e = 80$ *lux*. Beyond the critical distance, which is always relatively short, the number of *lux* increases more slowly, according to a law which depends essentially on the shape of the optical surfaces employed. At all distances the *mean* illumination in *lux* of a section through the beam is equal to the quotient of the total flux in *lumens* by the area of the section in square metres. If the beam is cut as it emerges from the apparatus the mean illumination obtained is $e = 24{,}000$ *lumen*/$1\text{m}^2 = 24{,}000$ *lux*. Generally, if a be the radius of the base of the beam, and b the tangent of the angle of divergence, the *mean* illumination of circular area illuminated at a distance, l, will be by the formula $e_m = 24{,}000 / \pi (a + b\,l)^2$ *lux*. Here we have $a = 0{\cdot}6$m., and if we suppose that $b = 0{\cdot}02$ we shall find at 1,000 metres that $e = 68$ *lux*, which is a different figure to that which we found for the *maximum* illumination along the axis.§

We thus see that the three fundamental units have their uses here in enabling us to easily distinguish the different kinds of effects produced by the projector, and thus to avoid all misunderstanding.

Example 3. *Public Lighting.*—Let us assume that a public thoroughfare is lit by arc lamps, and that it is required to know the *mean* useful illumination obtained. One could determine the curve of distribution of the arc when surrounded by its globe, and plot, according to the well-known method, the lines of equal illumination.* In this way we could determine the maximum, minimum and mean illuminations. But this delicate research is useless if the only thing required to be known is roughly the average illumination of the roadway, trees, and house-fronts. To obtain this it is sufficient to measure, by means of the intensity curve of the lamp, the flux sent out by it below the horizontal, planimetering the corresponding part of the transformed curve (Rousseau's method) multiplied by 2π.† The product of this flux into the number of lamps divided by the total illuminated area in the street in square metres gives the mean illumination in *lux*;‡ for, as we know, one *lumen* is the flux capable of illuminating 1 sq. m. by one *lux*. The flux is thus an approximate measure of the useful effect of the lamps. When a town buys light for its streets from a company, it might, I suppose, pay for it according to the number of *lumen-hours* supplied during the year below the horizon, and I do not think it would be impossible to draw up lighting contracts in this form.

Example 4.—*Interior Lighting of a Ball Room.*—The illumination at any point in an enclosed space varies according to the direction of the surface on which it is measured; the maximum illumination is the intensity of the luminous field in the same way that the density of the magnetic flux in air is the intensity of the magnetic field. The eye, however, as a rule judges of the illumination of a room by the average illumination, e, of the walls. This, to give the same useful effect, should be inversely proportional to the diffusing power d of these walls. We thus have, taking k as a constant, $ed = k$. If we call a the absorbing power, and S the total superficial area of the walls, we find, neglecting the effect of the furniture, &c., that the total luminous flux which it is necessary for the lamps to produce should equal the flux absorbed:

$$\Phi = a\,e\,S = S\,k\,\frac{a}{d} = S\,k\,\frac{a}{1 - a}.$$

That is to say, it should be proportional to the *total* superficial area of the floor, roof and walls of the room,§ and a certain number of *lumens* are required per square metre. Where incandescent lamps are employed, since the flux is equal to the product of the nominal intensity in *pyrs* into a constant, special to each lamp, we can practically say, "So many *pyrs* are required per square metre"; but this is at bottom a bad way of expressing the matter, and it is better to keep to the first. For example, if $k = 5$ *pyrs* and the coefficient of absorption of the walls $a = 0{\cdot}60$, 7·5 *lumens* will have to be produced per square metre of floor, roof and walls. The preceding formula has the advantage that it takes rational account of the area and nature of the walls of the room.

Conclusion.

I trust I have shown by these different examples all the advantages of constantly bringing into photometric calculations the notion of luminous flux, of pursuing the usual plan of applying to quantities of different nature equally distinct units, and of dispensing with the anti-scientific word "candle," which now gives rise to continual misunderstandings.

Physical quantities.	Symbols and defining equations.	Dimensions.	Names of the practical units.
Luminous intensity ...	I	[I]	*Pyr*, or "bougie-décimale," $\frac{1}{20}$ violle.
Luminous flux	$\Phi = I\,\sigma$.‖	[I]	*Lumen*.
Illumination	$e = \frac{\Phi}{S}$	$[I\,L^{-2}]$	*Lux*.
Intrinsic brilliancy......	$i = \frac{I}{S}$	$[I\,L^{-2}]$	*Pyr* per sq. cm.
Intrinsic radiation	$\phi = \frac{\Phi}{S}$	$[I\,L^{-2}]$	*Lumen* per sq. cm.
Time-illumination	$j = e\,t$	$[I\,L^{-2}\,T]$	*Phot*, or *lux second*.
Quantity of light	$Q = \Phi\,t$	[I T]	*Rad* (or *lumen-second*) *lumen-hour*.

The system of units which I propose is summed up in the little table above. I take intensity as the fundamental magnitude in

* The idea of flux is the most natural one to employ here, since it corresponds to a real quantity, whilst the mean spherical intensity is a fictitious constant. If people had always considered the flux they would not have committed the grave error, which is to be found in nearly all books, relative to the well-known formula,

$$\text{I mean sph} = \frac{M}{4} + \frac{H}{2},$$

which gives the mean spherical intensity of a continuous-current arc as a function of the horizontal intensity H and the maximum intensity M, and which may also be written thus—

$$I = \frac{H}{4} + \frac{H + M}{4}.$$

The authors, as a rule, say that the first term may be taken as representing the mean superior hemispherical intensity and the second the inferior, when they should say

$$\text{I hemi. inf.} = \frac{H + M}{2},$$

$$\text{I hemi. sup.} = \frac{H}{2}.$$

A mistake of this kind is not possible when we consider the flux above and below the horizontal, for if a lamp gives 1,000 *lumens* below the horizontal, and 200 above, the total flux is evidently 1,200 *lumens*, the mean spherical intensity being $1{,}200/4\pi$ *pyrs*, and the hemispherical means respectively $1{,}000/2\pi$ and $200/2\pi$ *pyrs*.

† This might be more clearly called the *tele-intensity* of the projector.

‡ *See* "Théorie des Projecteurs Electriques," published by A. Lahure in Paris, Rue de Fleurus.

§ The value of the mean illumination is in general without interest; what is important is the maximum illumination along the axis at a distance greater than the critical. That is why a projector is usually defined by its nominal power (theoretically determined) or its true power (experimentally determined).

* Interesting examples of the application of this method will be found in the remarkable work of M. Maréchal on the lighting of Paris, in which it has a most happy extension in so far as public lighting is concerned.

† If we employ a globe of which we know the hemispherical efficiency below the horizontal, this operation is unnecessary. All we want to know is the values of the fluxes in *lumens*, and to multiply them by the coefficient of the globe.

‡ This is so, regardless of the angle of the illuminated surfaces at each point. The same method applies to the determination of the illumination of a circular area having as centre the foot of the supporting post. The planimetering of Rousseau's curve should in that case be restricted to the angle subtended by this circle.

§ The reasons which are brought forward to prove that it should be equal to the volume do not seem to me to be very clear; at any rate, they do not show the error of the above reasoning.

‖ σ solid angle; dimension: a number.

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accordance with present usage, without, however, endeavouring to connect it with others, because it is a physiological rather than a physical quantity. This system of units, being entirely in conformity with those dealing with electricity and magnetism, could be adopted, with modifications if need be, for the same reason as its predecessors; it is, indeed, difficult to understand why that which is unanimously recognised as useful and even necessary in every branch of physics should, without proof, be deemed superfluous in photometry.

THE LIVERPOOL OVERHEAD RAILWAY.

(*Concluded from page 601.*)

Mr. M. FITZMAURICE observed that, so far as could be gathered from the Papers, and the information was only gained from the expression "iron viaduct," the floor and the main girders were of iron and not of steel. He would like to know what led to the adoption of the former metal instead of steel, particularly for the floor. Many engineers would doubtless not use steel in the atmosphere of towns, as it was stated to rust quicker than iron under such conditions; but that might be easily prevented by effective painting, and the design of the structure under consideration seemed to lend itself easily to being kept in repair as regards painting. Another reason might be that as the rolling loads were comparatively light (a fact which was well represented in the small ratio of depth to span in the main girders), it might not have been possible to take full advantage of the extra strength of steel in the way of diminishing sections. That, of course, would only apply to the main girders, and not to the floor. The floor described certainly possessed many advantages over other modern trough-floors, especially when used with two main girders as in the present case, in contradistinction to three main girders. When used as an ordinary ballasted floor the lines of riveting on the under side must cause a good deal of leakage after a time; but when, as was sometimes done, the hollows were filled with light tar concrete with a layer of asphalte on the top, a good watertight floor was obtained. In either case the weight of filling was less than in the majority of trough floors. He supposed that there were some stiffening diaphragms in the length of each trough to prevent any deformation of the thin curved plates. The thickness adopted for the curved plates; viz., $\frac{5}{16}$in., seemed very little, and would, of course, only be justified in the case of a non-ballasted floor where the plates were easily inspected. He would like to know whether the pure asphalte, which was found to be the best material to cover the plates with, had shown any tendency to scale off under the vibration set up by the traffic, what thickness of asphalte had been used, and whether it had been applied in one or more coats. The junction of troughs with main girders was nearly always a leaky place, and he would like to know whether any difficulty had been experienced there; also, how the troughs were connected with the main girders between the stiffeners, whether with short lengths of angle-bars or with continuous angle-bars. When the former method was adopted the webs of the main girders, especially when of iron, were often seriously racked. Of course, there must be a good stiff connection, as the flooring acted as wind-bracing between the main girders. The pitch of the troughs did not appear to fit in with the ordinary 4in. pitch of riveting in the main girders. The flooring described was no doubt the best flooring that could have been adopted for the line under consideration, as the floor for a whole span could be riveted in place by hydraulic power. When, however, that type of flooring was sent down to the country in separate pieces, the riveting by hand ought to be carefully inspected, as it was not so easily riveted by hand in place as some other sections.

Referring to the difficulty of getting the curved plates to keep their shape while cooling, the same difficulty had arisen with some of the curved plates for the tubes at the Forth Bridge; and, after several trials, it was found that the best way to meet the difficulty was to squeeze the plates a second time in the hydraulic press when cold. The floor seemed to be remarkably stiff, as in the experiments carried out with it the deflection with 30 tons on three troughs was practically nil. The question occurred to him, did the experiments on the strength of the floor give any idea of what the actual strain in a trough was under the traffic which it had to carry? He thought not; and, after all, that was what was wanted to be ascertained. The principal thing which prevented one trough from taking all the load on one axle, when the axle was directly over it, was the rail (in the case in question, the longitudinal sleeper) distributing the load over adjacent troughs. The stiffness of the rail was, therefore, the principal thing to be considered. The stiffness of the floor had to be considered in a less degree. A very stiff floor did not give such a good distribution as a more elastic floor, within certain limits. In the case considered, the maximum weight on an axle could not be more than one-half that on an ordinary locomotive axle; the floor was not nearly so heavy as would be adopted on an ordinary railway, and the 56lb. flat-bottomed rail had probably not half the stiffness of an ordinary 80lb. double-headed rail. He did not wish for a moment to insinuate that the stresses in the floor under consideration were more than ought to be allowed, as, during the twelve months in which a five-minute train service had been in force, any weakness would soon have been detected. But it would have been of interest to know what the actual working-stress in the floor was and over how many troughs the load on one axle was distributed. It was very difficult to determine this in ordinary trough-floors without a good deal of expense and elaborate preparations. In the case under consideration it could easily be determined by means of stress-gauges, such as the Stromeyer gauge, as it was possible to attach them directly to the floor. A most interesting experimental determination of the actual stresses in the troughs could, therefore, have been made with different sections of rails, which would have been very useful for future reference. Some assumptions must have been made when designing this floor, such as over how many troughs the weight on an axle was distributed, and whether the troughs were to be considered fixed or free at the ends. It would be interesting to know these points, and also whether they were found to hold in practice.

The New York Elevated Railway had been mentioned in the Paper, but it was difficult to compare its actual constructive cost per mile with that of the Liverpool Overhead Railway. Of course, in both cases, allowances would have to be made for the differences in cost of labour and material at times of construction.

Mr. JOHN HAYES remarked that, whilst every credit was due to the foresight of Mr. Lyster, the engineer to the Liverpool Dock Board, in seeing almost from the first that electric traction was likely to be the most suitable for the line described in the Papers, it was, in the light of subsequent events and after the undertaking has been brought to a successful issue, somewhat difficult to conceive how any other system of traction should have been seriously entertained by its promoters. Alongside the greater part of the railway at Liverpool, and in close proximity to it, were huge warehouses, generally filled with cotton, grain or other highly combustible material; in addition to which, shipping at the various docks, and cargoes on or about the wharves, added to the serious risk and danger which would have been ever present had steam locomotive engines been adopted as the motive power, with the possibility of sparks from the chimneys of such engines.

A matter of no little importance in connection with the construction of the line, not referred to by the authors, was that the contractor had placed the manufacture of nearly the whole of the heavy main girders carrying the railway, as well as the swing-bridge at the Stanley Dock, with a local firm, and thus close to the base of operations; and as it had fallen to the lot of Mr. Hayes, as the General Manager of those works, to supervise the manufacture of some 5,000 tons of the plate girders, as well as castings and other important work, he might say without hesitation that the course adopted had greatly facilitated the execution of the work—far more so than perhaps anyone not directly concerned might imagine. With a view to minimise the cost and trouble involved in a contract of such magnitude, it was true, as the author had pointed out, that the normal span adopted for the girders was 50ft., but that had to be departed from in many places to avoid interference with existing lines, roads, gateways, and other structures; and, even in many cases within Mr. Hayes' knowledge, where the normal 50-foot span was adhered to, there were exceptional features introduced as the work proceeded, which constituted such girders, in every sense of the word, "special."

As regarded the details of manufacture in connection with the wrought-iron girders, although they were of the usual character followed on such works, a few remarks might not be out of place. The whole of the plates were delivered on the works from Middlesbrough by rail, in suitable lots, and, after levelling, were placed on plate-edge planing machines, all drilling of angles, plates, &c., being carried out under multiple drilling machines; the T-iron stiffeners for the web of girders were all bent or "joggled" hot under hydraulic presses, the ends of the stiffeners being afterwards cut off with cold circular saws; whilst the riveting was effected by pneumatic riveters on the Allen system, the working pressure (air) being 70lb. per square inch at the receiver. When completed, the girders were lifted by powerful overhead cranes on to railway trucks, and were delivered direct on to the site of the Overhead Railway in Liverpool. The same economical principle of local manufacture had been also followed in the manufacture of the Hobson arch-plate flooring, which had been adopted throughout the railway, at a yard at the north end of the line or upon the actual site of the work.

Mr. CLAUDE W. HILL remarked, in regard to the Eickemeyer system of winding, that the author of the second Paper had been the first in this country to recognise its merits and to adopt it. The advantage which it gave of enabling a damaged coil to be removed and replaced with a good one, without having to strip the entire armature, constituted a great advance over the ordinary

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construction of wire-wound drum armatures. A somewhat similar system applied to bar-wound drum armatures would offer considerable advantages. In the present system of constructing those armatures, a series of radial or spiral connectors was mounted at each end of the armature, and the bars were then laid on the periphery and joined to the end connectors by solder. Those joints greatly increased the resistance of the armature, making it two or three times greater than if the conductors were of solid copper; and there was the further disadvantage that the heating due to the soldering was liable to injure the insulation. If the bars and connectors were joined together first, and were then mounted on the armature, the joints could be thoroughly brazed or electrically welded, thus materially reducing the resistance of the armature and avoiding risk of injury to the insulation, as the insulating of the conductors would be done after the jointing. In order to see if such a construction were mechanically possible, he had a rough model armature constructed on this principle a few months ago, and had found that such construction was quite feasible.

Mr. Lincoln Moss, of New York, observed that the first Paper mentioned the New York Elevated Railways as having no parapets. The Sixth Avenue main line was a parapet structure, the tracks running between two outside pin-connected through trusses. His experience was decidedly in favour of deck structures with well-designed guard timbers and rails weighing 90lb. per yard. The excellent floor system of the Liverpool line could not be used in New York, as an open-work structure was required, to cast the last possible shadow. Drip pans were there used on the locomotives, and under the structures over the crosswalks. His experience was also adverse to close columns. As regards motive power, it would have been a mistake to have equipped the Liverpool line with steam locomotives. Since the Manhattan Railway Company experimented with an electric locomotive in 1889, wonderful progress had been made. At that time, he had reported that a two-fold increase in the efficiency attained might be anticipated, making the cost of electric traction, including fixed charges, $2\frac{38}{100}$ times as much as with steam locomotives. That prediction of four years ago had been exceeded, and the best electric railways in the United States give more than three times the efficiency found in his tests. The electric locomotive had then but a single reduction motor—at that time the economy of using two or more motors in series-parallel combinations was not appreciated—and the speed was controlled by varying the field strength and introducing external resistance, causing enormous losses. He had taken a 400-H.P. card when the electric locomotive was exerting only 10 H.P. on the train in starting. The cost of electric machinery had also been reduced by more than one-half in four years. He could not see why the Liverpool plant was not direct-coupled instead of rope-drives being used. The motor car was certainly preferable to a separate locomotive, costing less at first, reducing the non-paying weight to a minimum, and being cheaper to work and to maintain. The fuel consumption on the Manhattan Elevated Railway averaged 42lb. per train mile, including heating the trains. The standard trains weighed 110 to 130 tons loaded. The best locomotives on that line averaged a train mile on less than 30lb. of coal. The cost of construction and working in Great Britain was evidently much less than in the United States, where a mile of first-class elevated road cost £100,000 to £120,000, without rolling stock. It was hardly fair to compare the cost of equipment and working per mile of the Liverpool line with that required for the New York lines; for during the busy hours of the day the trains in the latter city were only 1¼min. apart, giving 450 tons per mile to be moved, whereas the Liverpool line, working 5½ miles of road on 5min. intervals, with trains weighing 39 to 50 tons, had only 96 tons per mile to be moved. In New York there were also long gradients of 1 in 50, and curves of 90ft. radius.

Mr. O. F. Nichols stated that the Liverpool Overhead Railway had attracted great attention in America on account of its low cost, and because it was the first permanent elevated railway operated by electricity. The construction of the closed floor, possible under the special conditions, increased the weight of the structure, but did not materially increase the general cost, while it furnished a neater and more permanent floor system than was practicable on the American lines. Comparing the structure with about three miles of line completed in Brooklyn within the past year, following part of the Fifth Avenue line, the following points might be of interest. The Brooklyn line was worked by steam locomotives weighing 28 tons each, drawing three to five coaches of about the same length as the Liverpool carriages, and weighing 16½ tons each when loaded, with full seating capacity for 48 passengers. The American lines encouraged standing loads, and carriages frequently carried 80 passengers, then weighing about 19 tons each. The portion of line referred to was an extension of the Brooklyn system, which now had 20 miles of line in four different branches.

The weight of the new steel structure of the Brooklyn line was about 3,000 tons per mile. The total cost, with an allowance for rolling stock of sixty coaches and nineteen locomotives for 3½ miles of line, was practically the same as for the Liverpool line, £90,000 per mile. An excess of about 20 per cent. in weight of structure was imposed by the necessity of spacing the bearing columns inside the curb lines of the street, at about 45ft. apart transversely—the track girders being spaced in pairs, one girder nearly under each rail, and the tracks 28ft. between centres. This permitted the use of island stations, which were much more convenient and economical in operation than outside stations. The erection, by a traveller with three booms on the front end—one of 30ft. long on each side and a central boom 75ft. long—seemed to have been effected with greater rapidity than at Liverpool; partly, no doubt, from the possibility of delivering the material on the street, whence it was hoisted into position. Under favourable conditions, twelve spans of 52ft. each were erected in one day, representing about 350 tons of material and 625 linear feet of structure. It was difficult to understand how an important line could be worked satisfactorily with one large and three smaller swing bridges at or near the middle of it. The traffic on the Liverpool line was about one-seventh of that on the Brooklyn line, about one-thirtieth of that of the New York lines, and about 20 per cent. less than that of the Fifth Avenue branch of the Brooklyn lines.

The use of electricity on the Liverpool line rendered it highly interesting to those who had given much study to the problem of city railways. The results, as given in the Papers of Messrs. Greathead, Fox and Parker, naturally led to comparisons with those of other lines—so far, it must be admitted, to the advantage of the Liverpool line. The electrical conductor and collector were simpler, and in every way better, than those used on the Intermural Railway at Chicago. Those employed at Chicago could not have been used had there been switches and turn-outs on the line. The method of obtaining power for the Intermural line precluded the possibility of obtaining accurate information as to the cost of working; which was, however, placed at about the same value as for the Liverpool line.

Should the developments of dynamos and motors continue to improve as they have done during the past four years, no one would think of operating the elevated railways of the future by any other medium than electricity. With the introduction of electricity would come shorter, lighter, and more frequent trains, with the avoidance of shunting at terminals, and the reduction of staff. It had been clearly demonstrated that high speed could not be maintained with frequent stops; 15 miles an hour seemed to be about the maximum average speed between terminals with stations less than one quarter of a mile apart. Once considered as a question of weight and power of locomotive, high speed for such service had come to be regarded more as a question of acceleration and retardation. For still greater speed there must be express lines with long runs. The conditions for maximum speed were, that stations should be as far apart, and gradients and curvature as light as practicable; acceleration and retardation, and facilities for loading and unloading passengers the best attainable. A table appended would illustrate results obtained as to station-spacing, time and speed. It was not exhaustive or minutely accurate, being merely certain average values on several lines.

An increase in the weight of locomotives by 10 per cent. on the Brooklyn line decreased the time in starting about 10 per cent.; but it retarded the time of stopping a little more than that, owing to the greater momentum of heavier engines and the inability of drivers to make quick stops with the vacuum brakes in use. The working expenses on three elevated railways are given.

The ton mile included coaches, but excluded motors. In the third column for American lines, the cost of train, wages and coal were reduced by one-half to make them correspond more fairly with the Liverpool line; it was, however, difficult, owing to varying conditions, to make such comparison absolutely just. Owing to the small traffic on the Liverpool line, it was not surprising to learn from the half-yearly report to the shareholders on February 13th, that the working expenses were £13,623, or 74 per cent. of the gross earnings, as against 56·7 per cent. for the Brooklyn lines, and 50·7 per cent. for the Manhattan lines for the year 1891. If the train mileage was taken for the entire half-year, at the same figure as for the third quarter, or 40,440 miles per month, the total for the half-year should be 242,640. The working expense of £13,623 probably covered maintenance of way and station service not included in the Table given. Those items amounted on the American lines to 20 per cent. of all the working expenses. If taken at the same rate for the Liverpool line the net working expenses for the half-year on the basis of the Table amounted to 10·894 pence per train mile as actual cost, against 4·017 pence as the average for the months of July, August, and September, given by the author of the second Paper. Probably some details were omitted, or not fully explained, which would account for the apparent difference between the results given in the Paper and those deduced from the reports to the shareholders.

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Space, Speed and Time on several Elevated Railways.

Lines.	Space between stations.	Time in seconds.				Speed in miles per hour.		
		Starting.	Total between stops.	Stopping.	At stop.	Maximum between stations.	Average between stations.	Including stops.
	Feet.							
Liverpool Overhead line ...	2,225	...	91	...	23	35	15·55	12·65
Brooklyn Elevated Fifth Avenue line..	1,829	23	86	25	11½	30	14·7	13·00
Chicago Elevated line. {	2,645	...	98	...	..	28	18·5	...
	1,366	...	68	...	...	22	13·7	...
Chicago Intermural line ..	880	11	26	20	...	32	14·0	...

Working Expenses of three Elevated Railways.

Items of Cost.	Liverpool Overhead Railway, July, 1893.		Manhattan Railway, 1892.			Brooklyn Elevated Railway, 1892.		
	Pence per		Pence per			Pence per		
	Train mile.	Ton mile.	Train mile.	Ton mile.	Ton mile.	Train mile.	Ton mile.	Ton mile.
Supervision......	0·416	0·014	2·860	0·036	0·036	1·250	0·021	0·021
Motor and train, wages	1·694	0·056	9·725	0·122	0·061	6·650	0·111	0·055
Coal..............	0·589	0·020	4·680	0·058	0·029	4·500	0·075	0·038
Oil, waste, and grease	0·140	0·005	0·400	0·005	0·005	0·130	0·002	0·002
Water	0·010	0·0003	0·400	0·005	0·005	0·195	0·003	0·003
Stores and sundries	0·049	0·0016	0·277	0·003	0·003	0·295	0·005	0·005
Cleaning and repairs, rolling stock	0·829	0·0276	4·100	0·051	0·051	1·670	0·028	0·028
Total pence	3·727	0·1245	22·442	0·280	0·190	14·690	0·245	0·152
Passenger train-mileage	39,250		9,107,000			2,789,000		
Passenger ton-mileage	1,177,500		728,560,000			167,340,000		

Dr. Du Riche Preller thought that the conclusions of the authors concerning the superior advantages of motor-cars as compared with electrical locomotives were only applicable to certain local conditions, like those of Liverpool. Having lately had occasion to devote attention to comparisons of that kind, in view of several electrical lines with which he was at present occupied in Switzerland, he had found that it was very hazardous to generalise, and that each case must be judged on its merits. He had found, for instance, that on steep gradients the train load for 50 passengers by motor-car, electrical locomotive, and steam locomotive was 1 to 1½ to 2; but, on ordinary gradients, the proportion was very different as the number of cars increased. With two or three cars the weight was about equal; with four cars the electrical locomotive possessed a decided advantage over motor-cars. Moreover, the electrical locomotive ensured easier and safer manipulation of the train by one man, greater space for lodging large motors, easier attendance, and a saving in repairs. The power and traction expense at Liverpool of 4d. or 3·5d. per train mile was certainly moderate, but by no means phenomenal; indeed, having regard to the practically level character of the line, to the low cost of fuel (averaging 10s. per ton), to the low coefficient of friction, and to the large train mileage, he would have expected them to be less. On the Marseilles line, for instance, which had rising and falling gradients as high as 1 in 16, and where briquettes cost at the lowest 20s. per ton, the cost of power and traction was a little over 3d. per train mile; at Florence, with continuous gradients up to 1 in 20 and 1 in 12·5, and briquettes at 30s. per ton, the cost was 4d. At Buda-Pesth and on other lines in Europe, 4d. covered the entire working expenditure. The total working expenses at Liverpool had been up to the present time 13·5d. per train mile, and had absorbed no less than 86 per cent. of the receipts; whereas, even on the City and South London line, which was in every respect worked under far less favourable conditions, they were only 66 per cent., and on many other lines well within 50 per cent., which, with electrical traction, might be regarded as the normal rate.

With regard to the electrical plant, he wished to ask the authors to state what, in the dynamos, was the total loss due to the armature resistance, hysteresis and eddy currents; what was the maximum loss of potential at the end of the line, and the mean loss on the line; what system of lightning-arresters, if any, was used: and lastly, what was the sectional area of the copper bonding at the joints of the rails in relation to that of the rail and conductor section? American practice tended to very heavy bonding, the reason for this being the frequently defective permanent way of American lines. The increase in the weight of rails up to 90lb. per yard, as at Philadelphia, was *per se* no effectual remedy. Girder rails for tramways were used both on the Continent, where they were first made by the Phœnix Works, and in England up to 110lb. per yard; but, being generally laid direct on the ground without cross or longitudinal bearings, a subsidiary wire running under the head of the rails was always required to prevent considerable leakage. Extensive corrosion of gas and water pipes occurred on certain trolley lines where the current was made to pass from the rails or subsidiary wire through the cars to the contact wire instead of *vice versâ*. That system had the advantage of the arc forming on the arc as positive pole and thereby saving the contact wire; but it required high insulation of the permanent way; and, where that was wanting, electrolytic action by erratic watts or shunt currents would obviously occur.

With reference to the motors of the Liverpool cars, the Eickemeyer cool winding was neat and ingenious; but in the design of the motors as a whole, Dr. Preller thought the contractors of the electrical plant might have done better; and, in order to make this clear, he would compare the Liverpool motors with those constructed by Messrs. Brown, Boveri and Co., of Baden, Switzerland, for the Heilmann electrical locomotive. The steel-clad, gearless motors, of which there were eight in that locomotive, one to each axle, were four-poled, and the Gramme armature consisted of 136 coils of six turns, each placed in grooves and Pacinotti teeth, the wire being 8·2 square millimetres in section. The resistance of the steel field-magnets was 0·74 ohm, and that of the armature 0·125 ohm, being considerably less than that of the Liverpool motors, which had been given by the author of the second Paper as 0·37 ohm and 0·67 ohm respectively. The weight of the motor was 2·7 tons. At 310 revolutions per minute, corresponding with a speed of 40 miles per hour (the diameter of the wheels being 3·8ft.), and a pressure of 410 volts, the motor gave 60 H.P.; at 388 revolutions (or 50 miles per hour), 75 H.P.; and at 450 revolutions (60 miles per hour) the tested maximum power was 80 H.P. Taking the power of the Heilmann locomotive motors at 75 H.P., and that of the Liverpool motors at 47 H.P., and their weight at 2·7 tons and 2·5 tons respectively, the comparative weights were 72lb. and 116lb. per H.P.; in other words, the motors referred to gave, at less weight per unit, considerably more power than those used at Liverpool.

Mr. Mark Robinson expressed surprise at the statement made in the second Paper to the effect that an efficiency of 88 per cent. had been obtained with horizontal engines driving dynamos by ropes. Not only so, but this 88 per cent. was merely an average, for in the appendix it would be found that one of the trials gave 88·8, and another 89·6 per cent., and this with the low mean cylinder pressure appropriate to a condensing engine. The dynamo, it was stated, had an electrical efficiency of 97·7, and if 1 per cent. only were allowed for losses by hysteresis and Foucault currents, and 0·7 per cent. for the increased friction from the three bearings (two of them with a side strain) against the one bearing of a direct-coupled dynamo, the commercial efficiency became 96 per cent.—a very fine result, if correct. Allowing to the engine even the high brake-efficiency of 91 per cent., there was a little over 87 per cent. combined efficiency for the engine and dynamo together. What, then, were the ropes about when 89·6 per cent. was reached? They must have been making power. Why not have more ropes?

He did not desire to enter upon a controversy as to rope-driven and direct-coupled generating plant, for the victory of the latter was beyond recall. All would concede, however, that when one got rid of the ropes one certainly cut out some loss of power, whether large or small, though what that loss might be was as yet somewhat a matter of opinion. Happily, some exhaustive trials were about to be carried out abroad, and, pending the report of those trials, he doubted if anyone would think it safe to assume the transmission loss at less than 5 per cent.; his belief was that it was much nearer 10 per cent. It was, in fact, obvious that, instead of 88 per cent., not even 80 per cent. combined efficiency could be accounted for, except by a combination of perfections in engine and dynamo which no one could believe in without the strongest evidence.

But the evidence against those figures was not only their inherent improbability. He had had the advantage of speaking with an eye-witness of the trials, an engineer, in fact, who had taken part in them, and he had learnt, in the first place, that the indicator was fixed upon a pipe joining the two ends of the cylinder, and thus was connected with either end only through a pipe of

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considerable length and with undesirable bends in it. Everyone knew the effect of such an arrangement in reducing the size of the diagrams. In all probability the indicated horse-power was materially understated. In the next place, the water resistance behaved as water resistances generally do behave on such occasions, and it was impossible to maintain a steady current. The Kelvin hecto-ampere balance, perfect as it was in many respects, was an unsuitable measuring instrument under the circumstances stated; because, owing to its extreme sensitiveness, it could not easily be balanced with an unsteady load; a recording wattmeter ought to have been employed. What certainty, or what probability even, was there that the diagrams from the steam cylinders coincided in time with the electrical readings?

It was stated in the Paper that the trials lasted over three hours and a-half, and a statement was given of the coal used in that time, and the coal per electrical horse-power was worked out. But anyone familiar with boiler trials would know that a three and a-half hours' trial was almost useless, as a relatively small error in estimating the comparative weight of fuel on the bars at the beginning and end of the trial might produce most misleading effects. If anyone still supposed the figures to be reliable, let them be compared amongst themselves. Thus, take the last two columns in the first Table, p. 555. With the same revolutions, the same vacuum, practically the same steam pressure, there was 87·5 per cent. efficiency when the engine indicated 408 H.P., and 89·6 per cent. when it indicated 385 H.P., or 23 H.P. less. If one thing was certain about engine efficiencies, it was that a diminished load tended to reduce brake efficiency, not to improve it; yet here, with a lighter load, the efficiency increased. What would the engine-makers say to their condensing engines being debited with 2·96lb. of coal per indicated horse-power in order to bring out this amazing combined efficiency of 88 per cent.? If the coal used at Liverpool were credited with the evaporation of only 7lb. of water per lb. of coal (even with the help of economisers), they would have 21lb. of steam used per indicated horse-power, with the engines working at a favourable mean pressure, and with an excellent vacuum. He refused to believe that as much as he did the 88 per cent. combined efficiency. It might be supposed that results so extraordinary, and so contrary to previous experience, would, before publication, have been re-tested frequently, or at least certified by the names of independent and recognised authorities in the difficult science of engine testing. But there was no such authentication. If not challenged, such statements would remain on record as a stumbling-block in the way of truth. It was no imaginary danger, for those misleading figures had already been used to that end. He had actually received a letter from the United States, written before the publication of the Paper, in which its figures had been quoted as evidence that the supposed advantages of direct driving had now been disproved in England! He was sorry to find fault with any detail of a Paper of so much interest and value; but it was sometimes a duty to speak out.

Capt. H. RIALL SANKEY, R.E. (ret.), wished to call attention to a few of the anomalies in the load curves, Figs. 8 and 9 (*The Electrician*, Sept. 7). From these it would appear that the load on the engines varied very slowly, the maximum variation being about 400 amperes in about half-an-hour, and the average about 100 amperes. That was different from what occurred on other electric railways. It was also unlikely that on October 10th, from 5 to 9 a.m., eight trains would take nearly the same average load as twelve trains on the same day between the hours of 9 a.m. and 5.30 p.m.; whereas, on October 18th, eight trains took about 400 amperes average load against 800 amperes for the twelve trains. Again, on April 14th, when seven trains were running between 1.30 and 3 p.m., the average load was about 250 amperes, and yet on the same day, with the same number of trains running, the average went up to 800 amperes between 4 and 5 p.m. The solution of those anomalies was, however, not far to seek. It was stated in the Paper that the amperes and volt readings were taken once in every half-hour; and evidently those intervals were far too great in the case of a load varying as much and as suddenly as that on an electric railway. He had seen a load curve of the Liverpool electric railway for which readings had been taken every minute for one hour; and the result was entirely different from what was shown in the Paper, but agreed with those of other electric railways. It was important to notice that the load curves given in the Paper did not therefore give the real output of the plant; and the Table, showing amongst other things the coal burned per kilowatt-hour, was consequently unreliable.

Mr. JAMES N. SHOOLBRED found the Paper of special interest from the fact that his early days had been spent in railway work, then for several years his occupation had been among heavy iron constructions for buildings and for railways, and latterly he had devoted much time to the industrial applications of electrical energy. A lengthy residence in Liverpool had also made him acquainted with and appreciative of the many difficulties which had to be overcome, as well as the various conditions which had to be complied with, in the construction of this railway. Respecting the mode of constructing the line, there was but one point to which he wished to draw attention, and that was the arched plate flooring. Granting all the advantages claimed for it in the Paper (of strength, of lightness, and of tending to an even distribution of the rolling load), there still remained a grave objection, in his opinion, to the use of steel plates only $\frac{5}{16}$in. in thickness, placed under the conditions which were found at Liverpool. The plates were exposed to the action of the damp sea atmosphere, over the larger part of both their upper and lower surfaces, and also to the effect of rain over about two-thirds of the broad crown of the upper surface. While, owing to the comparatively small height to which the V-channels had been filled up, as well as to plugging up (which often occurred) of the water-outlets from these channels, the upper un-filled portion of the V-channels became in most cases, he had noticed, a receptacle for stagnant water. Under those conditions, he considered it probable that, in the course of a few years, the plates would become pitted and reduced irregularly in thickness. When, also, it was borne in mind that the longitudinal timber sleepers carrying the train-loads rested directly on those arched floor-plates, it would be seen that a state of things fraught with chances of accident, and even with danger, might very possibly arise. He certainly was of opinion that it would have been more economical to have used a somewhat heavier flooring from the commencement.

The comparative tractive effects of electricity and of steam, as shown in Table B of the first Paper, were striking. He considered likewise that the selection in this case of the independent car motor had been a wise one. The driving arrangements had, no doubt, been much simplified by the use, sometimes "in series," and sometimes "in parallel," of the motors; those arrangements were much in advance of the older devices involving chain or tooth gearing. By far, however, the most important electrical question which had been solved by this most instructive enterprise was, in his opinion, the fact that the line was worked practically on what would be termed "low pressure" by the Board of Trade; and without having recourse, despite the length of the line, to those high pressures which constituted a source of danger to life. Furthermore, the mode of working was such that it could be made readily to combine with low-pressure continuous-current arrangements for electric supply for town distribution, adapted to the five-wire arrangement and also to the subdivisions thereof, where in use. This would no doubt be the case more fully in Liverpool, as the demand for the supply increased. The importance of the "low pressure" solution was very considerable, especially in towns where tramways existed; and where these last could be treated electrically on somewhat the same lines as in the present railway—local circumstances, especially as to the conductors, being taken into consideration.

Mr. THOMAS PARKER, in reply to Mr. Aspinall's remarks, observed that the statement as to running at 12 miles per hour, with 16lb. of coal, required to be qualified. The frequent stoppages and accelerations formed a great portion of the work done, and only allowed the trains to attain an average speed of 12 miles per hour. Those accelerations had to be effected in a minimum of time; and, as regards the question of train mileage, there was a considerable mileage travelled by the Liverpool Overhead Railway trains which was not taken into account in the mileage given. The figures given included repairs and renewals to the whole of the haulage plant. The difference between 22½lb. of coal per train mile during the months of April and May, and 16lb. per train mile during August, was accounted for by the larger number of trains in use during the latter month, giving a more even load at the generating station. To compare the trains used on the Metropolitan suburban lines with those of the Overhead Railway, it would be necessary for the former to make the same average speed and the same number of stoppages in an equal distance. He knew of no suburban line which had so high a speed as the Overhead Railway, having regard to the number of stoppages in the distance. The question of end and side-doors was discussed and carefully considered, and he agreed with the opinion of the engineers that the method of receiving and delivering passengers was the quickest and most convenient that could have been adopted. The questions raised by Mr. Crompton as to the efficiency obtained at the generating station would be found answered in Mr. Parker's reply to the discussion. He was unable to give Mr. Nichols an analysis of the figure for working expenses on the Liverpool Overhead Railway, viz., £13,623, which had been taken from the balance-sheet. The Paper did not deal with the traffic and other expenses of the line, but the haulage and the renewal of the haulage plant. In reply to Mr. Mark Robinson, he could only reiterate that the tests were made under the supervision of, and were checked by, the Company's engineers, and were not made for any purpose beyond ascertaining the economical value of the plant for the satisfaction of the representatives of the Overhead Railway Company.

Mr. J. H. GREATHEAD, in reply to the correspondence, observed that Mr. Aspinall seemed to think that the figures given in the

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Paper were directed to the disparagement of the steam locomotive, and had assumed that the comparisons instituted went further than was actually the case. There was, for instance, no comparison with the working of the locomotives on the main lines of this country; and Mr. Aspinall's suggestion, therefore, that "engine mile" should be used instead of "train mile," had no relevancy; at the same time, whilst he had taken exception to the comparisons instituted with the working of the Elevated Railways in New York, suggesting that they should have been made with railways in this country—overlooking the fact that there did not exist in England a railway worked by steam locomotives so nearly akin to the Liverpool Overhead Railway as were the American lines—namely, having comparatively light trains, stopping at very short intervals (about one-third of a mile), and attaining under these conditions a speed of about 12 miles an hour. Again, in pointing to an English line, and stating that if the authors had been anxious to ascertain what a locomotive dealing with suburban traffic consumed, they should refer to Mr. Stroudley's Paper of ten years ago, presumably Mr. Aspinall had referred to an earlier statement of Mr. Stroudley* in reference to the working of the Brighton line between Victoria and London Bridge, because Mr. Stroudley's Paper of 1884 did not deal with suburban traffic. Mr. F. Fox and he had considered that case because it did comply to a certain extent with some of the conditions—the trains and locomotives were comparatively light, and the service was somewhat of the same character; but, upon looking closely into the facts, it became clear that the main governing condition, namely, the distance between the stations, was widely different, being nearly a mile instead of one-third of a mile. As Mr. Aspinall, however, had laid special stress upon this matter, because, as he had stated, if the comparison was to be made about fuel consumption, "it should be made with English railways, and not with American, where but little care was taken about economy in fuel," it might be interesting to institute a comparison based upon the figures given by Mr. Stroudley, and estimating the effect of the more frequent stoppages of the trains. The Brighton locomotives described by Mr. Stroudley weighed 24 tons, all on six-coupled driving wheels 4ft. in diameter, having cylinders 13in. in diameter, and a 20in. stroke, and steam pressure of 140lb. per square inch; the average weight of the trains was stated to be 59 tons, the average speed 15 miles an hour, the average stoppages about 1,500 yards apart, and the coal consumed was given at 21·63lb. per mile. Calculating the average power exerted by the locomotives, it would appear that they consumed about 3·9lb. of coal per indicated horse-power per hour; and that in order to maintain a speed of about 12 miles an hour (including stoppages) with the same trains, on a line having stations one-third of a mile apart, their consumption at the same rate would be about 60lb. per mile, instead of 21·6lb.—the average weight of a train, including locomotive and passengers, being taken at 90 tons—as compared with the 16lb. of coal per mile for the 38-ton trains at Liverpool; the coal used in the steam locomotives being of a superior character, and costing considerably more than the class of coal used at Liverpool. To complete the comparison it might be added that the tractive force per ton of train (75lb.) was very little more than that given in Table B for the District Railway locomotives, though the maximum tractive force per ton of locomotive (328lb.) was considerably in excess of the District engines, but was still less than half that of the electric motors at Liverpool. The comparison suggested by Mr. Aspinall was, therefore, on the whole not less favourable to electric traction at Liverpool than the comparison made in the Paper with the American lines. With regard to the suggestion that the working expense at Liverpool did not include a proper provision for renewal of plant, which Mr. Aspinall had taken from the Liverpool Overhead Railway Company's accounts as having cost £73,744, it was right to state that the figure given in the amounts included not only the locomotive plant, but also the carriages, the buildings, and the foundations at the generating station. The Company's accounts did include a proper provision for the renewal of plant, and that provision, added to the actual cost of working since it had been taken over by the Company, would still leave the total locomotive expenses at less than 4d. per train mile. As regarded the design of the carriages, Mr. Aspinall, when he expressed surprise that they had not been constructed similar to those in use on the elevated railways of New York, had no doubt overlooked the fact that in Liverpool two classes of passengers had to be dealt with; and he appeared also not to have observed that the Liverpool carriages did possess central passages. The Liverpool carriages had been found in actual working to be very convenient, and the side doors did not interfere with the passengers on the platforms.

It was satisfactory to find that Mr. Lincoln Moss, who conducted the experiments on the Manhattan Railway referred to in the Paper, was of opinion that, as regarded motive power, it would have been a mistake to have equipped the Liverpool line with steam locomotives, though it was difficult to understand why he should have though it unfair to compare the cost of working the Liverpool line with that of the New York lines, on account of the greater number of trains running upon the latter, because the effect of a more frequent service upon electrically-worked lines was to reduce materially the cost of working. The Paper defined clearly the difference between the weights of trains on the two lines. Allusion had been made by Mr. Nichols to the Liverpool Overhead Railway as the first permanent elevated railway worked by electricity. As a matter of fact, it is the first elevated railway so worked, having been established before the Intermural Railway at Chicago, to which Mr. Nichols had referred. It did not seem to be necessary to follow Mr. Nichols' comparisons of the cost of working the Liverpool, Manhattan and Brooklyn railways; because, without having the details of prices and cost, and the amount of labour, upon which his figures were based, it was impossible to form any estimate as to actual results. It was, however, satisfactory to find that, notwithstanding that the cost of wages and coal had been reduced by one half on the American lines, the cost per ton mile on the Liverpool line with its comparatively short train mileage was still considerably below that of the American lines. As to the estimates of percentage of working expenses to gross earnings in the several cases, such comparisons, though convenient commercially, in comparing like with like, were not reliable; because they depended on the amount of traffic and earnings, and were therefore not indicative of economy or otherwise in the working. The Paper dealt only with the locomotive expenses, and not with the total expenses of the railway—a fact which Mr. Nichols did not appear to have appreciated. It was not contended in the Paper, as Dr. Preller had suggested, that motor-carriages were better than separate locomotives under all conditions; on the contrary, it was shown that different cases required different treatment. Into Dr. Preller's comparison of the total cost of working the Liverpool Railway with that of working the City and South London line, it did not seem to be necessary to enter; the conditions being widely different, and the ratio of expenses to gross receipts not affording a satisfactory gauge. The locomotive expenses of Continental tramways worked by electricity did not appear to be comparable with those of the Overhead Railway, in the absence of fuller details of the tramway working, weights drawn, mileage, and so on.

In reference to the few remarks that had been made upon the structure of the railways, Mr. Shoolbred's criticism upon the arch-plate flooring was directed against the thickness of the plates—namely, $\frac{3}{16}$in.—which he considered too thin for safety and economy, having regard to the possible effect of the damp sea atmosphere and rain. That, however, was entirely a matter of maintenance; the plates, if properly coated, would last indefinitely; if they were twice as thick, and were neglected, they would not last very long. Some of them which had been fixed for about four years showed no signs of deterioration.

With regard to the strength of the decking referred to by Mr. Fitzmaurice, it might be stated that the heaviest weight on an axle was 6·6 tons, or 13·2 tons for the two roads; while the tests showed that there was no sensible deflection with a load of 30 tons, and no permanent deflection with 105 tons distributed on three arches of the decking.

* Minutes of *Proceedings* Inst. C.E., Vol. XXXVII., p. 29.

THE ELECTRIC BRAKE IN PRACTICE.*

BY ELMER A. SPERRY.

Enterprise in the United States for the public convenience of her citizens is truly phenomenal, and reaches its highest expression in conveniences for travel. Vast skill and almost untold resources have been devoted to perfecting means for overcoming inertia, and quickly accelerating cars and trains, which are ever increasing as to their weight and capacity. It is proverbial that while these advancements have been going forward, comparatively no attention has been paid to the mechanism for retarding, and quickly, but smoothly, bringing the cars and trains to a stop.

As the practice of the steam railroad engineer as to road beds, speeds and weights are gradually approached, his experience in the solution of this most important problem of braking should be studied with care. In so doing, however, the features wherein the street car problem is differentiated from the steam road problem should be kept prominently in mind. We must remember that the locomotive engineer is provided with a complete, expensive and somewhat intricate apparatus with which to de-energise his train. The periods of its application are comparatively infrequent, and as to personal capabilities, he is schooled and trained for years before ever being allowed to touch either the throttle or the air valve. While working, his pressure gauges allow him to adjust the brake application to a nicety. Moreover, the time

* Abstract of a Paper presented at the meeting of the American Institute of Electrical Engineers, September 19th.

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allowed for the total retardation, and final stopping of his train is usually very long as compared with that allowed in street railway practice.

Of the two, the street railway problem is the more exacting, and in the hands of far less experienced operators; and yet we are told that the mechanism involved in its solution must bear only a small ratio to the cost of the total equipment. Owing to the recently-developed relation between effective braking and the accident and damage account, the purchaser will be spurred on to careful investigation as to the brake applied to his cars, and will be willing to spend sufficient time and money to effectually control retarding, as well as accelerating the car. To be sure, as little expense should be incurred here as possible, but enough to fully meet the requirements. Especially is this true, now that ample power for applying the heaviest brakes is at hand, and even if used in a wasteful and extravagant manner in the largest amount possible, is entirely without cost, and its means of control already at hand. The importance of this proposition should at once command the attention of all, and commend the problem as such to the engineer.

Examination of accounts of the electric street railway companies of our large cities reveals the fact that the item of damage, already very great, is one of growing importance. Investigation of the circumstances and detailed statements of numerous items taken at random from the damage account, point at once and in no uncertain way to the inefficiency of the present hand brake. In many instances, could the car or train have been stopped within a comparatively short distance, the accident and resultant damages would have been entirely averted. The first investigation led to others with the same result, and in consequence the writer is prepared to show that nearly 85 per cent. of the accidents directly occurring, are due to the inefficient operation of brakes. The growing frequency of accidents, and the constantly increasing demands of the public for damages, are indications that have not been made to impress the mind of the engineer, or I am sure adequate means would have been forthcoming for the correction of so grave a fault inherent in all the present systems of power-operated street cars. Some of our municipal authorities are taking action with reference to the increasing frequency and severity of accidents, and although no thorough scientific investigation of the matter has been published, yet it is a startling fact that with the present hand brake no electric or other equipment to-day stands provided with anything in the line of an emergency brake. In so grave and urgent a case, what can be done in the line of remedy? The question naturally arises: Will any system of braking worked upon or in connection with the ordinary wheel of a vehicle be sufficient for the stop required? What is the maximum efficiency obtainable by the brake working through the wheels? Is it sufficient to arrest the car before accident in case of emergency? Can it be made in any event a sufficient accident preventer? The popular notion that most accidents are due to brake failure is true; but in a way that is little understood, the failure being one of degree. It may not be known that under proper and standard conditions any car or train may be brought from a speed of 10 miles an hour to absolute rest inside of 10ft. It is not generally appreciated that the wheel brake has ample capacity to accomplish this. The former investigations of the writer with reference to adhesion under conditions of acceleration and retardation, climbing and descending hills, afford ample proof that the rail adhesion through the wheels gives the wheel brake more than capacity sufficient to accomplish this result. For instance, assuming any weight and load, say 17,000lb., the stored up energy, 64,426 ft. lb. can with ease be dissipated within 20ft. for the ordinary equipment, and less than half of this distance, or a little over 9ft., under conditions of coupled drivers, or if the wheels are compelled to revolve in unison. This latter consideration will be seen to have quite an unexpected as well as pertinent relation to the problem. It will be seen by a glance at the figures that the centre of gravity of the mass is far above the wheel contact with the rail. The retarding effect takes place on the base line in a plane below that of the centre of gravity, really the farthest projection downward of the mass as a whole. A sudden stop operating on this base line tends to pitch the upper portion forward, bringing nearly all of the weight, and with it the retarding capacity, upon the front pair of wheels. The brakes in the rear pair in the ordinary equipment will have but little effect; if, however, by any practicable method they are coupled to the forward drivers, the brakes on this rear pair still remain active and of full effect. This is true even if the back pair should be lifted clear of the track. With increased weight upon the forward drivers comes ample increased adhesion, thus preserving the full tractive effort of the total weight intact for purposes of stop, which is impossible in the ordinary equipment. These effects are all aggravated in case of short wheel base. The present tendency toward a longer wheel base is a step decidedly in the right direction, and should be encouraged. The effect of shifting the load in reference to the axles will be especially noticed in descending hills, as shown in Fig. 1, where the momentum of the rapidly retarded mass tends to shift the load centres still further forward, in some cases almost wholly on to the front drivers. It will be seen to have a greater effect than in *ascending* grades, where in stopping, the inertia tends to correct the position of the shifted load; whereas going down, in stopping, the momentum as stated tends to still further aggravate the condition. The practical effect of this may be seen whenever an ordinary street car mounted upon springs of fair resilience is quickly stopped. The car will be seen to suddenly right itself, having been pitched forward in the process of stopping (*see* Fig. 2), the front springs being depressed and the rear springs extended. These considerations all go to show in a new light the advantages to be derived from coupled drivers for general street railway service.

Bearing these facts in mind, let us turn for an instant to the ordinary hand brake. The ratio in the brake levers will be found in the modern trucks to be anywhere from 6 to 11½, averaging about 8½ to 1. The lever arm of the brake staff will be found to be anywhere from 6in. to 13in. Assuming 11in. as the average, the radius from the centre of the brake chain to the centre of the brake staff will be 1¾in., giving thus 6·28 to 1, or a total leverage of 53·4 to 1 from the operating handle to the brake beam. Two elements now have to be assumed. First, the friction coefficient of the brake shoes acting upon chilled wheels. Second, the power upon the brake staff. The writer has endeavoured to cover both of these unknown quantities by actual experiment, giving the results in the tables. Table I. was taken by a dynamometer being fastened directly to the brake staff handle in line of the pull of the motorman, a cast-iron brake wheel 16in. diameter from centre to centre of a 1¼in. rim bearing

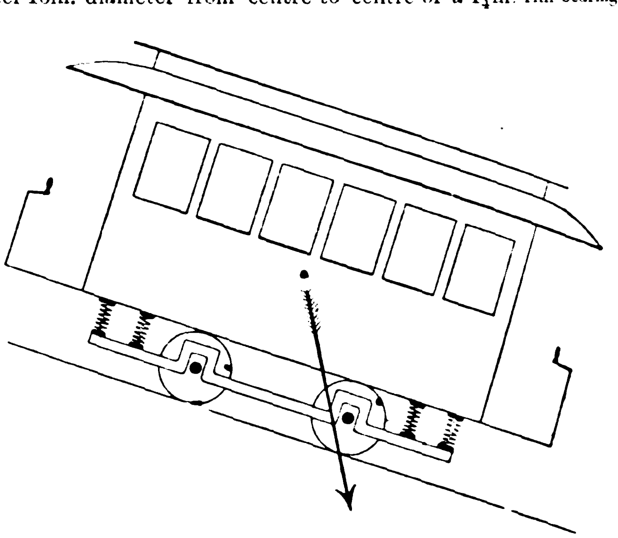

Fig. 1.

the handle. A number of experienced motormen were invited to test their strength upon this handle, and careful readings were taken. It was noticed that the right arm of the more experienced motormen was much more developed than the left, a fact which I think has been pointed out before. The extent of this development in the forearm is certainly quite marked, showing that the gripping muscles and weight of the body are the elements brought most into play.

Table I.

No. of motorman.	Weight of motorman.	Gradual pull with one hand.	Jerk with both hands on hand wheel.	Emergency jerk with both hands on hand wheel.
6	140	112	135	275
58	200	135	275	335
264	287	145	235	312
62	175	125	212	285
123	153	125	245	310
60	185	150	200	300
26	170	150	275	350
96	155	135	210	325
246	135	110	175	325
287	135	125	250	350
66	160	125	250	405
4*	176	100	200	400
266	185	175	250	375
		Av. 131·7	Av. 224	Av. 338·23

* 9 years in service.

Right arm, circumference of forearm, 12¾in.
,, ,, biceps, 14¼in.
Left arm, ,, ,, forearm, 11⅝in.
,, ,, biceps, 13⅝in.

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Columns 1 and 2 indicate respectively the number of the motorman and his weight.

Column 3 indicates the greatest possible steady pull with the right hand on the handle, bringing into play all possible weight of the body.

Column 4 indicates the same conditions as column 3, the motorman in this case grasping the hand-wheel with both hands, some motormen using gloves to prevent their hands slipping. None of the men could maintain these values for more than half a second.

In column 5 is indicated an "emergency stop." The motormen were told to "break the machine" if possible. In this test the body was braced, sometimes with the knee against the dasher rail, the needle registering the highest jerk usually given with a sudden lunge of the body.

It will be seen that the power applied by the steady pull of the average motorman is about 131·7, and can be made to run up in case both hands and the weight of the body are used, to about 224 average, but this value cannot be maintained. The average values of column 5 cannot be used in these calculations, for the reason that although they show the pressure it is possible to reach by jerking upon the hand-wheel, these pressures cannot be maintained, and therefore cannot be depended upon for braking effect. The tests show that the full power that can be maintained upon the brake lever for a sufficient length of time for the purposes in hand, does not exceed an average of 180lb.

Table II.

Speed rev. per minute. 33in. wheel.	Brake pressure. Lb.	Traction. Lb.	Coefficient. Per cent.
Varying, 150	900	87·4	9·7
125	900	91·7	10·2
100	900	99 8	11·1
78	900	118·0	13·2
56	900	133·0	14·8
38	900	150·4	16·6
20	900	154·0	17·1
4	900	174·6	19·4
Constant, 105	300	29·4	9·8
...	500	50·5	10·1
...	750	91·0	12·0
100	1,150	125·0	11·2
...	1,500	178·0	12·0
...	2,2[illegible]0	305·0	14·4
94	3,780	488 0	13·2

Table II. was obtained as shown in Fig. 3. A brake shoe that had been run in service about three or four days was taken with the axle carrying its co-operating wheel lifted out of the truck and placed between the centres of a lathe, the load upon the brake shoe accurately measured, and the shoe held from movement around the wheel by a dynamometer. Every precaution was taken to avoid handling the periphery of the wheel or the face of the brake shoe, and even the dust was left upon it so as to conform as nearly as possible to the normal conditions of practice.

Tracing our 180lb. application to the brake beam, with allowance for loss by friction, we have 3,840lb. applied to each of the two shoes, which upon the chilled surfaces are found under ordinary circumstances by Table II. to give a coefficient of about 12 per cent. This would give a retarding effect of 460lb., which is less than one-third that easily obtainable were the power needful for its application at hand. The coefficient under these conditions would have been about 37 per cent. to realise anything like the total value of the retarding effect of the wheel. This, under condition of chilled and glazed surface, is entirely out of the question, showing at once the necessity of power in the application of brakes, if anything like their full value and use is to be obtained. This is also amply borne out in practice, as those who have tested this point well know that under ordinary conditions it is next to impossible to slip the wheels of a motor car by the hand brake.

In the electric brake, on the other hand, the fact that the truck parts are not bound up and locked into a solid mass by the enormous pressure of the heavy brake levers and shoes is found to prevent racking and straining the truck, as well as jumping the track and curves when the brakes are set. The axles and truck parts are perfectly free for easy and normal movement even when the brake is exerting its full power. Great reduction of wear at the pedestal journals is also found, owing to entire absence of all of the usual heavy pressures of the brake shoes. We can all see that by applying adequate power and control to the wheel brake, this element of the equipment may be raised to the position of an indispensable safeguard, the value of which can only be appreciated as its hitherto undeveloped resources are brought out, demonstrated, and rendered simple and easy of application and control. In practice the greatest necessity for maximum brake application exists at the higher speeds. From Table II., it will be noticed that at just this point the failure is greatest, the coefficients being least; increasing as the speeds decrease. This has always constituted the one grave fault of the air brake in railway service. The intensity of its application should be greatest when the speed is greatest, and decrease as the speed drops off. As will be shown farther on, this point has been fully covered in the electric brake, which is the first time that the varying application has even been embodied in practice, and especially in such a manner as to perform its important function automatically.

A plan, especially one pertaining to electrical matters, after having been proven mathematically to be feasible, is far from being realised. Many are the practical difficulties to be surmounted before a thoroughly commercial, or anything like a standard, apparatus has been produced. Especially is this true in the electrical field. Many subtle influences and energies are at work which well

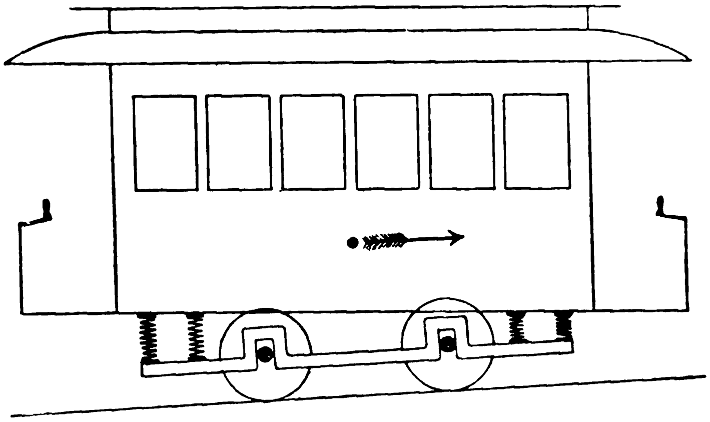

Fig. 2.

nigh overwhelm the experimenter. In a new field but few precedents are at hand, and these are apt to be extremely unreliable, and in the nature of a blind leader of the blind. The practical application of the electric brake, although probably no exception to the general rule, amply illustrates the wide distance to be spanned between the conception of the idea and the commercial apparatus itself. For years the writer has believed that electricity was vastly preferable to any other force for the application and control of brakes. Working first on the solution of the continuous-brake problem for railway trains, he built his first electric brake apparatus in '82, and has studied and experimented on the problem in its various phases almost continuously since that date, with more or less encouragement in the line of substantial progress. As to its application to electric cars, the apparatus was successfully applied on some double truck cars in Illinois, one of these cars weighing as

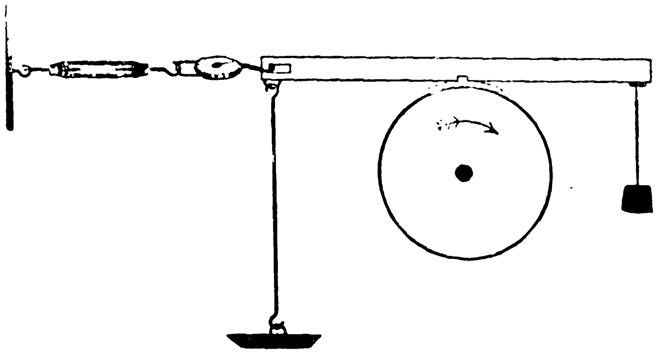

Fig. 3.

much as 12 tons. The first equipment was constructed some five years since. This apparatus has been constantly undergoing alterations and been experimented with, until for the past 18 months a constantly increasing number of electric cars, equipped with it, have been in regular service, some of these running, with change of motormen on each of 13 daily trips, the same motorman having the car once in about three days, making it impossible for the men to become familiar with the operation of the brake. During this time one car has made upwards of 70,000 miles, hauling a trailer about 48,000 miles, during some special weeks of test, making from 178 to 220 miles daily. It is only under such rigorous conditions of actual operation that rapid progress can be made in reduction to practice. All machinery or apparatus must pass this ordeal successfully before it can be brought into thorough commercial shape.

At the mention of electric brakes the engineer at once admits that they should be entirely feasible, and usually adds that there

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is plenty of electrical energy at hand from the central station to retard and control as well as to propel the car. This, however, is not the method undertaken by the writer. To employ the central station current for operating the brakes would be to limit very materially their usefulness and certainty of operation. The braking current, although used at comparatively infrequent intervals, and then only for a short period, should for this reason be absolutely certain and unfailing in its action, and not subject to any "heart failure" of the central station, or sudden cessation caused by the opening of the circuit breakers, the interruption of the line, the flying off of the trolley, failure of the fuse, or failure at other more or less vulnerable points. The electric brake under discussion has been operated over a year on equipment upon different roads, from electricity generated independently of the trolley connection, the braking current not being derived from the central station but produced by the power of the moving car, which power it is desired to get rid of, or destroy. The brake thus operates equally well with the trolley off, and, as will be understood from the following description, the trolley current has nothing at all to do with the car while the brake is being operated, except possibly to maintain the light circuit. The electric brake at the same time is entirely independent of the hand brakes, which may or may not be present upon the equipment. The braking action being altogether independent of the ordinary brake shoes, it is not found necessary to employ them in connection with the electric brake, although in the earlier forms they were used, and in the case of trail cars, especially in heavy service and on grades, some engineers prefer to use them at the present time. The current employed by the writer for operating the brakes is developed by automatically turning the motor or motors into generators. As these are driven forward by the moving car they develop current which is controlled as to intensity by the starting rheostat of the car. The braking current is thus produced at the expense of the mechanical energy stored up in the moving car, which, being consumed, causes a retardation and final stopping of the mass as a whole. The current so generated may be furthermore led through a brake magnet, as above seen, to apply the brake shoes; it may arrest the motion of

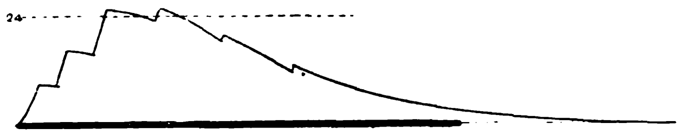

FIG. 4.

the car direct by magnetic adhesion, or develop heavy retarding currents in the moving metallic mass by magneto-induction. When an active local circuit is used the latter method is usually employed, for reasons which will be made more apparent.

In developing this system, the point which seemed fraught with the most difficulty, and which has finally received the simplest solution of any in connection with the problem, was that of obtaining always and with absolute certainty sufficient current at the lowest speeds without the aid of the trolley current. Teaser coils were at intervals resorted to, maintaining connection with the trolley circuit. "Artificial teasers" were also used, being a device by means of which the trolley circuit was entirely done away with, and which worked well. Observations made from time to time in connection with these experiments led to an exhaustive investigation of residual magnetism, in consequence of which structural means were adopted to utilise to the full the residual magnetism of the motor. This supply is constantly being renewed with every energising of the car. This method was found to be the simplest as well as the most effective. The connections, and, in fact, the whole arrangement of the electric brake upon the car, is extremely simple. This is shown by the fact that only one small extra wire needs to be run to the controller in addition to the ordinary wiring of the standard equipment without the electric brake. The certainty of operation is evinced by the fact that at present writing over 150 of the equipments have been placed, which are making upwards of 10,000 miles daily in regular service. Early in the experimentation a phenomenon was observed in reference to the persistence of the current even after the motor had stopped. This is due to the slow action of the decreasing magnetisation, taken together with the reaction or self-induction effect of the fields, and any brake coil or coils that may be in the circuit. The movement of the magnetic lines, which persist after, and in fact long after the motion of the motor has ceased, generates potential. In many instances it is possible to draw an arc from the rupture of the brake circuit one second after the motion has ceased, showing the presence of current in the local circuit. Fig. 4 has been developed from the average stop to show the curve of current in reference to the motion, the black lines indicating the period of motion during the application of the brake, and the curve indicating the current intensity and its duration. The current flowing after motion ceases, though small, is found exceedingly useful in holding the car from starting itself, even on quite a heavy grade, as only a small quantity of energy added to the already great friction of quiescence will prevent the car from starting. This persistency of current is also found useful to destroy the magnetism of the brake magnet, in case it is desired to suddenly move the car forward again. The tendency on the part of the windings at the moment of rupture to generate an opposing E.M.F. tends to suddenly free the magnet from its face, a purely accidental feature, which is of great value and utility in this connection. The wonderful energy of the withdrawal of the lines of force being in its manifestations a phenomenon of magnetic viscosity, is illustrated by the following fact: With a perfectly dry track a great force is required to shear the adhesion and start the wheels slipping. A car going down a grade under these conditions where no brake magnets are present, will, with a sudden application of the electric brake, generate sufficient current to not only arrest the motion of the wheels but start them going in the opposite direction; the reverse motion being maintained through an interval truly remarkable, in some instances running as high as one and one-half seconds. It will be borne in mind that all the above phenomena are entirely independent of the central station current, the trolley connection having been severed before the brake is applied.

(*To be concluded.*)

THE CLARK CELL WHEN PRODUCING A CURRENT.*

BY S. SKINNER, M.A.

The electromotive force of the Clark cell when not producing any current has been frequently determined, and has been found to be of so constant a value that it is now used as a standard. In the following an account is given of a series of experiments made on cells when producing currents, with the view of ascertaining (1) how far the total E.M.F. round the circuit differs from that of the open cell, and (2) how this new value for the E.M.F. changes when the current is maintained. If these quantities can be accurately measured, it follows that a cell might be used for producing currents of known value.

The experiments were made on three cells, all much larger than the ordinary Board of Trade pattern of Clark cell. Cell B was made July, 1891, and the area of its exposed zinc surface is approximately 14·4 square centimetres. Cell L, made November, 1892, is a much larger cell, fitted up in a cylindrical jar 22cm. high and 13cm. in diameter. The zinc plate exposes an area of about 95 square centimetres. Cell N, made July, 1893, is intermediate in size, and exposes about 29cm. of zinc surface. In all three cells the zinc plate, a piece of common zinc sheet, is placed horizontally, and they have the same E.M.F. within two parts in 5,000.

The external resistance used consisted of thick wire coils or of a special wire resistance immersed in a large tank of paraffin oil.

As an instance of what happens when the poles of a cell are united, the author describes the following experiment: On July 25th the cell L had an E.M.F., with its poles open, represented by 5,009 on the compensator. The poles were then joined by a resistance of 1,000 legal ohms, and their potential difference, taken as quickly as possible, was then rather more than 4,983 and rather less than 4,984. Then a resistance of 500 legal ohms was substituted for the 1,000; the potential difference fell to 4,959. Next, with 200 legal ohms the potential difference was 4,885. Lastly, the poles were opened, and the E.M.F. of the cell was found to be 5,009. It is seen from these numbers that the cell recovered its E.M.F. entirely after the various operations, and this is a typical instance of the behaviour of the cells.

The important determination of the resistance of the cells was made by the method of opposition, and by the use of an alternating current. By opposing any two of the cells, the resulting E.M.F. was so small that, making them an arm in a Wheatstone arrangement, there was no deflection in the bridge galvanometer. The bridge was fed with an alternating intermittent current by means of the commutator used by Mr. T. C. Fitzpatrick in his electrolytic measurements, B.A. report, 1886. The errors to which this method of measuring battery resistance is liable are two: first, from self-induction, and second, from polarisation at the electrodes. The only conductor containing self-induction of any magnitude is the galvanometer coil, and as the method is a zero method this does not matter. The second error is eliminated by using an alternating current. However, following Fitzpatrick's method, tests were especially made for polarisation by varying the ratio of the arms and by varying the speed of the commutator.

* Abstract of Paper read before the Physical Society.

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By means of the method described by the authors and Mr. Glazebrook (*Phil. Trans.*, 1892), the results in the following table were obtained. The units of E.M.F. are appropriately $\frac{1 \cdot 4}{5000}$ volts.

Table I.

Cell and date.	E.M.F. of cell open = E.	Potential difference for the cell producing approximately.			
		0·0014 amp. $r=1000$ legal ohms.	0·0028 amp. $r=500$ legal ohms.	0·C07 amp. $r=200$ legal ohms.	0·01 amp. $r=147$ legal ohms.
L. July 20 ...	5010	......	......	......	4837
L. „ 23 ...	5009	4985	4961·5	4890·5	......
L. „ 25 ...	5009	4983·5	4959	4885	......
N. „ 25 ...	5007·5	4959·5	4912	......	......
B. „ 25 ...	5007	4971·5	4938·5	4841	......

Using, then, the equation

$$e = \frac{R+r}{r} \times \text{potential difference},$$

where e is the value of the E.M.F. required to produce the observed current, R is the internal and P the external resistance, values of e are deduced, from which are obtained the values for

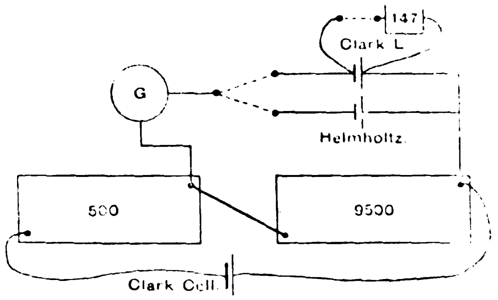

Fig. 1.

$E-e$, the E.M.F. of polarisation being $-(E-e)$. It will be observed that for a given cell the E.M.F. of polarisation is directly proportional to the current density.

Table II.

——	$E-e$ for 0·0014 ampere.	$E-e$ for 0·0028 ampere.	$E-e$ for 0·007 ampere.	$E-e$ for 0·01 ampere.
L.	......	......	.....	29
L.	4	8	21	......
L.	4	10	26	......
N.	18·5	36·5	.. ...	......
B.	4	7	17	... ..

The experiments to be described in this section show how the potential difference varies when the cell is allowed to produce a current for some time. For these experiments the standard of refer-

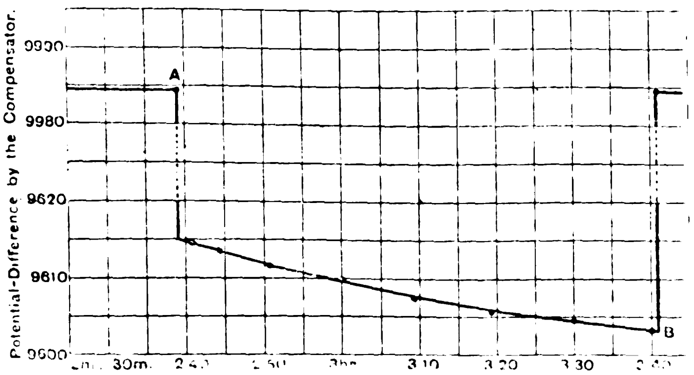

Fig. 2.—January 16, 1893. Temperature 12°.—At A, the Clark cell L was short-circuited by 147 ohms. At B, the circuit was broken.

$$\text{Unit of E.M.F.} = \frac{\text{Clark}}{10{,}000}.$$

ence was a set of Helmholtz cells described in the Paper quoted above; they were immersed in a tank of paraffin oil. On January 17th they were submitted to a very rigorous test for constancy, extending over four hours, a Clark cell being the standard. It is not necessary to say anything further about them.

The arrangement used in the experiments is illustrated in the accompanying diagram (Fig. 1), which clearly explains itself.

A set of observations is given in the accompanying diagram (Fig. 2).

The four experiments made gave an average fall of seven units in the hour, and from the table we have the polarisation on immediately making contact equal to 29 units $\left(\frac{\text{Clark}}{5{,}000}\right)$, or 58 of our present units. The polarisation, or $-(E-e)$, for a current density of $\frac{0 \cdot 01 \text{ ampere}}{100 \text{cm.}^2}$ for cell L may at any time be expressed approximately by $-(58+7t)$, where t is the time in hours, and the unit of E.M.F. is $\frac{\text{Clark}}{10{,}000}$. Expressed in volts this is—$(0 \cdot 00854 + 0 \cdot 001\,t)$. It is deduced from experiments on cell L, and only indicates the general order of magnitude of the effect with the other cells.

Conclusion.

Throughout the calculations it has been assumed that the total E.M.F. round the circuit is equal to that of the cell at rest; and therefore that the E.M.F. overcoming polarisation can be obtained by subtracting from the E.M.F. of the cells at rest the observed current. With the exception of small Peltier effects, I know of nothing against this assumption.

The results of the experiments are:—

(*a*) The E.M.F. of polarisation varies directly with the current-density in a particular cell.

(*b*) The E.M.F. of polarisation slowly increases when the current is maintained.

From the magnitudes of the quantities found in these experiments, it follows that small currents of approximately known value can be obtained by the use of large Clark cells of small internal resistance, which may be neglected in comparison with the large external resistance. The experiments show that the large cell L when producing 0·01 ampere was not at all disturbed. This corresponds to a current density $\frac{0 \cdot 01 \text{ ampere}}{95 \text{ (centim.)}^2}$. Now in a Board of Trade pattern Clark cell there is generally an exposed area of zinc equal to 2 (centim.)^2, and as the current taken is never greater than $\frac{1 \cdot 43}{10{,}000}$, a 10,000 ohm coil being used in series with it, it follows that the current density with this value of current is very much below that which has been found to be safe in these experiments.

In the experiments of Threlfall the sign of the term depending on time was found to be negative. In some of my earlier experiments it appeared to be negative; but this was traced to irregularity in the working of the compensator, and the effect has always been positive since the Clark cells have been used in the place of Leclanché.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

NEW BOOKS AND EDITIONS.

The 1894 Edition of "The Electrician" Electrical Trades' Directory and Handbook contains 1,000 closely-printed pages, and several new and useful features have been added. The price of the Directory and Handbook, from October 1st, is 5s. post free; abroad 5s. 6d. *The 1895 edition is in active preparation.*

"Electric Motive Power."—A new work, by Mr. Albion T. Snell, with this title, will be ready in October. It will contain the latest information respecting the application of electric energy to mining purposes, in which the author has had much experience. The book is well printed, on good paper, and will contain nearly 250 illustrations, a large proportion of which have been specially made for the book. The price is 10s. 6d., post free 11s. (abroad 11s. 6d.). Orders can now be sent in.

"The Work of Hertz."—The lecture delivered by Dr. O. J. Lodge at the Royal Institution on June 1st is reprinted with corrections and additions, and many original illustrations, price 2s. 6d. net.

"Electric Lamps and Electric Lighting," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., will be ready early in October, handsomely bound, full of original illustrations, designs, initials, &c. Price 7s. 6d., post free.

"Electrical Engineering Formulæ," a pocket-book by W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. (abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application to the Publisher.

"Electromagnetic Theory," by Oliver Heaviside, is now ready, price 12s. 6d. (abroad 13s.). Prospectus on application.

"The Incandescent Lamp and its Manufacture."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application to the Publisher.

"Drum Armatures and Commutators."—This book, written by Mr. F. Marten Weymouth, is also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

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TENDERS INVITED.—The Directors of the Lancashire and Yorkshire Railway invite tenders for the supply of the Company's ordinary requirements of various articles during the twelve months ending October 31, 1895. The list is set out in our advertisement columns, and further particulars and forms of tender can be obtained at the Stores Department, Osborne-street, Manchester, where samples can also be seen. Tenders have to be in by 10 a.m. on October 8th.

——— Mr. John Annan, manager for the liquidator in J. W. Hobbs and Co. (Limited), invites tenders for the supply and erection of boiler house plant, engine house plant, switchboard, instruments, &c., for the electric light and power installation at the large block of hotel buildings now erecting on the Salisbury Estate, Victoria Embankment, and Strand, London, W.C. Plans and specification, &c., can be obtained of Mr. R. Hammond, consulting engineer, Ormonde House, Great Trinity-lane, E.C., on and after October 5th; and tenders must be sent in before Friday, October 26th. Further particulars are given in our advertisement columns.

——— Persons willing to tender for supplying, fixing, and maintaining fire calls and telephones for the Stroud Volunteer and Local Board Fire Brigades should send tenders by October 2nd to the clerk to the Stroud Local Board

TENDERS ACCEPTED.—The contract for the cables for the extension of the electric light by the Glasgow Corporation, amounting to about £4,000, has been secured by W. T. Henley's Telegraph Works Company (Limited).

——— The Cardiff Corporation have accepted the tender of Messrs. Fergusson and Co., Cardiff, for wiring the Town Hall and Market-place, at a cost of £523. 10s.

SALE BY AUCTION.—Messrs. E. and H. Lumley announce the sale by auction, at the Mart, Tokenhouse-yard, London, E.C., of the lease of valuable premises in Hanover-square, London, W., between Regent-street and Bond-street, specially suitable for a business requiring spacious show rooms, with workshops and other accommodation attached. Further particulars are given in our advertisement columns. The sale will take place on Tuesday next, October 2nd, at 2 o'clock.

APPOINTMENTS.—Our note of last week respecting Mr. J. B. Mitchell should have stated that he had been appointed electrical engineer to the Dewsbury Corporation.

DISSOLUTIONS OF PARTNERSHIP.—The partnership existing between H. Coltman and Sons, of Loughborough, mechanical engineers, boilermakers, &c., has been dissolved, Mr. H. Coltman retiring.

——— The Mossley Rubber Company, Mossley, Chester, india rubber manufacturers, has been dissolved. Debts will be paid by Mr. E. Davis, who continues the business.

PERSONAL.—Mr. S. A. Edwards, metal merchant and agent, of 30, Easy-row, Birmingham, has taken into partnership Mr. W. H. Hatton, of Victoria-buildings, Birmingham, and the firm will in future trade under the name of S. A. Edwards and Co.

AMALGAMATION.—The Swiss Metallurgical Company and the Company for the Manufacture of Aluminium have been amalgamated, with, it is stated, a capital of 11,000,000 francs.

BANKRUPTCY.—Mr. Henry W. Figg, of 37, Upper Thames-street, has been appointed trustee of the estate of Messrs. Young and Buss (see *The Electrician*, September 14th). At the first meeting of creditors, last week, the liabilities were estimated at from £5,000 to £6,000, and the assets at about £4,900.

BANKRUPTCY STATISTICS.—The eleventh annual report of the working of the Bankruptcy Act, 1883, is just issued. The receipts for the past year amount to £153,420, and the expenditure to £167,019. The receipts include £72,159 for stamps and £60,750 for fees. The expenditure shows an increase over the previous year; but there is still a net surplus, for the ten years during which the Act has been in operation, of £145,471. It is pointed out that a saving has been effected to the exchequer during this period of £25,000 as compared with the previously existing system, and this result has been obtained concurrently with the reduction in the number and amount of insolvencies and in the cost and duration of the bankruptcy proceedings, an increase in the proportion of assets distributed amongst creditors, and a much stricter enforcement of the penal provisions of bankruptcy law. Additional security against fraudulent bankruptcy is given under the present law by the public investigation into the conduct of the debtor and the causes of his failure. The average cost of administration of estates by official receivers under the present Act during the past three years was 21·01 per cent. of the gross assets, as compared with 43·95 per cent. in the case of similar failures where the estates were administered by non-official trustees under the Act of 1869. It is remarked that such a large reduction in the cost of bankruptcy administration is an undoubted public advantage. During the year under review failures representing £7,492,367 were chronicled, the assets reaching £2,818,448, and an estimated loss to creditors of £5,588,936. This is a decrease in the estimated loss in comparison with the previous year of £1,102,705. In addition there was, under the Deeds of Arrangement Act of 1887, an estimated loss to creditors of £5,280,165, which shows a substantial advance on the figures of the previous years.

LESLIE v. ROGERS.—In the City of London Court, Mr. William Hicks, solicitor, appeared for the plaintiff, the Receiver of Woodhouse and Rawson (Limited), Queen Victoria-street, who sought to recover the sum of £12. 18s. 6d. for goods supplied to the defendants, Messrs. Arthur and J. W. Rogers, trading as the Mechanical Engineering Company, of Saffron-hill, London. The defendants disputed some of the items of the account, because some of the goods were ordered by their manager for himself. In the end the Court found for the plaintiff for the sum of £9. 12s. 8d.

TRADE MARKS IN GERMANY.—In reference to a note which appeared in our issue of the 15th inst., the Secretary of the London Chamber of Commerce points out that the provisions of the law respecting the protection of trade marks (November, 1874) will continue to apply to marks entered in pursuance of that law in the register of marks until October 1, 1898. The protection afforded to merchandise marks under this older law expires simultaneously with the entry in the new register, which comes into force next month, or, failing this, with the term ending on October 1, 1898.

MESSRS. CHARLES CHURCHILL AND CO.—This firm have been appointed agents for Great Britain of the Brown and Sharpe Manufacturing Company, of Providence, Rhode Island, U.S.A.

"WEBBER" APEX CONNECTOR.—We are informed by Major-Gen. Webber that the ordinary means of using a plug attached to the wire and inserting it in the socket affixed to this apparatus was discarded by him some two or three years ago, and the obvious alternative of reversing the ordinary arrangement so that no "live ends" should be exposed to accidental short-circuiting, was registered by him in January, 1893. He has adapted such a socket and connection to the apex of a conical lamp shade for a table standard. The standard and base need not be fitted with lamp holder or wires; all the electric part of the fitting is attached to the shade.

EPSTEIN ACCUMULATORS.—In reference to the statement made in our Trade Notes last week, referring to the manufacture of Epstein accumulators by a leading firm of electrical engineers, under the supervision of the Epstein Company, we are requested to state that this is inaccurate. The Epstein batteries are being made exclusively by the Company at their own works at West Kensington.

OIL ENGINES.—We have received circular particulars of the Imperial oil engine made by the Imperial Gas and Oil Engine Company. The circular gives particulars of horizontal, portable, and marine engines made on this principle, for which the advantages of simplicity and economy are claimed.

STEAM TRAPS.—Messrs. Alex. Turnbull and Co., of Glasgow, send illustrated particulars of their patent suspension and compression spring balance steam traps, as well as of the multiple expansion steam trap made by them, for which many advantages are claimed. These traps are direct acting, and are of simple construction. They are made without cranks, levers, balls, sliding sleeve, or shutting valves. The spring of the float vessel is made of special metal, which is practically non-corrosive. The multiple expansion steam trap consists of a series of rods connected by plates and suspended loosely by a regulating screw, so that the valve which is formed on the bottom end of the centre rod is just touching the seat when there is very little water in the trap. Messrs. Turnbull are bringing out a stop and junction valve, for which it is claimed that several new and prominent features are introduced, making the valve suitable for all pressures.

THE OBACH DRY BATTERY.—Messrs. Siemens Bros. and Co. are introducing a new dry cell, the invention of Dr. Obach, and it is claimed that this has a higher electrical output than any other dry cell in the market, that it is free from local action and consequently, remains practically unchanged when not in use. The brass terminal is fixed to the carbon electrode in a novel way, whereby corrosion is prevented. The cells are manufactured in four standard sizes, distinguished by the letters A, B, C, and D. Each cell is so designed that a maximum output is obtained with a minimum weight. The large size A is recommended in all cases where a large output or a high rate of discharge is required; for instance, for occasional use with small glow lamps, galvano-cautery, induction coils, &c., as well as for ordinary telegraph work, and specially for cable work. Size B (medium) is for working bells, open-circuit telegraphs, or telephones, portable glow lamps, hotel indicators, railway signalling apparatus, &c.; size C (small) for testing, electro-medical work, &c.; and size D (extra small) for portable testing batteries, and electro-medical purposes. The E.M.F. of the cell is 1·5 volts. Tests given in a pamphlet issued by the makers show that the E.M.F. of some B size cells, stored on open circuit during 10 months, and tested at regular intervals, only amounted to about 4 per cent., thus showing no appreciable local action, and that the cells maintain their initial E.M.F. even during long storage. Even after ten months' storage the internal resistance was found to be only 0·26 ohm, *i.e.*, very slightly higher than at first, and the very small loss principally

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takes place at the beginning of the storage. Tests are also given of the cells when closed continuously through an external resistance of 10 ohms, until the potential difference had dropped to about half its initial value, and also the subsequent recovery of E.M.F. on open circuit. The figures show that even with such a high rate of discharge the cells last a considerable time. Among other tables given is one showing the results of some practical tests of a battery of 10 cells, size B, connected in series and working a telegraph line with Morse recording instruments, connecting Messrs. Siemens' London office with their works at Woolwich. After 14 months' use, the cells working from 10 to 6 daily, the E.M.F. had decreased but very little, and the internal resistance remained practically the same as at first. The E.M.F. diminished slightly during the first six months, but remained perfectly constant after that time for at least eight months.

Messrs. W. H. Allen and Co.—This firm have completed their new works at Bedford, which are now in working order. The works are built on a site adjoining the main line station, and are therefore very convenient, being only one hour's journey from St. Pancras, London.

Lubricators.—Messrs. W. H. Willcox and Co. have recently brought out a new safety automatic double-feed crank pin lubricator. This is absolutely new, and Messrs. Willcox are the sole makers.

Gas for Domestic Purposes.—Complaint is made by the leading firms of ironmongers of the action of the gas companies in supplying and fixing stoves, chandeliers, and other domestic appliances at a price which practically creates a monopoly for the gas companies in these articles. The result of the action of the gas companies is that many of the leading ironmongery firms find their large stocks thrown on their hands without probable purchasers. It is pointed out that the companies fix and let out on hire a vast number of cooking stoves at considerably less than cost price, making up for any loss incurred by a largely increased consumption of gas at the present heavy price of 3s. 1d. per 1,000ft. It is stated that the number of gas stoves for cooking purposes hired out by the London companies reaches 100,000.

Catalogues.—The Acme and Immisch Electric Works have just issued a new catalogue and price list of Ayrton and Perry's direct-reading ammeters, voltmeters, &c., and of patent cam lock, quick-break lock, and other switches, main and branch distributing switch-boards, the Cockburn reliable fuse, and other apparatus manufactured by the Company. The catalogue is issued in sheet form for handy reference.

Electro-Harmonic Society.—The first smoking concert of the season will be held this (Friday) evening, at the St. James's Hall Restaurant, at 8 o'clock.

Aberdare.—Steps are being taken to form a local company for the purpose of utilising the Provisional Order which has been obtained for the electric lighting of Aberdare, and a deputation has just visited the Pontypool electric lighting station, where the system in use was inspected.

Aberystwyth.—The long-expected testing of the electrical plant took place last week, and everything was found satisfactory. It is understood that the current will shortly be turned on to the lamps on the Esplanade.

Acton.—The Works Committee reported to the last meeting of the Local Board that they had had under consideration two letters from electrical engineering firms with reference to the proposed sale of the Board's Electric Lighting Order, but had not yet come to a decision.

Bacup.—The Bacup Liberal Club is to be lighted and ventilated by electricity at an estimated total cost of £350.

Ballaarat (Victoria).—The Ballaarat Electric Supply Company (Limited), which holds concessions from the City Council, is about to start operations and to erect a plant of the value of £40,000 for the supply of electricity for public and private purposes. The Railway Department has already arranged with them for the supply of current for lighting the Ballaarat station and yards. Prof. Threlfall, of Sydney, and Mr. Ellson, of Adelaide, have been appointed joint consulting engineers for the scheme.

Basingstoke.—The Borough Surveyor has issued a circular to the inhabitants stating that the Town Council have under their consideration the advisability of adopting the electric light, and, as a preliminary, are desirous of ascertaining to what extent private consumers are likely to avail themselves of it.

Battersea.—The Special Committee appointed by the Vestry to consider the question of installing the electric light in the parish have prepared their report. They are strongly of opinion that it would be inadvisable to allow the powers of the Vestry to pass into the hands of a company, and, although they are not at present prepared to recommend the Vestry to take immediate steps to obtain a Provisional Order, they suggest that the matter should stand over with the understanding that the Order be applied for eventually.

Brechin.—Mr. Robert Duke, of D. and R. Duke, Denburn Works, Brechin, has offered to supply current from the firm's works to light St. Ninian's-square, the improvements to which are nearly completed. The Town Authorities are to bear the cost of erecting lamps, &c., for the installation. Mr. Duke's offer has been accepted.

Cambridge.—During the vacation, considerable additions have been made to the supply of current for house, shop and church, but chiefly college, lighting. Ten colleges are connected, and consume large amounts of energy, whilst in Caius and Sidney the light has been installed throughout in place of gas, including courts, staircases, and men's rooms. The New Sidgwick Hall of the ladies' college at Newnham, is wired throughout, and current will be available by the beginning of term. Holy Trinity Church has adopted the light, and the demand for private house lighting is largely on the increase, a mile of main being laid in the growing residential district of Newnham. Messrs. Baily, Grundy and Barrett (Limited), of Cambridge, have been busy with wiring contracts. Owing to the contract with the gas company, which has still some time to run, street lighting beyond a limited amount is in abeyance. To meet the increased demand, a new Parsons steam turbine alternator is being fixed for the winter months.

Cardiff.—At a special meeting of the Corporation on Monday it was stated, in answer to a question, that the electric lighting station would be opened in a week or two.——The Lighting and Electrical Committee of the Corporation have issued a pamphlet containing some particulars for the guidance of intending users of the electric light. The pamphlet gives estimates of probable cost in accordance with the number of lamps required, and briefly describes the advantages of the electric light over other methods of illumination.

Carriage Lighting.—In further reference to the new carriage which has been built for the German Emperor, this is provided with electric lamps, which, it is stated, each contain small accumulators. One is placed on the breast of each horse, another on the point of the pole of the carriage, and others at the sides and rear of the vehicle. By this means the glare is kept from the horses' eyes, and the route of the vehicle is brilliantly illuminated for a distance of about 40 paces.

"Cassell's Popular Educator."—Part I. of the new issue of this well-known publication is just out. Each part is to be copiously illustrated, and the work, when complete, is to contain a number of maps and plates printed in colours.

Castleford (Yorks.).—The Local Board have decided to leave the question of the electric lighting of the town for consideration by the new District Council.

Commission of Sewers (London).—The Commissioners have referred to the Streets Committee the letter from the Post Office authorities, together with the return made by the Postmaster-General to the House of Commons, containing drafts of the proposed new agreements between the Post Office and the National Telephone Company and the "New" Telephone Company.

Country House Lighting.—Messrs. Drake and Gorham have received instructions to instal the electric light in Mr. R. Clifford-Smith's house at Ashford Hall, near Derby. A dynamo of the latest pattern, driven off a water turbine, will charge a battery of 53 D.P. cells. The firm's spring contact main switches will be adopted, as well as a Nevile patent accumulator switch.

Coventry.—The current for the electric lighting of the Technical Institute is, for the present, to be supplied by the Coventry Gas Fittings Company, pending the completion of the Corporation's supply station.

Cowper Street School (London, E.C.).—A series of commercial classes are about to be held in connection with the Old Boys' Club of this school, in which the subject of electricity is to be dealt with by Mr. F. Wyndham Smith. Connected with these classes there is also one for rough sketching for business purposes. Mr. F. R. Taylor, the honorary secretary at the schools, will supply all further information.

Douglas and Laxey Electric Railway.—Mr. R. C. Brebner, contractor for the permanent way of this line, writes to say that, while the trade journals have given credit to the contractors for the engineering portion of the scheme, no reference has been made to those responsible for the permanent way work. The Groudle and Laxey section of five miles, with a masonry viaduct of over 70ft. in height, has been constructed throughout in seven months as a double line, although tenders were originally taken for a single line only. This work has been accomplished by Mr. Brebner's staff and sub-contractors by working double shifts on several sections of the work without any extra charge to the railway company, and for this it is claimed considerable credit is due to those who have done the work.

Dundee.—At a meeting of the Finance Committee of the Dundee Gas Commission on Monday a very satisfactory statement was submitted regarding the income for the past six months for the supply

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of electric light. It had been estimated that there would be an increased receipt for the whole year of £671; but should the receipts for the second half-year increase at the same rate as in the January-June period that estimate will be considerably exceeded.

ELECTRICAL ENGINEERING IN GERMANY.—It is reported that Messrs. Ludwig Loewe and Co., engineers, Berlin, and the Union Electricitäts-Gesellschaft of the same city, together with a group of bankers, are forming a large new company to carry on an electrical engineering business. The Allgemeine Electricitäts-Gesellschaft of Berlin has, it is stated, acquired land at Wilhelminenhof, on which to establish a large accumulator factory.

THE ELECTRICAL TREATMENT OF MINE TAILINGS.—The South African correspondent of the *Financial News* states that the cost of treating tailings by the new Siemens-Halske electrical process of the Rand Central Ore Reduction Company is stated at 3s. per ton, including 10d. for filling and discharging the vats and 6d. for cyanide consumed. This cost has been tested by actual working for four months, and with a cyanide plant of 6,000 tons to 8,000 tons capacity it is hoped that the treatment can be carried out for 2s. 6d. per ton. The Rand Central Ore Reduction Company, the agents for Messrs. Siemens and Halske, of Berlin, are said to be desirous of a very small royalty—say, 3 per cent.

ELECTRICITY IN MINING.—At the meeting of the Glencairn Gold Mining Company, at Johannesburg last month, the Chairman informed the shareholders that the Directors had increased the electrical plant, and were now pumping from the lower levels to some extent by electric power. This plant, which was now in full working order, was giving every satisfaction.——The General Manager of the Transvaal Gold Exploration and Land Company, for which an electric mining plant has been sent out to South Africa, reports that the foundations for the generator are completed, and that work has been begun on the turbine and generator buildings.

EXPORTS OF TELEGRAPH WIRE AND APPARATUS.—There was a big drop in the exports of telegraphic wire and apparatus from this country during August last, both as compared with the preceding month and the corresponding period of last year. From £303,483 in July the exports last month fell to only £67,550, which is a decrease of no less than £109,309 on the exports of August, 1893. It is a little more satisfactory to turn to the figures, as given below, relating to the exports during the first eight months of the year, as compared with the corresponding periods of the past two years: First eight months of 1894, £1,254,774; 1893, £733,359; 1892, £731,496.

FERMOY.—At the last meeting of the Town Commissioners the clerk read communications received from the Town Clerks of Bray, Carlow, and Kilkenny *re* the cost of electric lighting in those towns, which is supplied by private companies. After some discussion, the clerk was instructed to ask the engineers of the Kilkenny and Bray Electric Light Companies on what terms they would come to Fermoy to confer with the Commissioners, and to prepare an estimate of cost.

FLEETWOOD.—The Fleetwood Commissioners have instructed their clerk to apply to the Board of Trade for an extension of time in which to carry out their Provisional Order. The Commissioners held that this course had been rendered necessary by the neglect of the Board of Trade in not appointing an inspector to hold an inquiry.

FULHAM.—At their last meeting the Vestry decided to adopt the Electric Lighting Acts, and to provide all the necessry plant for street lighting and the supply of current to private persons.

GEELONG (VICTORIA).—The Town Council have appointed Mr. Ellson, of Adelaide, consulting engineer for their light works, which are estimated to cost £16,000.

HOTEL EXPENSES.—Mr. Oswald R. Swete, electrical engineer, was sued at the Worcester County Court by the proprietress of the Feathers Hotel, Ledbury, for the sum of £18. 0s. 5d., the amount of an hotel bill. Defendant admitted the money was owing, but contended that the debt was incurred while he was acting as engineer to the New British Electrical Installation Contractors (Limited), and that that Company were liable for the amount. They were accordingly made a third party to the action. The husband of the plaintiff said that he interested himself in the idea of an electric lighting installation for Ledbury, and called with Mr. Swete upon the principal tradespeople, with a view of forwarding the scheme. Mr. Swete was subsequently engaged in fitting up an installation about a mile from the town. In accordance with his instructions the hotel bill had been sent in to the Company, and the witness stated that although the bill had been several times discussed, on no occasion had the Company repudiated liability; in fact, a portion of the original bill of £21 2s. 5d. had been paid by the Company, this being a charge for posting. Mr. Swete stated that the expenses were incurred in transacting the business of the Company; but whether the Company had benefited by the expenditure he could not tell. He considered the Company had acted very harshly towards him in refusing to pay the bill; but this was repudiated by the Company's counsel, on the ground that Mr. Swete had no authority to incur such charges, or to "do the thing handsomely," as was suggested. In the end the jury found for plaintiff for £17. 18s. 5d., judgment being given against the Company for this amount.

HUDDERSFIELD.—The Town Council have adopted the recommendation of the Rates and Rents Sub-committee that, while no reduction should be made in the charge for the supply of the electric current, discounts, varying from 2½ to 10 per cent., according to the number of units taken, should be allowed. For motive power and domestic purposes other than lighting the current will be supplied at the rate of 4d. per unit.

HULL.—The reduction in the charge for the electric current which has been decided upon by the Corporation will take effect from the beginning of October.——The Hull General Post Office is to be installed for the electric light, the order for the work having been placed in the hands of Mr. G. B. Blanchard.

JOHANNESBURG.—The citizens of Johannesburg are agitating for the Sanitary Board to take over the business of the Johannesburg Lighting Company.

KIDDERMINSTER.—At the last meeting of the Town Council an inquiry was made as to whether the question of electric lighting had been dropped. Between £300 and £400 had been spent on preliminary inquiries, and anxiety was expressed as to whether that was to be wasted. In the absence of the Mayor, who is Chairman of the Law Committee which has the matter in hand, no answer could be given.

KILLARNEY.—At the monthly meeting of the Board of Governors of the Killarney District Lunatic Asylum, on Thursday last week, a report was read from Mr. Walter Leake, who had been instructed by the Board to examine the recent alterations and additions to the Killarney Electric Light Company's station. Mr. Leake reported that a "Giant" turbine of 64 H.P had been added, and arrangements made for the putting down of a second turbine. He was further of opinion that the Electric Light Company were now in a position to supply the asylum with electric current for lighting purposes. He recommends that the contract for lighting the asylum should be for fifteen years, with power to determine in periods of five years, and that the asylum should have the first claim on the output of the Company's station. It was proposed that Mr. Leake's report be printed and circulated, and that its further consideration be deferred until the next Board day; but an amendment that the Killarney Electric Light Company's tender be accepted, that the Board of Control be requested to ratify such acceptance, and that the necessary funds for the electric lighting installation be applied for, was carried by a majority of 1. A protest was handed in by the mover of the original resolution on the ground that no notice had been given of the intention to move an amendment, and notice was given for the next meeting of the Board of a motion to rescind the resolution now carried.

LUTON.—The Town Council last week unanimously resolved to instruct the Highways and Lighting Committee to consider and report upon the advisability of the Corporation applying for a Provisional Order.

LYMINGTON (HANTS.)—At the last meeting of the Town Council Admiral Earle asked if the Public Lighting Committee had ever considered the advisability of having the town lighted by electricity. Many towns smaller than Lymington had the electric light, and it had been found to effect a saving for the ratepayers. The Chairman of the Committee (Dr. Hill) stated that the electric light question had seriously occupied his thoughts, but when the subject was once brought before the Council he understood that it was definitely decided not to substitute electricity for gas.

MAILS TO THE EAST AND FAR EAST.—Mr. T. Carew Martin, of the *Pioneer* of India, writes that an important concession has just been granted by the Post Office in respect to the outgoing Indian mails, which also affects the mails to Egypt, Ceylon, the Straits Settlements, China, Japan, Australia, and New Zealand. At present the latest hour at which a letter for India or the East can be posted on Fridays at Charing-cross Post Office is 7 p.m., at St. Martin's-le-Grand 7:30. From October 5th letters with an extra late mail fee will be received at Charing-cross Station, London, up till 8:10 p.m.

NEWCASTLE.—The *Newcastle Leader* states that the opinions of high legal authorities obtained by the Newcastle and Gateshead Gas Company were submitted at a recent meeting of the City Lighting Committee. Under these opinions it is affirmed that the Company are entitled to charge the town for all the lamps in the streets extinguished by the electric light. The Corporation of to-day are further bound, apparently to the end of time, to pay 1s. a week for each lamp lighted. Councillor Goolden, the present

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sheriff, took action in this matter some time ago, showing that the city had to pay the same price now, when the net cost of gas to consumers is 1s. 8d. per 1,000 cubic feet, as when the charge was over 4s. But it is in the original bond, and it is probable that the "pound of flesh" will be exacted.

NEWPORT (MON.)—The question of adopting the electric light for the Free Library has been referred by the Corporation General Committee to a sub-committee. It is estimated that the total annual cost will be about £100.

THE "PATENT SOLICITOR."—A summons has been taken out at the City of London Court by the Incorporated Law Society against Mr. Charles S. Hulser for unlawfully acting as a solicitor. The defendant pleaded that he did not know he was doing wrong, as he was only acting as a "patent solicitor." The defendant promised not to use the word again, and agreed to destroy the printed matter bearing the offending word. The case was adjourned for a week to allow this to be done.

POPLAR (LONDON, E.).—The District Board of Works are sending round a circular to the inhabitants, asking if they would take electric current if it were supplied by the Board at 6d. per unit for lighting and 4d. per unit for power purposes.

RAVENSTHORPE (YORKS.).—The electric light has been installed in the stores of the Ravensthorpe Self-Help Co-operative Society. The plant comprises 10 arc lamps of 2,000 c.p. each, and 8 of 1,000 c.p. each, and 7 32-c.p., 90 16-c.p. and 1 8-c.p. incandescents, or a total of 116 lights, representing 29,672 c.p. The current is supplied by a 300-light Kapp dynamo, driven by a 12-H.P. gas engine. The whole of the installation has been put in by Messrs. Ullathorne and Hartley.

RUSSIAN EXHIBITION.—The Russian Government warns merchants and manufacturers that the forthcoming exhibition at Nijni Novgorod is confined solely to Russian products. Persons professing to be agents for space at the exhibition should therefore be distrusted.

SIEMENS-HALSKE PROCESS.—It is stated that the May Consolidated Mining Company has decided to use the Siemens-Halske process in connection with their new cyanide works now constructing.

ST. AUSTELL.—An Indian bazaar is being held at St. Austell in aid of the building fund of the new premises of the local Young Men's Christian Association, and a very attractive adjunct has been provided by Messrs. Veale and Company (Limited), who, in a "Palace of Electra," have an interesting exhibition of electrical apparatus of all kinds.

STIRLING.—A special meeting of the Police Commissioners was held on Monday, when it was decided to apply forthwith for a Provisional Order.

SWANSEA.—The Electric Lighting Committee of the Town Council are engaged in taking preliminary steps towards obtaining a Provisional Order.

THE TELEPHONE AT THE LAW COURTS.—It is stated by the London correspondent of the *Edinburgh Evening News* that the Lord Chief Justice has given permission for an experiment to be tried at the Royal Courts of Justice (London) in the use of the telephone, for the purpose of enabling solicitors and others interested in cases being tried in the courts to listen to what is going on. The experiment is at present being made in the Lord Chief Justice's own court, where, during the recess, a receiver has been placed close to the bench, a second at the desk of the clerk of the court, and a third at the counsels' desk. If the experiment should prove successful, it is stated that the telephone will shortly be introduced into the other courts.

WALTHAMSTOW.—A special meeting of the Local Board has been convened for the purpose of considering the desirability of applying for a Provisional Order.

WANDSWORTH (LONDON, S.W.).—At the meeting of the Wandsworth District Board of Works last week, in reference to notices from the County of London and Brush Provincial Electric Lighting Company (Limited) of their intention to lay mains and construct transformer chambers in roads throughout the district, it was unanimously resolved that the Board disapprove of the proposed works and plans, and that the Company be informed that the Board object to the construction of the transformer chambers in the public way, and to the unnecessary number of crossings proposed.

WELLINGTON (N.Z.)—Considerable dissatisfaction was expressed in the Town Council recently at the unsatisfactory state of the electric lighting arrangements. With the water power and appliances at hand, Wellington, it is said, should be the best lighted city in New Zealand, instead of which it was the worst. A meeting is to be called of the Electric Light Committee, who will go thoroughly into the matter.

WORKS LIGHTING.—Messrs. J. H. Holmes and Co. are putting down a large electric lighting installation at the works of Messrs. George Clarke (Limited), of Sunderland. Forty-five arc lamps, each of 2,000 c.p., will be installed, the current being supplied by two large "Castle" dynamos driven by Crossley gas engines.

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by **MR. J. C. CHAPMAN**, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

September 5, 1894.

16,918. A. FOX. London. Improvements in access and junction boxes for electric conductors.

September 6, 1894.

17,000. J. W. ROGERS. London. Improvements in electric arc lamps.

September 7, 1894.

17,047. E. TYER. London. An improvement in electrical lock and block apparatus for railway points and signals.

17,065. S. Z. DE FERRANTI. Liverpool. Improvements in, or relating to, electric cables, wires, or conductors for conveying electricity to vehicles or travelling motors.

17,066. S. Z. DE FERRANTI. Liverpool. Improvements in electric cables.

17,077. W. P. DANDO and J. E. A. GWYNNE. London. Improvements in lenses and electric arc lamps, more especially intended for use for theatrical stage purposes.

17,129. P. STOTZ and F. W. SCHINDLER-JENNY. London. Improvements in electrically-heated soldering irons.

17,130. P. STOTZ and F. W. SCHINDLER-JENNY. An improved apparatus for electrically heating liquids.

September 10, 1894.

17,178. J. P. WEST. London. An improved combined grain cleaner and magnetic separator.

17,180. R. H. JAHR. London. Improvements in electric arc lamps.

September 11, 1894.

17,235. G. L. F. PHILIPS. Holland. Improvements in electrical incandescent lamps.

17,281. W. J. STILL. London. An improved transmitter or transformer for electric currents.*

SPECIFICATIONS PUBLISHED.

NOTE.—All Specifications can now be obtained at the uniform price of 8d. each.

1893.

16,307. SWINBURNE. Electric meters.

17,025. SHARP. Electric glow lamps.

17,189. MUNRO and MCFARLANE. Electric switches.

19,688. RICHARDSON. Electrical decomposing apparatus.

19,791. HURTER and OTHERS. Electrolytic cells.

19,934. ABEL (Compagnie anonyme Continentale pour la Fabrication des Compteurs à gaz et autres Appareils). Electricity meter.

20,059. MITCHELL. Medico-electric bands and belts.

23,177. JOLLY (Richmond). Electric time switch, &c.

24,017. STOUTS. Obtaining and depositing metals by electrolysis, &c.

COMPANIES' MEETINGS AND REPORTS.

Direct Spanish Telegraph Company (Limited).

The forty-second ordinary general meeting of the Company was held at the offices, Winchester House, Old Broad-street, on the 21st inst., under the presidency of Mr. Edmund Etlinger.

The MANAGER (Mr. Charles Gerhardi) read the notice calling the meeting and the minutes of the previous meeting, which were approved by the present meeting and signed as correct by the Chairman. The report of the Directors was taken as read.

The CHAIRMAN: Our Chairman, Sir John Pender, is detained abroad, and I have been asked to preside at the meeting to-day. We will go through the report together, and I will make such observations on the different paragraphs as I consider necessary. The first paragraph states that the accounts for the half-year ended June 30th last show, after providing for debenture interest, a balance to the credit of profit and loss of £4,075. 15s. 10d. Last year, at the corresponding period, the balance was £4,645. 13s. 9d. There is, therefore, a decrease in the net receipts of £569. 17s. 11d. As long as trade is depressed—which, unfortunately, we have to hear at every meeting we attend—we cannot expect our traffics to be very high, but we must do the best we can as matters are. The actual decrease in the receipts is £851; but against that we have a saving in debenture interest of £284. 12s. 0d., and a saving in working expenses of £43. 4s. 1d., together £327. 16s. 1d., which leaves a decrease of £523. 3s. 11d. There is, however, a slight addition in extra expenses amounting to £64. 14s., so that our net decrease is, as I have already said, £569. 17s. 11d. The next paragraph deals with the traffic receipts only, and they show a decrease of £868. 12s. 9d. as compared with those of the corresponding period of 1893. There is, however, nothing to be done but to wait patiently until traffic revives; but I may say, with regard to this subject, that quite recently—this month—there has been a marked increase and things look better. Whether that is going to continue or not I do not know, but it looks as if trade has made a fresh start. This may possibly be a great deal owing to the settlement of the new tariff in America, because pending that a great deal of business was not proceeded with at all; but, so far as I am aware—and I have personal experience in the north

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of England—things are reviving, American trade is improving, and I know that at Bilbao the local traffic in ironstone is beginning to look up. I think, therefore, we may assume that a start has been made in the revival of trade, and if that really is so, we shall be benefited in common with everyone else. The next paragraph refers to the working expenses, which are practically the same as in the corresponding period of last year. They are really £43 less. With reference to this question, I may point out that it is impossible to reduce working expenses simply because your traffic falls off. If you did so you would come to a deadlock the moment traffic revived. The next paragraph refers to our cables, and the land lines connected with them, which have continued in good working order throughout the half-year. That is satisfactory, and requires no comment. Reference is made in the next paragraph to the construction of a new breakwater at Bilbao, which placed the Company under the necessity of moving the shore-end of the Falmouth-Bilbao Cable to a point outside the new breakwater further down the bay. The removal was effected without any appreciable interruption of communication, and the cost is chargeable to the harbour authorities of Bilbao. The harbour authorities found it necessary to construct a new breakwater at the mouth of the river, and that crossed the line of our former cable. We therefore had to take the cable up, and move it outside the new breakwater. The work necessitated the sending out of a ship, and also the construction of a mile and a-half of additional land lines. The cable work was done, with their usual skill and rapidity, by one of the steamers of the Eastern Telegraph Company, and the land lines were constructed by our superintendent, who is a very capable man. With respect to the outlay on this work, very little cost was incurred during the half-year to June 30th. The accounts had not been settled and they are not settled now, but the small amount we had paid up to that date is included in the balance-sheet under the heading of "Amounts due outstanding," because the authorities of Bilbao are chargeable with the whole of this outlay. The actual amount involved in the work we cannot tell yet, as the accounts are not prepared. The next paragraph deals with the debenture question, and we say: "The £62,000 Six per Cent. Debentures, which matured on May 1, 1894, have been paid off, and £30,000 new debentures have been issued, bearing interest at the rate of 4½ per cent. The difference of £32,000 was provided for by making the final call of £1 per share on the 12,931 Ordinary shares, and by taking £19,069 from the reserve fund."

When the time came for paying off the £62,000 of our old Six per Cent. Debentures there were various ways of carrying out this measure with our resources, and after a great deal of deliberation we came to the conclusion that the way mentioned in the report was the best all round. The effect on the Company by the change is as follows: The £62,000 of Six per Cent. Debentures absorbed annually £3,720 in interest. The £30,000 of new debentures, at 4½ per cent., will require only £1,350 per annum. Therefore there is an apparent saving of £2,370 annually. I say "an apparent saving," because, as we have taken from the reserve fund £19,069, we must allow the loss of interest on this sum, which, as it yielded 3⅓ per cent., amounted to £630. The net annual saving, however, is £1,740. Our idea is to create a fund to redeem the £30,000 of new debentures within twenty years, and for this purpose we ought to set aside £1,120 every year. Taking that from the £1,740 there would remain a net balance of £620, which is as nearly as possible equal to 1 per cent. on the whole of the Ordinary share capital of the Company paid up. On the whole, therefore, this operation is a profitable one for the Company. The position will be that if we have a normal traffic we shall be able to provide for the debenture interest, the debenture redemption, the interest on the Preference shares, and £5,000 a year for the reserve fund, and we shall then have 1 per cent. to add to whatever dividend we earn from the traffic only. I think you will consider that that is not a bad arrangement. The next paragraph deals with the appropriation of profit. After adding the usual sum of £2,500 to the Reserve Fund, the Balance of Profit and Loss amounts to £1,575. 15s. 10d. To this the Directors propose to add £951. 15s. 10d. from Interest and Profit on Investments, and recommend the payment of the dividend at the rate of 10 per cent. per annum on the Preference shares, and a dividend, free of Income Tax, of 1s. 8d. per share, being at the rate of 4 per cent. per annum on the capital paid up from the due date of payment, on the Ordinary shares of £5 each. We have never before paid a dividend of so much per share; it has always been so much per cent., but this year we had to act differently, as we had to pay a dividend on £4 per share for six months, and on £1 per share from the date the call was made to the end of June. That made it a complicated affair, and it could not be worked out at per cent. We therefore say so much per share, but it is the same as before, practically 4 per cent. I hope, however, that we shall go back again to the system of per cent., as it requires a little mental effort and possibly the use of a pencil and paper to work it out when a dividend is declared of shillings and pence per share. The reserve fund will now amount to £21,270. 19s. 11d. The last paragraph of the report is as follows:—

"As the attendence of Shareholders at the Autumn General Meetings is very small, and as the Articles of Association require only an Annual Meeting to be held, the Directors propose that in future only one General Meeting shall be held, viz.:—in the month of March, but intend to pay an Interim Dividend in October, if earned." You are all aware that the attendance at the autumn meeting is very small, and, as you know, the preparation of the accounts in your hands occupies a good deal of the time of the staff, besides which these meetings cost money—not any large amount, but still a sum which is worth saving. The Directors think it will be satisfactory to the shareholders if the meetings are held once a year, as contemplated by the Articles of Association. If anything extraordinary happened, we should, of course, have to call you together, but practically I should think that one general meeting a year will answer our purpose. I now propose—

"*That the report and accounts now presented be and are hereby received and adopted.*"

Mr. JOHN DENISON PENDER seconded the motion.

Mr. COCHRAN said he did not know whether he quite understood what was proposed by the Directors; but he gathered, from what the Chairman had stated, that they proposed to set aside, out of the profits, a sum of about £6,150 a year. It seemed to him that this was laying a rather heavy burden upon so small a Company, for what was proposed would take a large slice of the profits. Some of them had been shareholders for a long time in the Company, and had had experience of its bad and its better times. He had always been a hearty supporter of the Directors in making the Company a sound one, but he thought that the Board were now disposed to put rather a stiff screw on the shareholders. He congratulated the Directors on the result of the operation which had got rid of their Six per Cent. Debentures, replacing them by others bearing only four and a-half per cent., and wiping off nearly half of the debenture liability. Having done so much, however, and having now acquired the basis of a fairly respectable reserve fund, he thought that the Directors should deal with a somewhat lighter hand with the revenue of the Company. Unless under exceptional circumstances, he thought that they ought to be contented with the setting aside of £5,000 a year out of the revenue. The shareholders had received only a very moderate dividend for a commercial venture, and only on one-half of their capital. He thought the Directors ought to reconsider the matter before imposing the proposed additional burden on the net revenue of the Company.

The CHAIRMAN, in reply, said that the Directors fully sympathised with what Mr. Cochran had said. No one was more anxious to get an increased dividend than the Board, but they had to consider not only the question of what was advantageous to each individual shareholder, but what was best for the Company as a whole. The £5,000 a year which they placed to the reserve fund had always been regarded as a right and proper proceeding, and, in fact, if they had not made this provision, the shares would have been at a large discount instead of at par. A cable company without a large reserve fund was a thing without a foundation. As regarded the amount which they proposed to set aside for the redemption of the present debentures, what they were aiming at was to free the Company from all debt. If they could set aside a sum which would extinguish the whole of the indebtedness of the Company in 20 years, its position would be vastly strengthened, and although they might for some years, assuming that the traffic did not increase, receive only a reasonable dividend, still they would have in prospect a position of considerable prosperity. The great thing in a concern such as theirs was to have a backbone in the shape of a reserve fund, to do away with indebtedness and then to "pocket" the difference. They had well considered the matter, and he really did not think it would be wise to raise their dividend by not making provision for the redemption of the debentures. They had placed the amount of the debentures at a moderate sum, and they ought to make provision for redeeming them. When they had Six per Cent. Debentures out they made no provision, but they knew that when the time came they would be able to issue new debentures at a low rate, which 4½ per cent. was if the Bank rate went up to the same rate. The shareholders, who had for the most part taken the debentures, must regard the provision of a redemption fund as a protection of their interest. If the Bank rate went up to 5 per cent. they would not be able to replace the present debentures, and they would have to go back to Six per Cent. Debentures again. He thought that the Directors were acting only wisely in what they proposed to do in this matter. As an individual shareholder he would certainly like a larger dividend; but, as he had said, they had to look at what was best for the Company as a whole.

Mr. DYETT inquired at what rate the new debentures were issued, and if any were left.

The CHAIRMAN replied that they were issued at par, and they had all been taken up. The amount applied for was in excess of what they had to place. With the present Bank rate the interest of 4½ per cent. seemed large, but it would not appear so if the Bank rate went higher. It was a reasonable rate of interest, and anyone who held the debentures was justified in expecting that the Company would make provision for their redemption. He then put the resolution, which was carried unanimously. He afterwards proposed the payment of the dividend at the rate of 10 per cent. per annum, less income-tax, on the Preference shares, and of a dividend, free of income-tax, of 1s. 8d. per share, being at the rate of 4 per cent. per annum on the Capital paid up from the due date of payment, on the Ordinary shares of £5 each.

Mr. J. D. PENDER seconded the motion, which was carried unanimously.

Mr. COCHRAN then proposed a vote of thanks to the Chairman and Directors. He said he still thought that the Directors were laying rather a heavy burden on so small a Company, although if prosperity should set in and larger profits be made, the shareholders would not feel it so much as they otherwise would do. As to the prospect of any great increase in the Bank rate, he shared the view which was entertained generally by financial people, that the present position was likely to be very largely permanent. He thought that the security for the Company's Four and a-Half per Cent. Debentures was not a bad one, considering the rapid way in which the reserve fund was being built up. However, the Directors were entitled to their own view, and, after all, if there was any fault it was on the side of safety.

Mr. DYETT seconded the motion, which was carried unanimously.

The CHAIRMAN briefly acknowledged the vote, and the proceedings then terminated.

Edmundsons (Limited).

We have been favoured with the following report of the proceedings at the sixth annual meeting of the above Company, held at the offices, Great George-street, Westminster, S.W., on the 13th inst., Mr. J. W. Edmundson presiding:—

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"The report and statement of accounts were taken as read. In moving the adoption of the report, the CHAIRMAN congratulated the shareholders upon a satisfactory year's working. Although the profits for the past year were not so large as in several previous years, they were satisfactory when the great depression in trade and the large amount of competition were taken into account. The outlook for the present year was satisfactory, as they had a larger amount of work in progress than was the case at the same time last year, including, among other installations, the lighting of Warwick Castle, Duncombe Park, Elveden Hall, Copped Hall, Nidd Hall, Wood Hall, and the New Asylum for Sunderland. An important contract had also just been signed for lighting a portion of the town of Shrewsbury, provision being made in the first instance for 5,000 lights, and the Directors hoped that they might be able to extend the Company's operations in this class of work. The report and accounts were unanimously adopted, and a resolution passed directing the payment of a dividend at the rate of 6 per cent. per annum, on both Preference and Ordinary shares. Mr. Henry Wigham, the retiring Director, was re-elected, as were also the auditors, Messrs. May and Street."

Brush Electrical Engineering Company (Limited).

The following is the fifth annual report of the Directors of this Company, for the year ended June 30th last, to be presented to the shareholders at the general meeting to be held at Cannon-street Hotel, London, E.C., on Monday next, October 1st, at 3 o'clock :—

The profit and loss account shows a gross profit of £57,157. 19s. 4d. After deducting general charges, maintenance of buildings, plant and patents, interest on debenture stock, and sundry costs of removal, which the Directors consider should be written off the year's profit, there remains a net balance of profit amounting to £27,280. 12s. 1d., to which must be added the sum of £815. 5s. 3d., the balance brought forward from last account. After providing the full dividend on the Six per Cent. Preference shares for the year, and an interim dividend at the rate of 5 per cent. per annum, which has already been paid, on the Ordinary shares for the half-year ended December 31st, the Directors recommend that a further dividend, at the rate of 5 per cent. per annum, be paid on the Ordinary shares for the six months ended June 30th, leaving £3,788. 9s. to be carried forward.

During the year the sum of £3,710. 13s. 7d. has been expended on the purchase of additional plant and extensions at the Loughborough Works, where the whole of the regular home manufacturing work of the Company is now concentrated and carried on. The volume of business which the Company has been called on to undertake during the year, is again in excess of that in any previous period of its existence. The prevalent industrial depression has, however, brought with it increased competition and a general fall in prices, with consequent diminution in the rate of profits obtainable.

The Company's Vienna factory has yielded improved results during the past year, and shows a fair return upon the capital employed. Important central station contracts have been successfully carried out, and others are in course of execution. The glow lamp department has during the year largely increased its output, and is now manufacturing at the rate of half a million lamps per annum. The Australian branch of the business has laboured under great disadvantages, arising out of the financial crisis through which the Colonies have recently been passing ; under these circumstances the Directors are glad to be able to state that the bad debts incurred during the year amount to less than £50, and consider that great credit is due to the careful management with which the business has been conducted.

The works of the Company are at present fully employed, and the prospects for the coming year are satisfactory. The progressive change in the character of the industry from the lighter class of electrical engineering involved in numerous and isolated installations, to the heavier and more considerable works following upon the extension of electricity supply from central stations, is undoubtedly favourable to this Company. The contract with the City of London Electric Lighting Company for the supply and erection of generating plant and accessories for public and private lighting in the City of London has made satisfactory advance during the year. Contracts have also been entered into with the County of London and Brush Provincial Electric Lighting Company for the supply of plant and equipment of central station undertakings for the districts of St. Luke's, Wandsworth, and elsewhere.

Mr. Arthur Ayres, M.Inst. C.E., has accepted a position upon the Board, to fill the vacancy created by the death of the late Duke of Marlborough. Mr. A. H. Sanderson and Col. F. G Steuart retire by rotation, and, being eligible, offer themselves for re-election. The auditors, Messrs. Cooper Brothers and Co., also retire and offer themselves for re-election.

WESTINGHOUSE ELECTRIC COMPANY (LIMITED).—A meeting of the shareholders of this Company was recently held, at which the report of the Directors for the year ended September 30th last was presented. The Directors point out that the issue of the report and balance-sheet and the announcement of the annual meeting was delayed in consequence of pending negotiations between the English and American companies. There is a net profit for the period under review of £6,782, which, to the sum of £6,015 brought forward, leaves an amount of £13,015 to be dealt with. During the year 4,700 Shallenberger meters have been disposed of, as compared with 3,100 of the previous year, and the first eight months of the current year show a continued increase. Mr. Albert Kapetyn has been elected to a seat on the Board of Directors, vice Mr. J. D. Gibbs, who retires.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1894, pages 274-300, *&c., &c.*]

CAPSULE BATTERY COMPANY (LIMITED).—This Company was registered on September 25th, with a capital of £30,000 in £1 shares, to acquire patents and patent rights for galvanic batteries, electric call bells, and for or connected with brushes or other appliances for the curative application of electricity, to use electricity and every description of electric or electromagnetic appliance for purposes to which the same is applicable, and to carry on the business of electric, galvanic, and mechanical engineers, suppliers of electricity and galvanism, and manufacturers of and dealers in apparatus required for or capable of being used in connection with the generation, accumulation, supply, distribution, or employment of electricity or galvanism.

CARBON SYNDICATE (LIMITED).—This Company was registered on September 19th, with a capital of £100,000 in £1 shares, to carry on the business of manufacturers of and dealers in carbon plates, slabs, rings, crucibles, rollers, bars, rods, pipes, and other articles for electrical, electrolytical, or other purposes ; electricians, electrical and mechanical engineers, suppliers of electricity, manufacturers of and dealers in and agents for the sale of all apparatus used in connection with the generation, distribution, supply, accumulation, or employment of electricity, &c. The first Directors are Sir Coutts Lindsay, Bart., Charles P. Shrewsbury, John Cooper, and Frank L. Marshall.

TAYLOR, RIDER AND CO. (LIMITED).—This Company was registered on September 25th, with a capital of £2,500, in £1 shares, to acquire the businesses carried on by "Taylor and Rider," at 12, Albert-street, Deansgate, Manchester, and by James Grime, at Reynold-street, Hyde, Cheshire, and to carry on the business of sanitary, ventilating, lighting, heating, and electrical engineers, boiler makers, &c., heating apparatus manufacturers, &c.

CITY NOTES.

ANGLO-AMERICAN TELEGRAPH COMPANY (LIMITED).—The Directors of this Company have resolved, after placing £6,000 to the credit of the renewal fund, to declare an interim dividend for the quarter ending September 30th of 9s. per cent. on the Ordinary Stock and 18s. per cent., on the Preferred Stock, less income tax, payable on November 1st.

CITY AND SOUTH LONDON RAILWAY.—The traffic returns of this Company for the week ended September 23rd were £835, as against £775 in the corresponding period of 1893, being an increase of £60. The total receipts for the half-year amount to £10,237, as against £9,681 for the corresponding period of 1893, an increase of £556.

EVERED AND COMPANY (LIMITED).—The Directors of this Company have declared an interim dividend at the rate of 7½ per cent. per annum for the half-year ended June 30th last.

THE HOPCRAFT FURNACE.—The Engineering and General Contract Corporation is intimately associated with this furnace, from which high results were promised. These results have not been forthcoming, and the Hopcraft Furnace Company has proved a failure. This led to the appointment some time back of a committee of investigation to inquire into the methods adopted in floating the Furnace Company, and into the future prospects of that concern. The committee have just presented their report, in which the policy of the Directors is condemned in strong language. The report states that no attempt has been made to manufacture the Hopcraft furnace nor to remedy any of its notorious defects, that all engineering work has practically been abandoned, and that the condition of the Company's works and the costly machinery reflects discredit upon all concerned. Gross irregularities have also been allowed : no imputations on the honour or the integrity of the present Directors is alleged, but the irregularities referred to are ascribed to lack of knowledge or business experience. A separate report states that with regard to the Unity Engineering Works, East Greenwich, these are situated on the most remote and inaccessible part of the marshes, and the Company have them on their hands for an unexpired term of 18 years at a nominal rent. This report concludes :— "The valuable shafting is now mainly used as hen roosts or perches, the pattern-making shed as a carriage painting shop, the open shed as a stabling for some rough horses, all the property of the so-called caretaker, the whole presenting a most incongruous and dilapidated appearance. There are some few small upright engines which have apparently never been used, but which are now, through utter neglect, quite useless. Any evidences of the Hopcraft furnace beyond a few patterns and some gilded signboards are conspicuous by their absence, and there is nothing further to betoken the once alleged famous invention."

PRETORIA LIGHTING COMPANY (LIMITED).—The offices of this Company have been removed to 120, Bishopsgate-street Within, E.C.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended September 21st (after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited), were £3,598.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share	Last Dividend.	Name.	Previous Week's Price, Sept. 19.		Price Wednesday, Sept. 26.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Sept. 26. Highest	Lowest
			TELEGRAPHS					£ s. d.		Highest	Lowest
£1,012 880	Stock	10 0	Anglo-American	40	43	39	42	5 7 2	Jan., Apr., July, Oct.	39	..
£2,933,560	Stock	20 0	Do. Preferred	74	76	74	76	5 18 5	„ „	76½	75
£2,933,560	Stock	5/0	Do. Deferred	6¾	7¼	6¾	7¼	..	..	7¼	7
£184,500	100	4%	*African Direct Teleg. 4% Deb. (Reg. & Bearer)	102	106	102	105	3 16 11	January and July	103½	103
130,000	£10	3/0	Brazilian Submarine	12¾	13¼	12¾	13¼	4 18 1	Mar., June, Oct., Dec.	12⅞	–
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1906)	109	113	109	113	4 9 6	June and December	..	–
10,000,000	$100	$1¼	Commercial Cable Capital Stock	140	145	140	145	4 17 9	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	12	13	12	13	6 3 1	February and August	13	–
6,000	10	10%	Do. Preference 10 per Cent.	19	20	19	20	5 0 0	„ „	..	..
12,931	5	1/7½	Direct Spanish (£4 paid)	4¼	4¾	4¼	4¾	4 4 3	April and October	4⅞	4½
6,000	5	10%	Do. Preference 10 per Cent.	9½	10	9½	10	5 0 0	„ „	..	–
£30,000	Stock	4½%	* Do. 4½% Debentures of £50 each	105%	108%	105%	108%	..	..	9½	..
60,710	20	2/0	Direct United States Cable, 1877	8½	9	8¾	9¼	5 12 4	Jan., Apr., July, Oct.	9¼	8¾
400,000	10	5/6	Eastern	15¾	16	15¾	16	4 1 3	„ „	16	15⅞
70,000	10	6%	Do. 6 per Cent. Preference	16½	17	16½	17½	3 9 7	„ „	16⅝	16½
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	118	121	118	121	3 6 2	May and November	120½	118¾
£102,100	100	5%	* Do. 5 per Cent. Debentures, 1899	106	110	106	110	4 11 6	February & August	..	–
250,000	10	2/6	Eastern Extension	15¾	16	15¾	16½	4 6 10	Jan., Apr., July, Oct.	16½	16¼
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	116	120	116	120	3 6 8	February & August	117½	..
£62,700	100	5%	* Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103	106	103	106	4 15 6	January and July ..	..	–
£95,100	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb., 1900	103	106	103	106	4 15 6	„ „	..	..
£300,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.)	103	106	103	106	3 16 0	February & August	104	..
£200,000	£25	4%	* Do. 4% Mauritius Sub. Debs.	108%	111%	108%	111%	3 13 3	May and November	..	..
180,227	10	3 9	Globe Telegraph and Trust	8¾	9	8¾	9	5 0 0	Jan., Apr., July, Oct.	9	8¾
180,042	10	6%	Do. 6 per Cent. Preference	15¾	16½	15¾	16½	3 13 10	„ „	16½	15⅞
150,000	10	5 0	Great Northern	20½	21½	20½	21½	3 19 1	Jan., April, and July	20⅞	20½
£190,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	103	106	103	105	4 15 3	March & September	..	–
17,000	25	1¾%	Indo-European	46	48	46	48	5 4 2	May and November	..	..
37,548	10	5/0	London Platino-Brazilian	5	7	5	7	..	„ „	–	..
£100,000	100	6%	* Do. 6 per Cent. Debentures	106	109	106	109	5 10 7	March & September	..	..
£100,000	£100	4%	*Pacific European Tel. 4% Guar. Debs. "Red" 1942	104	107	104	107	3 15 6	..	..	–
11,839	8	4/0	Reuter's	3	5	3	5	..	April and October	..	..
3,381	£100 Cert.	25/0	*Submarine Cables Trust 6 per Cent.	107	112	105	110	5 10 1	„ „	109	..
15,609	10	5/0	West African Telegraph	3	5	3	5	..	January and July	..	..
£249,900	100	5%	* Do. 5 per Cent. Debentures	100	103	100	103	4 17 7	March & September	101¾	..
30,000	10	2/0	West Coast of America	2	3	2	3	..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	101	106	101	106	7 10 11	June and December	..	..
88,321	10	9d.	West India and Panama	1¼	1½	1⅜	1⅝	..	..	1½	1½
34,563	10	6%	Do. 6 per Cent. 1st Preference	10½	11	10½	11½	5 6 8	May and November	10⅞	10¾
4,669	10	6%	Do. 6 per Cent. 2nd Preference	9	10	9	10	6 0 0	„ „	9⅞	..
£80,000	100	5%	* Do. 5 per Cent. Debentures, 1917	108	111	108	111	4 11 1	June and December	..	–
64,242	15	7/6	Western and Brazilian	8¾	9¼	8¾	9¼	..	May and November	9¼	8¾
33,129	7½	7/6	Do. 5 per Cent. Cumulative Preferred	6¾	7½	6¾	7½	..	..	7½	6⅞
33,129	7½	4/6	Do. 5 per Cent. Deferred	3	3½	2¾	3½	..	..	3½	3
£171,900	100	6%	* Do. 6 per Cent. Debs., Series "A" 1910	106	109	106	109	5 11 1	February & August	..	..
£214,800	100	6%	* Do. 6% Mort. Debs., Series "B" 1910	106	109	106	109	5 11 1	„ „	..	..
$1,211,000	$1,000	7%	*Western Union 7% 1st Mort. (Building) Bonds	115	120	115	120	5 19 8	May and November	–	..
£166,900	£100	6%	* Do. 6 per Cent. Sterling Bonds	100	103	100	103	5 17 1	March & September	..	..
			TELEPHONES.								
44,000	5	10/0	Chili Telephone (fully paid)	1	2	1½	2½	–	..	..	–
224,850	10/0	2⅞d.	Consolidated Telephone Const. & Maintenance	¼	½	¼	½	..	May and November	¼	..
171,504	£1	6d.	Oriental Telephone and Electric (fully paid)	¼	⅜	¼	⅜	..	Yearly	..	..
484,597	5	3/4	National	4⅞	5⅜	4⅞	5⅜	4 17 7	June and December	5⅛	4⅞
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	14½	15½	15	15½	3 17 5	„ „	15¼	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	14	15	14	15	4 0 0	„ „	14½	14¼
119,234	5	3/4	Do. 5% Non-Cumulative 3rd Pref.	5½	6¼	5½	6¼	4 6 11	..	5⅞	5⅜
1,000,000	Stock	4½%	* Do. Debenture Stock, 4½%	109	112	109	112	4 1 8	January and July	..	..
58,000	5	1/0	United River Plate	1½	2½	2	3	–	„ „	..	..
£146,733	Stock	5%	Do. 5 per Cent. Debenture Stock	88	94	88	94	5 6 5	„ „	..	–
			ELECTRICITY SUPPLY COMPANIES.								
40,000	£10	..	City of London Electric Lighting (fully paid)	12½	13½	13	14	..	–	13¾	13¾
40,000	10	6,0	Do. 6% Cumulative Pref. (fully paid)	14½	14¾	14	15	4 0 0	..	14¾	14½
19,900	£5	..	Electricity Supply Co. for Spain	..	..	..	..	..	–	..	–
£30,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	4½	5½	4	5½	3 12 7	–	..	..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	..	..	..	..	..	..	..	..
8,322	£5	..	House-to-House Electric	..	..	..	..	–	–	..	–
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid).	..	..	..	..	–	..	..	–
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..	..	..	..	–	January and July	..	–
45,000	£5	2/6	Liverpool Electric Supply (fully paid)	6¾	7	6¾	7	–	..	..	–
111,000	5	..	London Electric Supply	½	¾	½	¾	–	..	..	..
49,900	£10	5/0	Metropolitan Electric Supply (fully paid)	9½	10	9½	10	2 10 0	..	9⅝	9¾
£150,000	Stock	4½%	* Do. 4½% Debs. (Bonds of £10, £20, and £40)	7	8 pm	113	114	..	June and December	..	..
6,452	£10	..	Notting Hill Electric	4½	5½	5	6	–	..	..	–
19,930	£5	2/0	St. James and Pall Mall	6¾	7½	7	7½	..	..	7⅛	7¼
20,000	£5	7%	Do. 7 per Cent. Preference	8½	9	8½	9	3 17 9	–	8½	–
59,900	5	2/0	Westminster Electric Supply (fully paid)	6¼	6¾	6¼	6¾	3 6 8	–	6¾	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
90,000	3	1/6	Brush Electrical Engineering	2⅝	2⅞	2⅝	2⅞	7 9 6	..	2⅞	2¾
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	2¼	2⅝	2⅜	2⅝	4 11 5	..	2⅜	2½
£125,000	Stock	4½%	* Do. 4½ per Cent. Debentures	109	112	109	112	4 0 4	March & September	..	..
20,000	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref.	1¾	2½	1¾	2½	–	January and July	..	..
12,139	5	..	Edison and Swan United	–		–		..	..	–	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	..		..		..	..	–	..
120,000	2	..	Electric Construction	¼	¾	¼	¾	..	–	⅝	⅞
12,845	2	..	Do. 7 per Cent. Cumulative Pref.	2	2½	1¾	2½	..	–	2⅛	–
91,195	2	10/0	Elmore's Patent Copper Depositing	⅜	1⅜	1⅜	1⅜	..	–	..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	¼	1¼	¼	1¼	..	..	..	..
50,000	10	10/0	India Rubber, Gutta Percha, &c., Works	23½	24½	23½	24½	5 2 6	February & August	24⅛	23
£200,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	104	105	102	104	4 6 7	March & September	105	–
15,995	£10	6/4	International Okonite Ordinary	..		..		–	..	..	–
16,000	£10	..	Do. 8 per Cent. Preference	..		..		–	December and June	–	–
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid)	–	½	–	½	–	..	–	..
78,919	5	3/6	Swan United (£3 10s. paid)	..		..		..	May and November	..	..
37,350	12	12/0	Telegraph Construction and Maintenance	41	43	41	43	4 3 9	March and July	42½	42
£150,000	100	5%	Do. 5 per Cent. Bonds	102	105	102	106	4 14 4	January and July	..	–
37,514	£5	–	Woodhouse and Rawson Ordinary (£3 15s. paid)	–		–		..	..	–	–
41,098	£5	..	Do. Preference (fully paid)	–		..		..	–	–	–
£63,870	10	10/0	W. T. Henley's Telegraph Works Ordinary	7½	8½	7½	8½	5 17 8	..	..	..
£30,000	10	..	Do. Preference	..		..		..	..	..	..
			RAILWAYS AND TRAMWAYS.								
£630,000	Stock	1%	City and South London Railway	36	38	36	38	1 16 2	May and November	..	..
7,000	10	5%	Do. 5% Perpetual Preference	12½	13½	12½	13½	3 14 1	May and November	12⅞	..
£67,130	Stock	4%	Do. 4% Perpetual Debenture	121	123	121	123	3 5 1	..	..	..
37,500	£10	1%	Liverpool Overhead Railway	7¾	8	7¾	8½	1 5 0	..	..	..
6,295	10	5%	Do. 5% Preference	12¾	13	12¾	13	3 16 11	..	..	..
£125,000	Stock	4%	Do. 4% Debenture	111	113	111	113	3 10 10	January and July ..	–	..

* In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption.

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THE ELECTRICIAN:

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NOTES.

In an article dealing with electrically-driven coal-cutters, which will be found elsewhere in the present issue, the author adverts to what may be termed the extraneous difficulties to be overcome before the community will be allowed to reap the full benefit derivable from the application of electric energy to the winning of coal. The mechanical engineer, it would appear, has brought the electric coal-cutter to such a point that as regards first cost, durability, reliability, and coal-getting capacity it would, if properly made use of, materially reduce the cost of winning a ton of coal.

To have done this is, however, only half the battle. The human mind obeys the first law of motion with irritating obstinacy. Everyone would, if he could, continue in a state of rest or of uniform, and usually uncommonly slow, motion in a groove, except in so far as he is compelled by force to hurry along or altogether come out of that groove. So long as miners were amenable to stock arguments and the public would pay the piper, the colliery manager, good easy man! not being acted upon by any external force, continued to do as he had always done, and if he did introduce coal-cutting machines, did so tentatively, half-heartedly, and without making adequate arrangements, mechanical or manual, for quickly clearing away the coal which was cut, so that the cutting plant was forcedly idle half the twenty-four hours. Then when one comes to the men themselves, it is too much to expect *them* to assist, by making their extinguisher as great a success as possible, in what they consider must lead to their own extinction. So that the community will have to await the advent of an external force before it can hope to reap any appreciable advantage from the ingenuity of the engineer.

The increasing disposition of the miner to capture all he can of the profits of capital, and the increasing indisposition of the public to bear the burden of high wages, are indeed potentially such a force. But, given a new colliery, started from the very beginning on the new lines, it ought, if there be any virtue in mechanical appliances, to be able to undersell. Once this possibility is made plain, as we anticipate it shortly will be at Eckington, the uniform motion of managers and men in a narrow groove will be effectually disturbed by the never-failing force of competition

Were it not for commercial considerations a most interesting Paper might be written for the Institution of Electrical Engineers on the use of steel for dynamo construction. But fear of mentioning makers' names, either in praise or disparagement, makes such a Paper impossible. The tracings of tests of steel which were handed round in the course of a recent Paper on magnetic testing were of little or no interest, since the names of the makers had been cut out. From a purely scientific point of view, nobody cares about the makers' names, and Prof. Ewing's book on "Magnetic Induction in Iron and Other Metals" loses nothing in scientific interest or usefulness by any such omissions. The employment of cast steel for dynamo magnets is not a mere matter of high permeability and few ampere turns, it is a complicated commercial question. Copper and total weight may be saved, but the cost of the material and of the tooling is greater, sometimes much greater than with cast or wrought iron. This question cannot be settled once and for all, each dynamo builder must find out for himself which material is best suited for his make of machine, for his tools, for his men, and for his market; and this is no easy task. In the works of one of the largest and most scientific dynamo makers we saw recently a great variety of steel magnet bars and castings, and there seemed to be scarcely two of the same kind. There was Gruyère steel, worm-eaten steel, wasp's-nest steel, and steel which looked like a longitudinal section of cane seen through a microscope. Drilling and tapping such stuff is no child's play.

It is quite the exception to find apparatus for testing magnet steel in a dynamo factory, not, we are inclined to think, because dynamo makers are not alive to the importance of high permeability and low hysteresis, but because they know that a scientific test of the material, even accompanied by a report from a high authority, saying "Decidedly superior to wrought-iron forgings," or "I have not hitherto met with any material so well suited for use in the field-magnets of dynamos," cannot settle the question whether it will pay them to use it. Nothing but the building of a dynamo and a careful noting of its cost of building, and of its output, will suffice; and they are well aware that, even having done this, they may never get a piece of the same quality again. But dynamo builders need not be utterly in the dark about the magnetic qualities of steel, even if they have no testing apparatus, for more than one maker is issuing particulars of tests. We have before us a pamphlet from Messrs. Edgar Allen and Co., in which a large number of

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B H curves are given, to large scales, together with reports by Prof. EWING and others, giving also permeability, coercive force, and remanence. Makers of sheet iron for armatures and transformers are also beginning to give such information, which ought also to be valuable. A matter of equal importance is the ability of a maker to supply more material of exactly the same quality. This Messrs. ALLEN and Co. profess to be able to do.

AN exhibition of various systems of photography by artificial light is being held at the office of *The Photogram*, in Farringdon-avenue. The Pilsen arc lamp, which has been described in these columns, and the Adamson system of glow-lamp lighting, are the two representatives of electric light methods, and they seem to hold their own against magnesium and Welsbach gas burners. The Adamson system consists of a ring of 40 25-c.p. lamps and a compound switch. The lamps are placed round the inside of a white dome reflector about 3ft. 6in. diameter, hung on a long counterpoised lever, allowing adjustment. Lamps of nominal 65 volts are used, but are run up during exposure to 100 volts. It is claimed that an exposure of one second will suffice for a portrait. For focussing and posing, 8 lamps at 65 volts are employed, and by means of a twenty-point switch, any number of pairs of lamps can be switched on. A second switch handle regulates the resistance. The over-run lamps, of course, give a fairly good actinic light, and the apparatus seems easy to control.

"DEADLINESS," like most things on this sublunary sphere, is relative, and the American trolley car, regarded purely as a man-slaying instrument, is doubtless quite innocuous when compared with the American level crossing; and, taking the latter as a standard, our transatlantic electrical contemporaries are probably quite justified in refusing to allow the epithet "deadly" to be applied to the trolley car. It is, however, only a very high standard that could prevent the record of the Brooklyn City Railroad from fully entitling its trolley cars to the adjectival prefix "deadly." During the year ending June 30th twenty-three persons were killed and thirty-nine were injured on the various Brooklyn City Railroad trolley lines. Of those killed two were passengers and three employés.

Cable Interruption:

	Date of Interruption.
Zanzibar-Mombasa	September 4th.
Macao-Hong Kong	September 25th.

"L'Energie Electrique."—Under this title there has just appeared in Paris the first number of a semi-monthly publication, which proposes to become the organ of "factory-owners, consumers and municipalities."

How Gas Proposes to Fight Electric Light.—The Launceston (Tasmania) Gas Company, finding that "they would in the future have to compete against the electric light," have decided to reduce the salaries of their staff by 10 per cent.

Provincial Municipal Electric Lighting.—The Mayor and Corporation of Aberystwyth have inaugurated the electric lighting of the marine front and main portion of the town. The lighting was carried out by Messrs. Bourne and Grant.

Electric Traction in Spain.—A concession has recently been granted for the construction and operation of an electric tramway giving communication between Barcelona and the suburbs of Sarria, Gracia, San Gervasio, San Martino and San Andres.

Interurban Telephonic Communication.—Telephonic communication was made available between Hamburg and Cologne on the 1st inst. The charge is 1s. for three minutes' conversation.——On the 1st inst., the telephone line between Ipswich, Colchester, Chelmsford, London, and Brighton, was opened for the public use.

Institution of Civil Engineers.—A recently-issued list of members, corrected to September 6, 1894, shows that there are now on the roll of the Society 19 honorary members, 1,837 members, 3,597 associate members, and 358 associates, together 5,811. The students attached to, but not forming part of the Corporation, now number 782.

International Telephony.—In the Danish Rigsdag recently, the Minister of Finance, in bringing forward the budget for 1895-96, demanded credits for the establishment of a telephonic service between Fyen, viâ Jütland, to the German frontier. This line is intended to form a link in eventual telephonic communications between Copenhagen, Hamburg, and Kiel.

French Telegraphic Rules and Regulations.—M. de Selves, the Director of Telegraphs, has, says *The Times* correspondent at Paris, given way, as was expected, to the outcry against his regulation ordering telegrams to be fully addressed. He has given instructions "that all telegrams, the address of which is sufficient to indicate the recipient without search or application for information, shall be delivered without delay."

The Proposed Pacific Cable.—The officers of the British cruiser "Champion," which vessel has recently surveyed Neckar Island, one of the suggested landing points for the Pacific cable, reports that under no circumstances would the island prove suitable for the landing of a cable, as the shores rise precipitously from deep water. This may, however, be said of most of the possible Pacific landing points, and the difficulty has been overcome in the cases of Madeira and St. Vincent by the use of a special type of cable.

Military Telegraphy.—In his account of the recent cavalry manœuvres *The Times* correspondent says:—"This was the first day on which the R. E. Field Telegraph was employed; it advanced *pari passu* with the eastern force, and constantly wired to Churn Camp, some twelve miles distant, reports of progress. On this and subsequent occasions, it accompanied cavalry at a trot, the wire being laid as fast as the cavalry advanced, and also being reeled up equally rapidly, even when the cavalry retired at the same pace. This is a most creditable performance, the more so because the R. E Telegraph Battalion has not professed to be able at present to accompany cavalry in the field. The possibility of the wire being utilised with cavalry having been thus demonstrated, the necessary organisation will, no doubt, be supplied."

Meter Testing.—It is a common experience with suspicious gas consumers that their meters, when tested, are certified as registering too low, with the irritating result that they not only have to pay the cost of the test, but receive the added insult of having their gas more accurately metered by a new meter. Electric meters, if we may judge by a paragraph in the annual report of the Surveyor to the Chelsea Vestry, propose to follow in the same path. Only one application was made to the Vestry during the year to have a meter tested, which was from 59, Cadogan-square. Mr. Morgan Williams tested it on behalf of the Vestry, and found that at the average load it registered 8·27 per cent. too low. It is needless to state that the Supply Company, on receiving this intimation, immediately fixed a new meter.

Local Authorities and Telephone Poles.—The Fife County Road Board says the Telephone Company must pay 2s. each for their poles or lift them. On the north side of the Tay some months ago the question of way-leave and rent, says the *Dundee Advertiser*, was fully debated; but the local authorities who entered into the discussion were scarcely so well prepared as the Fife folks. The latter have ascertained not only the capital and working expenses of the Company in Fife, but the amount of their income, and thus they are able to dictate their terms in no uncertain fashion. The increase in the rent

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is a heavy one; but the total sum demanded by the Board, when considered in relation to the amount earned by the Company in the county, is not unreasonable. Whether they think so or not, it is quite evident that the Company will be made to pay or lift.

Peculiar Effect of the Aurora.—A correspondent of the *Electrical World* of New York, relates that he had to use very frequently the telephone line from Digby to Westport in Nova Scotia, a distance of about 50 miles. The line is a single iron wire with earth return. The instruments used were ordinary Bell short distance telephones. There were no other wires within fifty miles. Whenever there was an aurora, or an electrical storm, he noticed the following phenomena: A person talking at the west end of line could be heard quite distinctly at the east end. But the person at the east end could not be heard at the west end at all, and the conversation would have to be repeated in the centre of line. During normal weather conditions conversations could be carried on distinctly in both directions, but always with an advantage from west to east. There is no question, he states, about the instruments, as they were exchanged without any change in the working being noticed.

A Constant and Reliable Battery.—A consulting engineer was being "pumped" in a friendly and unprofessional manner by an acquaintance, the other day. "You engineers," said the inquirer, "are prejudiced in favour of dynamos and steam engines for electric lighting, just because they are better for trade than batteries. More electricity is turned out from batteries all the world over and all the year round than from dynamos, but you combine together to prevent men like me from lighting their houses in a modest way with a simple battery. Now, tell me, are there not really constant and reliable batteries that you yourself use, perhaps not for electric lighting, but for other purposes? You say they are not suitable? Leave that to me, I'll see about that. What are they called, and how many go to the hundred, for you see I *do* know something about it?" "The Clark cell," replied the patient consulting engineer, "is recognised as the most constant and reliable battery. You must use 70 to get 100 volts."

Three-Wire System of Electric Traction.—Mr. A. G. Seaman writes us as follows:—

I have only just seen in your number of September 14th the account of the trolley line at Bangor, Me., by Mr. J. G. Carrol. I never had had any doubt as to the practicability of applying the three-wire system to small lines, but I had doubted whether it were worth the while. The line at Bangor is to a certain extent exceptional at present, owing to the comparatively long distance from the power house, and ought to be of considerable interest to similar places possessing water power. The difficulties do not lie on the line; but as I hinted in my letter of August 28th, and as Mr. Carrol points out himself, in the power house. The necessity of having to start two dynamos (one on each side of the system) as soon as the load becomes too much for those already running, and the loss of economy, due to the small load factor of the plant, occasioned thereby, most particularly in the power stations of trolley systems, where the load factor is never too good, the increased necessity for further spare plant, and the additional complication in the switchboard arrangements, have probably prevented the three-wire system from making way in traction work. These difficulties are being met in many lighting stations in London and elsewhere by winding the dynamos for the full pressure of the system, *i.e.*, in a case where there are 500 volts between each trolley wire and earth, the earth being the neutral or third wire, by winding the dynamos for 1,000 volts, and equalising any difference of demand in the two halves of the system by means of accumulators or motor transformers; these latter should be placed at the most central points in the distribution system. By this means the advantages of the three-wire system may be combined with the simplicity of the parallel system, with the gain of considerable economy.

An Interesting Isolated Electric Lighting Plant.—Mostyn House School, a preparatory school for boys, at Parkgate, Cheshire, has recently been fitted up with an independent electric light plant. The plant consist of a 12½-H.P. Hornsby-Akroyd paraffin engine, driving a Paterson and Cooper dynamo, and a double set of March's accumulators, running in parallel with the dynamo during the hours of maximum output. Current is thus supplied to 153 incandescents and one arc lamp. A novel feature of this plant is a set of electrically driven clocks, distributed all over the building. They are synchronised from one central self-winding clock, and all keep exact time with one another. The power is derived from a small battery of accumulators kept constantly charged by the lighting circuit. At fixed hours bells are automatically rung in all the various class-rooms and living-rooms. These hours are determined by a plug-board in the headmaster's room, and can be varied at pleasure to any given multiple of five minutes. It is satisfactory to notice that the cost of running compares very favourably, in actual cash expenditure, with the previous annual outlay for gas and oil lamps.

The Accident at Bankside.—Last Sunday afternoon two employés of the Brush Company were repairing one of the switch pillars which stand about 20ft. apart along the switch gallery of the station at Bankside. One of the men—a fitter—was at work behind the pillar about 5ft. from the gallery floor, having used a ladder for getting up. His labourer, a man named Hearne, took the ladder away unnoticed, placed it against an adjacent pillar which was "alive" at the time, and went up to the top where the only exposed contacts are. The first intimation that anything was wrong was conveyed by a scream from the injured man, and on the fitter coming round to the front he saw his mate lying on the gallery. He jumped down, and with the assistance of the station hands, who were soon on the spot, tried to resuscitate the man, but their efforts were unavailing. A doctor arrived shortly after the accident, but he immediately pronounced life extinct. The deceased had been employed on work of the same kind for about two months and knew thoroughly the danger of touching anything. Only 15ft. from where the accident occurred a notice was displayed absolutely forbidding anyone to do the very thing which led to the man's death. The pressure was 2,000 volts alternating.

Subjects for Papers.—The Council of the Institution of Civil Engineers invites original communications on the following, amongst other subjects:—"The Different Methods of Governing Steam Engines, so as to give Uniform Speed with Greatly Varying Loads"; "The Arrangements of Boilers and Engines best Adapted for Electric Light Stations under Different Conditions"; "The Purification of Sewage by Filtration, Precipitation, Electrolysis and otherwise"; "Alternate *versus* Continuous Electric Currents for (*a*) Electric Lighting, and (*b*) Transmission of Power"; "The Forms of Electrical Conductors for Lighting, Stationary Power, Heating, and Tractive Purposes"; "The Utilisation of Electric Lighting Plant during Hours of Small Demand"; "Electric Lighting and Haulage Plant in Mines and Collieries"; "The Application of Water Power, and its Transmission to a Distance by Electricity"; "Electrical Motors for (*a*) Inland Navigation, and (*b*) Ocean Vessels"; "The Use of Electrical Motors for Driving Machine-tools in Engineering Workshops"; "Coal-winning in Seams Situated at Great Depths below the Surface"; "The Effect of Small Quantities of Impurities in Commercial Copper as Regards its Use in Electrical Work"; "The Electrolytic Deposition of Copper"; "The Uses of the Rarer Metals, and the Modes of Extracting them from their Combinations"; "Aluminium, its Manufacture, Properties, Uses and Alloys"; "The Arrangement of Engineering Workshops, with Descriptions of Modern Machine Tools and Appliances."

Electrical Communication with Lightships.—The following letter from the Rev. T. Hancocks, which recently appeared in the *Daily Chronicle*, is of interest:—

SIR: My attention has been called to a statement in your paper, in which Mr. Julius M. Price declares that electrical communication with lightships is a failure. Kindly insert this correction, as one fact is worth many theories. The Goodwin lightship, situated at the north end of the Goodwin Sands, is connected with the shore by telephone. No part of the planet is more perilous than this spot, and the vessel is fully exposed to what sailors call "a breeze." Yet for seven months the telephone has worked admirably, as my experience tends to prove. One of her crew, a member of my church, had a son critically ill ashore, while his father was doing his two months on board. To relieve his anxiety I obtained permission at the coastguard station to speak the lightship. I told him the home news, had with him a general chat, and bade him good night. I easily recognised his voice, quite as well as I ever heard one through a land telephone, and the Goodwin is over six miles from shore; also, the officials assure me that the telephone is a complete success. There are only two drawbacks:—(1) The chafe of cable near the ship necessitates frequent repairs. Experience will soon suggest some safeguard. (2) The ship does not ride rough seas so lightly as before, owing to her being anchored by four heavy chain cables instead of one. This, while no danger, is less comfortable for the crew, as she ships more seas aboard. It has been suggested that each cable should be supported by a buoy, which would probably remove this defect. But already this telephone has proved its immense value in saving precious life and valuable property. At a wreck,

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as at a fire, the first five minutes are worth the next five hours, and since the cable, news of a ship on the Goodwins has reached land, the lifeboat has been dispatched, and all hands saved, with a speed incredible to former times. The cable is no failure, but a thorough success.

Aluminium.—It must be confessed that up to the present the uses which aluminium has been put to in the arts has scarcely come up to the high expectations of those who prophesied a metallurgical revolution as soon as aluminium could be obtained comparatively cheaply and abundantly by means of the electric furnace. Practically all that had been done with aluminium until now was to make it into forks, paper knives, and such like domestic trifles, although there had been many rumours as to the immediate adoption of aluminium for various military purposes, such as water bottles, cartridge cases, &c. It is, therefore, satisfactory to be able to chronicle the existence and successful trial of such a concrete piece of metal work as a second-class 60ft. torpedo boat, the hull of which is composed of 94 per cent. aluminium and 6 per cent. copper. This boat has been made to the order of the French Government by Messrs. Yarrow and Co., and, as compared to a steel boat of the same type, the scantling has been thickened about 25 per cent., in spite of which the total weight of the hull has been reduced about 50 per cent. The chief result of using the light material has been that a speed of 20½ knots has been obtained, in place of the 17 knots of similar steel boats. The alloy used by Messrs. Yarrow and Co. has a tensile strength of 14 tons to the square inch, and has a very high elastic limit. The price of the material for the hull and fittings varied from 3s. to 5s. a pound, and the metal used for this small boat cost over £1,000. All the aluminium plates and angles were imported from France.

A Necessary Contingency of the Telephone.—In the Recorder's Court at Belfast, last week, an action was brought by the National Telephone Company against Mr. John Robson, to recover the sum of £10, hire of a telephone and wire, which was alleged to be payable in advance, for the year commencing July 1, 1894. The defendant refused to pay, denied his liability to do so, and alleged that the telephone was a nuisance. The Recorder held that the Company was not entitled to maintain the action, and dismissed the case. In the course of the hearing of the action the following verbal encounter took place between Mr. Robson's counsel and the National Telephone Company's district manager:—Q. What is the object of the telephone? A. The object is to afford accommodation to people to converse with others at a distance.—Q. You are quite sure that it was a telephone you purported to supply to Mr. Robson? A. Quite sure.—Q. And not an alarum clock? A. Not at all.—Q. And I suppose it is one of the uses of telephone that it ought to wake you up in the middle of the night? A. It is one of the contingencies of the telephone that it would do so occasionally.—Q. Would it be a properly working telephone if it kept ringing all the day without being called upon at all? A. It would.—Q. And it would be a properly working telephone if, instead of hearing a communication from someone you wanted, you heard the private conversation of others? A. Yes, a perfectly proper telephone.—Q. And if you wanted to converse with someone about buying a house, you would not be surprised if you heard a concert in Dublin? A. Not at all.—Q. As a matter of fact, that is what the telephone was put up for? A. Oh, not at all; but it is a necessary contingency of the telephone.

Electric Traction at Havre.—On February 1, 1874, the town of Havre witnessed the "inauguration" of the first horse tramway in France. On the 25th ult. the first complete urban system of electric tramways in France was "inaugurated" at the same place, after having been at work since July. Judging by a five-column account, which appears in *La Semaine Electrique*, the ceremony seems to have been of an extremely pleasant character. The contractors concerned, viz., the Société Générale Française de Tramways and the Compagnie Française pour l'Exploitation des Procédés Thomson-Houston, issued no less than 400 invitations, supplied the invitees with a special train, "sumptuous" breakfast, luncheon and dinner, rides on ten electric cars all over the town, sleeping accommodation in the best hotel in Havre, finishing up with a special train back to Paris the next day. The chief technical item which seems to have struck the representative of our French contemporary dumb with admiration is the fact that the switchboard of the generating station, in spite of the size of the network which it serves, is only two metres by two metres, and contains but one single voltmeter and three ammeters. This severe switchboard simplicity by itself is sufficient to make us hopeful of the success of this tramway. Another item of some novelty in connection with this line is the fact that current is supplied by the local electric light company, although not from the lighting dynamos, since the company's system is alternating. The traction plant consists of three 4-pole 200-kilowatt 500-volt Thomson-Houston dynamos, rope-driven by Farcot-Corliss condensing engines. The rolling stock consists of 40 cars, 24 of which are driven by a single 25-H.P. single reduction motor, the balance having two such motors each. The network of the Havre Tramways Company is equal to 40 miles of single track.

Metropolitan Municipal Electric Lighting Stations.—The first week of the present month has been signalised by the opening of two municipal electric light stations on the outskirts of London. On Monday evening, the Hampstead Vestry station was formally "inaugurated," and on Wednesday evening the same ceremony was performed at Ealing.——The Hampstead Vestry's station is situated right in the centre of the district, and within a hundred yards of the boundary of the "compulsory area," which is of triangular shape, containing, from the electric lighting point of view, as fine a residential quarter as could be well imagined. Inside this area the Vestry supply is without a competitor; but there is a very profitable quarter adjacent to the "compulsory area," which is at present supplied by an enterprising local concern by means of overhead cables, which are a distinct disfigurement to the neighbourhood, and it is difficult to understand how the Company came to be permitted to erect such ugly excrescences. The Vestry plant comprises four Lancashire boilers fed by Bennis' mechanical stokers, one Willans-Siemens (alternator) combination of 300 H.P.; two of 150 H.P.; and one of 30 H.P., also two 25 H.P. 1,300-volt machines for the street arcs (Siemens). These machines, it should be mentioned, are in reality constant potential dynamos, but are made to give a constant current by hand regulation of the speed and by regulating resistances in the exciting circuit. The feeders (Siemens' concentric) feed transformers placed in pits under the pavement at 2,000 volts, the secondaries feeding into a three-wire network (Siemens' triple-concentric) at 200 volts. The station, which is located in the parish stoneyard alongside the London and North-Western Railway, has a nominal coal storage capacity of about 100 tons, and a water-tank of 10,000 gallons capacity. Some 1,300 lights are already connected to the mains, and about 3,000 more will shortly be ready to come on. Mr. R. A. Chattock, late of the Metropolitan Electric Supply Company, is in charge of the station.——The Ealing station, on the other hand, is situated at the extreme south of the district by the side of the sewage disposal and destructor station. The idea in locating the generating plant so far from the centre of supply is that the additional $C^2 R$ loss thus involved will be more than compensated for by the economy effected by making use of the waste heat from the refuse destructor "fume cremator," from which gases issue at a temperature, it is said, of between 1,200° F. and 1,800° F., and by using the sewage effluent for condensing purposes. It is expected that the total power obtainable continuously from the "cremator" will amount to about 50 H.P. The plant laid down is equal to the supply of 70 street arcs and 5,000 8-c.p. glow lamps, and comprises three Lancashire boilers, a 6in. cast-iron steam ring-main, McDougall mechanical stokers, and, for the public lighting, three Browett-Lindley vertical compound condensing engines, coupled direct to Siemens disc-armature 10 ampere 1,800 volts arc lighters running at 300 revolutions, and, for the private lighting, two Browett-Lindley engines, coupled direct to 60-kilowatt 2,000-volt alternators (40 ∿) and two similar engines coupled direct to 30-kilowatt alternators. The arc-light mains are concentric, lead-covered and armoured, and are laid directly in the ground; the lamps being of the Brockie-Pell type. The feeders, five in number, are also of the concentric type (Callender), and run to transformer sub-stations. The secondaries feed at 102 volts into a complete ring main.

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THE CHEMICAL THEORY OF ACCUMULATORS.—III.

BY E. J. WADE.

In attempting to select from amongst the various theories of the action of lead storage cells the one which best corresponds to the facts of the case, two classes of evidence must be considered. Obviously there is the direct evidence afforded by analyses of the electrodes and electrolyte and quantitative determinations of the different compounds present at various stages of charge and discharge, while the corresponding physical changes in the electrical resistance of the cell, colour and appearance of the electrodes, and so forth should also furnishsome supplementary evidence. But beside these there is very important indirect evidence to be obtained from comparisons of the observed E.M.F. of the cells with that calculated by means of thermo-chemical data; and if, for any assumed set of chemical reactions, a real agreement can be shown between the observed and calculated values, strong *primâ facie* evidence is afforded that these are the ones actually occurring. It may be as well to state the law governing these calculations, and to show briefly both how it is derived and how applied, for very little information on this subject is to be found in any works on electricity.

The fundamental laws of electrolysis, first discovered by Faraday, are as follows:—

1. The quantity of any electrolyte decomposed by a current is directly proportional to the strength of the current and its duration; that is to say, to the whole quantity of electricity that passes through it.

2. The quantity of each electrolyte decomposed by a unit quantity of electricity is perfectly definite and constant, and is termed its "electro-chemical equivalent."

3. The quantities of different electrolytes decomposed by a unit or any other given quantity of electricity and in direct proportion to their chemical equivalents or combining weights.

The nomenclature now generally used in dealing with electrolytical matters was also devised by Faraday. He called the component parts (not necessarily elements, but oftentimes compound radicles or groups of elements such as SO^4, NH^4, and so on), into which an electrolyte is split up by a current "ions," those liberated at the electrode by which the current enters being "anions," and the electrode itself the "anode"; and those liberated at the electrode by which the current leaves "kathions," and the electrode the "kathode." Nearly all the tables and data relating to electro-chemistry and thermo-chemistry are given in terms of the gramme as the unit of weight, and the coulomb or ampere-second as unit of electricity; but otherwise calculations could equally well be made in terms of the more commercial units, the pound and the ampere-hour.

It follows, from the last of the above laws, that the weights of the component parts or ions into which any electrolyte is decomposed will also be proportional to their chemical equivalents. Thus 74·5 grammes of potassic chloride will split up into 39 grammes of potassium and 35·5 grammes of chlorine.

It also follows that, knowing the weight of any one element liberated by a unit or a given quantity of electricity, the electro-chemical equivalent or the weight of all the others can be determined. Tables giving the electro-chemical equivalents of the elements may be found in many works on electricity, and are arrived at by multiplying their chemical equivalents into the electro-chemical equivalent of hydrogen. According to the most recent determinations, the electro-chemical equivalent of hydrogen in grammes per coulomb is 0·00001038. Chemical equivalents or combining weights must not be confused with atomic weights; but, with a few exceptions, they are the atomic weight divided by the valency. For example, both the combining and atomic weights of hydrogen are 1; but while the atomic weight of oxygen is 16, and of aluminium 27·3, their combining weights are only $\frac{16}{2} = 8$ and $\frac{27·3}{3} = 9·1$ respectively.

The researches of Joule into the relations of heat to other forms of energy, and his determination of the mechanical equivalent of heat, rendered it possible to express the energy liberated or absorbed by chemical combinations or decompositions in mechanical, and, therefore, in electrical units; and in 1851 Lord Kelvin, then Sir William Thomson, applied his data to the reactions taking place in electrolytic and galvanic cells,and showed how the E.M.F. produced or absorbed could be arrived at from theoretical considerations. The work done in any electrolytical decomposition is evidently expressed by the product of the quantity of electricity passing through the electrolyte into the E.M.F. required to effect it. Therefore, $W = QE$, where W is the work in watt seconds or joules, Q the quantity of electricity in coulombs, and E the E.M.F. in volts. This work has, however, been absorbed in breaking up a certain portion of the electrolyte into two simpler substances; and if these recombine chemically to form their original compound, they will give out as heat exactly the same amount of energy as was previously taken up; but it can now be expressed in a different way. The "calorie," or unit of heat, is the amount of heat required to raise the temperature of one gramme of water 1°C. It represents the same amount of energy as 420 kilogrammetres, or 4·2 watt-seconds, and these constants are termed Joule's equivalent or coefficient. Calling H the number of calories liberated by the recombination of unit weight of one of the decomposed ions, and e its electro-chemical equivalent; then eH will be the heat generated by the recombination of as much of that ion as would be set free by one unit or coulomb of electricity, and JeH will represent the electrical equivalent of that heat in watt-seconds, J being Joule's coefficient.

If, however, Q coulombs of electricity were passed through the electrolyte, Q times as much of the ion would be liberated, and Q times as much energy set free on recombination, so that

$$W = QJeH,$$

and therefore $$QE = QJeH$$

and $$E = JeH.$$

Now it has been shown above that the electro-chemical equivalent of any element may be arrived at by multiplying its chemical equivalent c into the electro-chemical equivalent of hydrogen h; that is to say,

$$e = hc.$$

Therefore
$$E = JhcH$$
$$= 4·2 \times ·00001038 \times cH$$
$$= ·0000436\, cH.$$

Although this equation is primarily one for determining the minimum E.M.F. necessary to produce decomposition in an electrolytical cell, or, as applied to storage cells, for ascertaining the E.M.F. required to charge them; yet it is equally applicable to the calculation of the E.M.F. generated by primary cells, or the discharge E.M.F. of secondary cells. This being so, it obviously follows that, provided the chemical reactions occurring during charge and discharge are exactly the reverse of each other, the E.M.F. of these two operations must coincide; or, on the other hand, if they differ it necessarily implies that some corresponding chemical difference must also exist. Of course, losses of energy due to the internal resistance of the cells are not taken into account in any of the preceding remarks—it is E.M.F. and not P.D. (potential difference) that is being dealt with—and this must not be forgotten when applying them practically.

It is evident that the above formula is of no use unless the value of H is known for the reactions under consideration. It is only within recent years that it has been experimentally determined for any considerable number of combinations, Berthelot, Thomsen, and Naumann being the chief workers in this field; and it is only still more lately that their results have been available in English in a collected form. They may, however, now be found in a book on thermal chemistry by M. M. Pattison Muir,* while numerous other determinations, made since that work was brought out, are scattered through the *Journal* of the Chemical Society, and other publications.

In thermo-chemical notation the heat evolved by the union of two or more elements or compounds is expressed as the "heat of formation" of one formula weight of the resultant compound, and the precise nature of the reaction is indicated by writing the chemical symbols of the component parts with commas between them, the whole being enclosed in a square

* "Elements of Thermal Chemistry." 1885.

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bracket. Thus, $[H^2,O]=68360$ means that the heat of formation of 18 grammes of water from 2 grammes of hydrogen and 16 grammes of oxygen is 68360 calories; $[H^2,S,O^4]=192930$, that the heat of formation of 98 grammes of sulphuric acid from hydrogen, sulphur and oxygen = 192930 calories; but $[H^2O,SO^3]=21320$ is the heat of formation of the same quantity of acid from water and sulphuric anhydride. The symbol Aq is used to indicate a large quantity of water, when solutions are being dealt with; thus, $[H^2SO^4, Aq]=17860$ stands for the heat evolved by largely diluting 98 grammes of strong acid, and $[ZnSO^4, Aq]=18430$ is the "heat of solution" of 161 grammes of anhydrous zinc sulphate. Some few compounds absorb heat in their formation, in which case the negative sign is written before the number representing the calories so taken up. For example, $[H^2O,O, Aq]=-23060$ indicates that the formation of 34 grammes of hydrogen peroxide by the combination of 18 grammes of water and 169 grammes of oxygen, in the presence of a much larger quantity of water, absorbs 23060 calories. The net result of a series of reactions involving the decomposition of some compounds, and the formation of others, is written in the form of an alegebraical equation, those bodies that are decomposed having the negative sign placed before them. Take, for example, the action occurring between zinc and sulphuric acid, in which zinc displaces hydrogen, zinc sulphate being formed and hydrogen sulphate decomposed. The ordinary chemical equation for this reaction is

$$H^2SO^4 + Zn = H^2 + ZnSO^4.$$

The thermo-chemical equation will be

$$[Zn,SO^4,Aq]-[H^2,SO^4, Aq]=145260-107530=37730,$$

and represents the heat liberated by the formation in solution of 161 grammes of zinc sulphate at the expense of 98 grammes of dilute hydrogen sulphate.

In the case of a double reduction, such as the action of dilute sulphuric acid on litharge, two new compounds are formed and two decomposed, thus:

$$PbO + H^2SO^4 = PbSO^4 + H^2O,$$

and the thermo-chemical equation for these reactions is

$$\left.\begin{matrix}[Pb,SO^4]+[H^2,O]-[Pb,O]-[H^2,SO^4, Aq]\\ 112970+68360-50300-107530\end{matrix}\right\}=23500.$$

The fact that heats of formation are expressed in terms of the formula or atomic weight of the resultant compound and its component parts, renders their application to calculations of E.M.F. very easy, for the figures throughout directly represent (c H $\times$ valency), and therefore

$$E=\frac{\cdot 0000436\times \text{heat of formation in calories}}{\text{valency}}.$$

The heat of formation is, of course, understood to be the net result of the whole of the electrolytic reactions taking place in the cell. Now almost all battery equations are bi-valent—that is to say, they are expressed in terms of the transfer of two atoms of hydrogen or its equivalent, and therefore

$$\frac{\cdot 0000436\times 46000 \text{ calories}}{2}=1 \text{ volt},$$

and $$E=\frac{\text{heat of formation in calories}}{4{,}6000};$$

or, putting this in words, a net heat of formation of 46,000 calories corresponds to 1 volt, and the E.M.F. of a set of battery reactions may be obtained by dividing their resultant heat of formation by 46,000.

Since Thomson's law was first enunciated a number of instances have from time to time been brought forward, for which it does not appear to hold good—in fact, the calculated E.M.F. of lead storage cells has never yet been brought into satisfactory agreement with the observed values—and it has been argued, therefore, that determinations made by its means have very little weight either one way or the other. It must be remembered, however, that the application of this law is not always so simple as may at first sight appear; obscure effects due to variations in degree of concentration or dilution, allotropic modifications and alterations in the physical state of the substances taking part in the reactions and so on, all have to be taken into account; and the data bearing on such points is often vague and meagre, and perhaps not very accurate or reliable. If, after all allowances have been made, larger discrepances still exist it seems safer on the whole to conclude either that some further modifying cause has been overlooked, or that the assumed chemical reactions are not those that actually occur, rather than to at once proceed to impugn the accuracy of the law itself.

Helmholtz has shown that the formula will need a temperature correction when applied to galvanic or electrolytic cells, whose E.M.F. varies, as the temperature changes either directly or inversely. No very exhaustive or concordant determinations of the temperature coefficient of lead storage cells appear to have been carried out; but from some made by Mr. Preece in 1883,* it is evident that it is at any rate very small, and not nearly sufficient to necessitate the correction being taken into account.

The chemical changes that occur during discharge have received far more attention, and been the subject of far more controversy, than those of charge, partly because it is the period in a cell's working that is of most importance from a practical point of view, and partly because it is then that the nature of such changes is most easily investigated. The E.M.F. corresponding to the various theories of their action during discharge can now be calculated from thermo-chemical data, according to the methods just laid down. The actual E.M.F. against which it has to be compared is that that obtains during the normal discharge of a cell; the abnormally high E.M.F. that exists for a short time after the cessation of charging—if fully charged—and the rapid fall of E.M.F. that takes place when over-discharged, both being due to abnormal reactions, which must be considered separately. It is a matter of common knowledge that the normal E.M.F. of a cell with ordinary strengths of acid is at least 2 volts during the earlier portions of the discharge, falling slowly to, say, 1·9 volts towards the end. It is true the potential difference may drop to 1·85 volts, or even lower, before the rapid falling off sets in; but the internal resistance of the cell has to be allowed for, and this is a fast increasing quantity at this time.

The first theory to consider is that which assumes that the metallic constituents of the electrodes take no part in the reactions; but that the whole of the energy of the cell is derived from the recombination of the oxygen and hydrogen occluded in their pores. The electrolytic equation may be represented thus:

$$PbO^2O \mid H^2O \mid H^2Pb = PbO^2 \mid OH^2 \mid OH^2 \mid Pb,$$

and the thermo-chemical equation:

$$[H^2,O]=68360=1{\cdot}485 \text{ volts}.$$

The next theory supposes that both electrodes are attacked with the production of monoxide or litharge, water still being the electrolyte, thus:

$$PbOO \mid H^2O \mid Pb = PbO \mid OH^2 \mid OPb,$$

and the thermo-chemical equation,

$$\begin{aligned}[Pb,O]-[PbO,O]&=50300-12000=38300\\ &=0{\cdot}82 \text{ volt}.\end{aligned}$$

Next it is allowed that sulphuric acid must be the real electrolyte, and acts on the negative with the direct production of lead sulphate; but the positive is reduced to monoxide as before, so that every molecule of acid consumed is replaced by a molecule of water, thus:

$$PbOO \mid H^2SO^4 \mid Pb = PbO \mid OH^2 \mid SO^4Pb,$$

and the thermo-chemical equation,

$$\left.\begin{matrix}[Pb,SO^4]-[H^2,SO^4,Aq]+[H^2O]-[PbO,O]\\ 112970 \quad - \quad 104630 \quad +68360 - \quad 12000\end{matrix}\right\}\begin{matrix}=64700\\ =1{\cdot}4 \text{ volts.}\end{matrix}$$

Although for the sake of simplicity the electrolyte is assumed to be a very dilute solution of sulphuric acid, H^2SO^4,Aq, the figure for the corresponding heat of formation is calculated on the basis of a very much stronger solution ($H^2SO^4,9H^2O$, which is rather more than one part of acid by weight to two of water, giving a solution whose specific gravity would be about 1·280) in order to give the resultant E.M.F. the highest value possible.

* *Proc.* Royal Society, 1883, Vol. XXXV., page 250.

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This equation also represents the E.M.F. according to the views of those who admit that lead sulphate is also formed at the positive electrode, but consider it is merely the result of a secondary reaction between the monoxide and the sulphuric acid, which would be entirely dissipated as heat without furnishing anything towards the E.M.F. of the cell:

$$PbO + H^2SO^4 = PbSO^4 + H^2O.$$

Various other theories have been propounded from time to time regarding the reduction of the lead peroxide at the positive electrode. It has been suggested that it is first reduced to metallic lead, and then sulphated by local action; while Mr. Fitzgerald has maintained that it is only reduced to sesquioxide (Pb^2O^3) before sulphating. As, however, these theories have never been widely held, and have very little, if any, evidence to support them, it is not worth while going into the details of their thermo-chemical reactions; but if worked out it will be found that, like those given above, the calculated E.M.F. falls far short of what is required in every case.

(To be continued.)

ELECTRIC MOTIVE POWER.*

BY ALBION T. SNELL.

(Continued from page 481.)

There has always been a certain fascination about the application of electric power to coal-cutting and rock-drilling. It is not difficult to appreciate this feeling when one has had some experience of coal-getting. Indeed, it has been felt for a long while that a mechanical means of hewing coal was desirable from all points of view. Yet, strange to say, the problem has presented so many difficulties that its successful accomplishment on a large scale still belongs to the future. Of course coal has been got by mechanical means in isolated cases for a long time past, and the difficulties are well known.

These may be regarded under two separate heads, each of considerable weight. The first refers to the mechanical side of the question, and hence properly belongs to the present discussion. The second relates to the system of working and the general management of mines, and cannot be treated here at length. But reference must be made to some of the difficulties thrown in the way of mechanical coal getting by the men and the masters. The use of a coal-cutting machine may seem to be simply a question of the price of coal hewn by it in comparison with the cost of hand-hewn coal. This is undoubtedly the case. But the cost of machine-won coal is at present necessarily based on figures resulting from the use of one or two machines instead of on the basis of a dozen worked on "faces" specially laid out for the purpose. It should be noted that the cost of the prime power for two or three machines is practically as great as that required for a dozen, and the system of mains need not be proportionately increased for the larger number, because the power does not increase in direct proportion to the number of machines, it not being possible to keep them all running at the same time. It is important, too, that machinery should be run as nearly continuously as possible, which suggests the employment of several shifts of men. And this is only possible, even if the men's union permit it, when the conditions are such that the coal can be carried away sufficiently quickly. In the majority of faces, as arranged to-day, this is impossible, and a machine cannot be kept at work continuously for even a shift of eight hours; so that the theoretical output of the machine is never reached from causes which are quite independent of the working capability of the machine. This points to a coal cutter of smaller capacity than those now in use—say a machine which would hole from 5 to 10 yards an hour, working under normal conditions and allowing the necessary time for clearing away the coal. Up to now the aim has been rather to produce machines which, under favourable circumstances, will cut from 20 to 40 yards of face per hour. But a very casual inspection of a coal mine will demonstrate that such a rate cannot be maintained for any length of time, simply from the difficulties of clearing away through gates two chains apart, even neglecting for the moment the difficulty of keeping the face clear from falls of roof during the time necessary for removing the coal.

If mechanical coal-getting is to be carried out on a large scale with the long-wall system, it will be necessary to modify the number and position of the gates in order to increase the facilities for clearing away. The question belongs to mining managers, and not to electrical engineers; and this is, perhaps, one of the chief reasons why mechanically-driven coal cutters have not made as much progress as their undoubted utility appears to warrant. A colliery is being opened out at the present moment near Eckington, in which the whole of the work will be done electrically, even to the driving of the fan. The coal will be worked on the pillar and stall system by Jeffrey coal-cutters. This undertaking is due to American enterprise, and will be watched with the highest interest.

It does not lie in the province of the present work to discuss the question of machines *versus* hand coal-getting. But it may be remarked that one of the best electric coal cutters, with two men to work it, will easily hole as much as from 20 to 30 hewers; thus largely reducing the number of men required below ground. And since the number of accidents bears probably some proportion to the number of men employed, the introduction of machinery should have the effect of largely reducing the loss of life.

The number of mechanical principles applied to coal-getting machines is astonishing, and the ingenuity displayed by many inventors who evidently are not in close touch with the principles of mining is equally surprising. Every conceivable method of cutting, drilling, boring, shearing, or picking coal has been designed, on paper at least, and many of them have been applied to more or less practicable machines. The earliest attempts were made in the direction of a mechanical pick. As

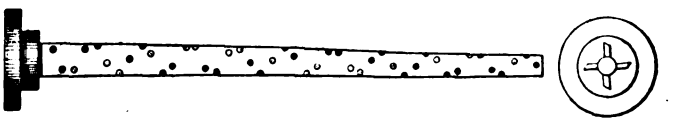

FIG. 119.—Goolden-Atkinson Cutter Bar.

might be expected, the pick, with the man at the back of it directing each blow, did much the better work, and the method was soon dropped. The drill and the circular saw have given the most successful models upon which to work out a cutter, and hence a variety of machines embodying these principles.

The machines which have survived the initial stages and give some hope for future success are divisible into three main classes:—

(*a*) Bar cutters.
(*b*) Rotary wheel or disc cutters.
(*c*) Drills.

Under the first head may be included all those machines which have a cutter bar revolving either at right angles or parallel to the face of the coal. This type has so far proved the most successful in this country and in America, the best known being the Goolden-Atkinson bar cutter of English invention, and the Jeffreys machine of American origin.

The essential feature of the Goolden-Atkinson machine is a tapered rotary bar, which is fitted with a series of cutters driven into tapered holes. They are arranged in a spiral form, the object being to clear out the cuttings and prevent the jamming of the bar. The shape, size, and general arrangement are the result of long and careful experiment by Messrs. Llewellyn and Claude Atkinson, the staff of Messrs. Easton, Anderson, Goolden and Co., and the Electric Coal Cutting Corporation. The cutter bar (*see* Fig. 119) is usually geared to the armature shaft by a pair of cast steel double helical wheels running in oil, and the cutter makes 300 to 500 revolutions per minute, depending on the material being cut. The motors are always wound in series, and hence the speed varies inversely as the resistance which is exactly the best condition for work of this kind, since it prevents undue shocks to the motor, and tends to keep the power absorbed within safe limits. The motor is thoroughly protected from mechanical injury either from falls of

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roof or sides, and the armature and commutator are fitted into a dust tight and flame tight compartment of dimensions as small as consistent with the safe and effective handling of the brushes. The cutting mechanism as a whole is made to swing through an arc of rather more than 90deg. on the turntable which carries it (*see* Fig. 120). This gives facilities for shifting the machine from point to point in the mine, and also enables the bar to cut its way into the coal until it is at right angles to the face and ready for holeing. Fig. 120 gives a view of the machine as arranged for work. In the early machine of this class the coal was always picked out to give the bar a start. Since the bar has to be carried by bearings it may be thought that coal cannot be cut level with the floor by the bar type of machine; but this difficulty is successfully met. By arranging the seats of the turntable at a proper angle, and causing it to revolve in an inclined plane, the makers contrive to keep the from the faces, leaving them ready for the machines. The system on the whole has worked well, and if it were not for the difficulties already referred to, the machines would turn out a much larger tonnage and, of course, return a larger interest on the capital outlay.

The experience of the Corporation, whilst it has demonstrated that nearly every mine, working long-wall, can be successfully operated by electric coal-cutting machines, has also brought into further prominence the essential difference between hand and machine working, and the great difficulties of getting not the men but the owners and managers to appreciate the difference, and to lay themselves out to apply to mines the discipline and regularity obtaining in manufacturing industries.

A modification of the Goolden-Atkinson machine has lately been introduced by Mr. Frederick Hurd, who for some years was

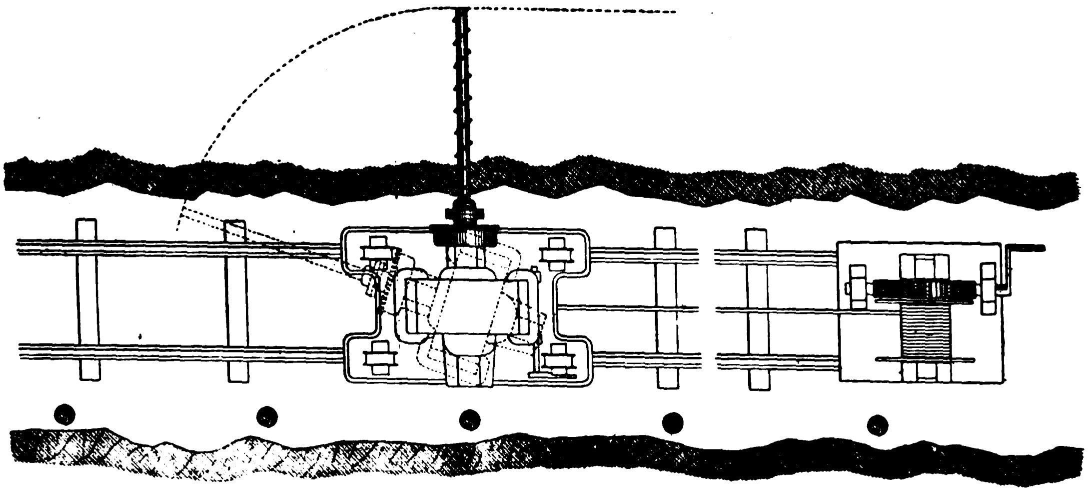

Fig. 120.—Goolden-Atkinson Coal Cutter. Method of Working.

bar nearly horizontal and below the level of the rails when at right angles to the face in the cutting position, and yet to lift over the rails when turned parallel to the face. In this way a flooring of regular slope is made at every cut, and forms the floor for the rails during the next cut. It is not found necessary to level the floor in the majority of cases, although when cutting in coal it may pay to do so. The feed is made by a hand winch as in Fig. 120, or it is worked automatically from the motor shaft. The author believes that hand feeding is found to be the more satisfactory with this machine.

The Electrical Coal Cutting Corporation have for some years been working coal at a contract price per ton hewn or per linear yard undercut to a specified depth. They supply the whole of the plant and the men to work the machine, while the colliery proprietors find the labour for clearing away the coal on the staff of Messrs. Goolden and Co. No particulars of its performance have yet been published. There is a scoop built at the back of the bar to assist the clearing of the cuttings from the hole. This may or may not be an improvement, experience alone can determine. There are also some interesting devices for ventilating the motor and safe-guarding it against the risk of exploding gas. These consist of an elaborate system for circulating fresh air under pressure along the conductors, which are encased in pipes for the purpose, and through the interior of the motor, the starting resistance, and switch-board boxes, &c. The object in view is, of course, most desirable; but the expense necessary to execute the system described in Mr. Hurd's patent specification is probably too costly for ordinary requirements.

(To be continued.)

A LEISURELY LIGHTNING FLASH.

After describing the recent accident at Aldershot, where a captive balloon was struck by lightning, the *Daily Telegraph* proceeded to discuss the historical experiments of Benjamin Franklin and Richmann with greater scientific accuracy than might be expected from a daily newspaper. It fell, however, into a pardonable error, and, after quoting Prof. Tait, said: "A flash of lightning lasts, roughly speaking, about the millionth of a second, as is proved by the fact that the most rapidly moving bodies appear to be at rest when illuminated by it. There is no doubt that if it could be made to endure one-tenth of a second, lightning would appear to be one hundred thousand times more brilliant than moonlight." This might have passed without comment six or eight years ago, but modern photography has shown that the quiver which is often seen in a flash of lightning is due to an actual persistence of the flash. Not, indeed, in a continuous stream, but a succession of flashes closely following each other in precisely the same path. We have a very remarkable negative before us, of a flash of lightning; but efforts at making a reproduction of it to place before our readers have not been very successful. Mr. Eric Crawley had a "Frena" camera in his hand during the thunderstorm of July 13, 1894, in broad daylight, and a vivid flash occurred; he quickly pointed the camera at it, and snapped the shutter, giving $\frac{1}{20}$ sec. exposure—a most useless waste of a film if the *Daily Telegraph* is right. The negative shows one faint forked flash vignetted off on one side, and a broad, ribbon-like flash, wider at one end than the other. The average width is about $\frac{1}{8}$th of an inch. The negative is about 3in. square. Assuming the angle of the lens is about 45deg., the angular width of the flash is nearly 2deg. or four moon breadths. One edge is more intense than the rest, but a powerful lens shows no longitudinal markings. There are, however, numerous transverse markings, some of which are reproduced in the engraving (Fig. 1), which has, with some difficulty, been made from this interesting photograph. The absence of longitudinal markings shows that, if a rapid succession of flashes was taking place, they were so numerous that they left no individual traces; and it is difficult to believe that the flash was in any sense continuous. The presence of fine transverse markings is probably due to a fine

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zigzag structure. This structure is shown, of course, on an entirely different scale, in Fig. 2, which we reproduce from Prof. S. P. Thompson's Paper on Influence Machines.* In this case the zigzags are no doubt due to the jumping of the discharge from dust particle to dust particle, like stepping stones. A large zigzag in a lightning flash may be attributed to differences of temperature or rain-drop density in the path,

Fig. 1.

but it is difficult to account for fine irregularities. Other photographs of lightning flashes have been reproduced in *The Electrician*, Vol. XXI, p. 699 and Vol. XXIII, p. 227. The remarkable feature of this photograph is, that at least a tenth of a second must have elapsed between the commencement of the flash and the attempt to direct the camera towards

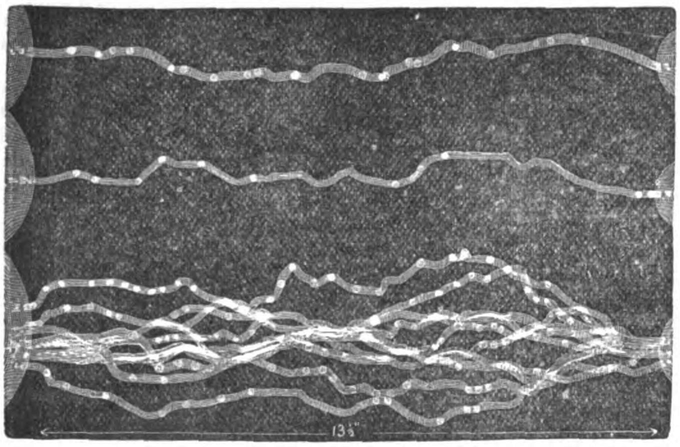

Fig. 2

it. How long it took to do this and to snap the shutter is impossible to guess. The great width of the photograph shows that the camera must have been in motion, and the intense edge, being on the same side in each case, shows that probably at the end of the exposure the camera was practically stationary.

* Society of Telegraph Engineers, May 31, 1888.

NEW AYRTON-MATHER GALVANOMETER.

Mr. R. W. Paul is bringing out a modified pattern of D'Arsonval galvanometer for laboratory and test-room work, where compactness and portability are not the chief essentials. In this instrument the working parts are more accessible and open to view than in previous patterns. The illustration (Fig. 1) shows the galvanometer mounted on a brass base, with levelling screws, and a circular level carrying a tripod on which the magnet is clamped. An insulated socket, connected to one terminal, is fixed beneath the poles of the magnet, and carries a vertical brass tube, cut away in front for the greater part of its length. The suspension strip is fixed to a torsion-head in the upper part of the tube, but is not screwed to it directly ; it first passes through a fine hole in a thin bronze spring, which yields when the instrument is set down roughly, and prevents breakage of the suspension. The lower end of the tube is fitted with an ebonite plug, through which a brass stud is screwed, whoes lower end makes contact on an insulated spring attached to the remaining terminal. This stud is slotted at its upper end,

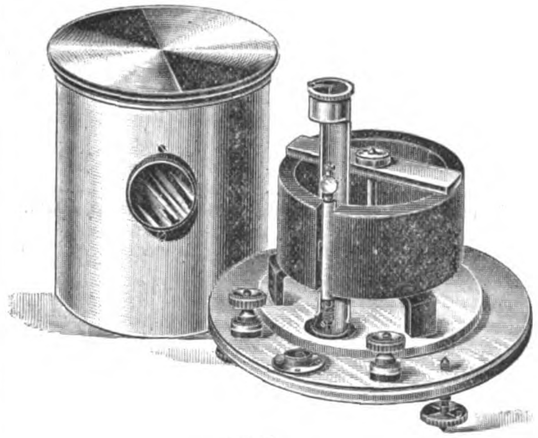

Fig. 1.

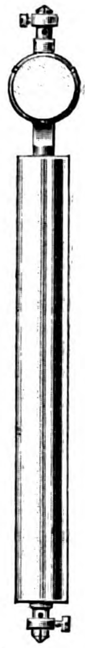

Fig. 2.

and fitted with a collar and set-screw to close the slot ; similar clamps, seen in Fig. 2, are provided at the extremities of the tube containing the moving coil, soldered contacts on the coil tube may be provided for those who prefer them. The cover is made with a lid which can be lifted off to get at the torsion-head and set the spot on the scale.

THE ELECTRIC BRAKE IN PRACTICE.*

BY ELMER A. SPERRY.

(*Concluded from page 644.*)

The current required to be developed to stop a car, when no other braking apparatus is used, is found to be only a fraction of that required to accelerate the car in the same interval. This may be easily illustrated by the lines in diagram 5, A being the electrical energy applied in a given acceleration ; B the resulting mechanical energy stored in the car after deducting all the wastes in the motor, and between the motor and the momentum ; C the average mechanical energy in the car at the time of applying the

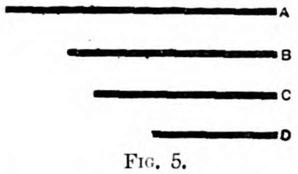

Fig. 5.

brake ; D being the electrical energy required to be developed for retardation after the efficiency losses have all been provided for out of the quantity C. Thus it will be seen that the so-called efficiency losses act in a two-fold sense, between A and B and between C and D, to reduce the amount of current required to be generated for braking purposes.

As to the effect of the electric brake on the total temperature of the motor the following experiments were made. A car and trailer were operated over the line in regular service 41·1 miles without the brake. The temperature of the atmosphere was noted every half-hour during the test, and the temperature carefully taken of all parts of the motor at the end of the run. The succeeding

* Abstract of a Paper presented at the meeting of the American Institute of Electrical Engineers, September 19th.

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day a similar run was made with the same trailer over the same track and in the same length of time, but with the electric brake in use, braking direct on the simple local circuit without brake magnets. The difference in the average atmospheric temperatures during the two days was six and one-half degrees, and the difference in the average temperature of the motor parts was seven degrees, making only a difference of one-half of one degree Centigrade as the total increase of temperature from the use of the brake. Observations in reference to the heat in the reostat were made, although no temperatures were taken, and no difference could be observed in reference to the heating of this portion of the equipment. The explanation will be found in the comparatively small amount of current as seen above, and the relative infrequency of its application, and short duration at the time of each application. The following wattmeter readings have also been taken :—

——	First trip.	Second Trip Trailer.
Reading of wattmeter, leaving Lake View ...	392,538·9	392,542·25
Reading of wattmeter, end of round trip ...	392,542·25	392,547·1
Number of full stops	55	53
Number of slow-ups	42	37
Time	1:40	1:35
Difference in reading	3·35	4·85

Constant of wattmeter equals "22" : total watts both trips, 180·4.

Diagram No. 6 indicates the connection of the wattmeter in the circuit.

Automatic resistances were even at one time used in the endeavour to relieve the motorman of *all* responsibility in connection with the

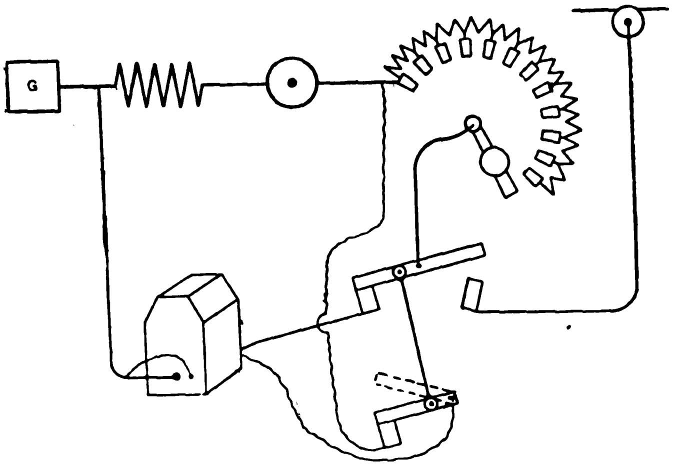

Fig. 6.

control in applying the brake, but superlative simplicity was found to be much more desirable than the superlatively automatic, and the automatic devices were seen to be entirely unnecessary, the apparatus as at present constructed being of great simplicity.

The diagram of the braking current in Fig. 4 (see *ante*, p. 644) shows the automatic decrease in the intensity of the brake application so desirable with the decreasing speed referred to above. As the speed decreases, the generator runs more slowly and consequently produces less and less current.

With this style of brake, the life of the wheels is increased from two to three-fold, thus affording a saving in the item next in cost to the electric maintenance itself, to say nothing of the entire saving in brake shoes. This is emphasised in the fact that the brake shoes are being constantly besmeared with sand and grit thrown from the wheels, and, when in this condition, they are brought against the wheels with the tremendous pressures noted above. A better method could hardly be devised for reducing both wheel and shoe. We little realise the great number of brake applications necessary in a day's run. Careful record has been kept of this point, giving in three days an average of 1,377 brake applications for a run of about 164 miles.

Another interesting feature in this connection is that a flat wheel from skidding is an impossibility. It will readily be seen that should the wheels stop, the generator connected with the axles ceases to produce current, and none, therefore, exists to farther apply the brake, and though they may be sliding forward on the rail, yet the wheels continue to rotate more or less, and constantly present new surfaces for the sliding contact.

The braking action is two-fold and is especially efficient. The rotating armature of the motor, instead of tugging ahead by its momentum, is itself pulling back and more or less powerfully braking the car through the gears by the retarding effort of the magnetism of its field while generating the braking current. The power required, therefore, to perform this work is taken from energy of the moving car which it is desired to destroy ; not only is the car thus retarded, but the electric brakes arrest the motion of the wheels direct, with a force that is remarkably powerful and under perfect control of the motorman.

Two forms of braking magnets are used, one for winding up a brake chain usually employed in connection with the trailer, and another for directly arresting the motion of the axles, one magnet only being used in connection with each axle. These magnets are truck-mounted, not an ounce of their weight being directly on the axle, and are so supported that their gravity acts to automatically retract them from the brake face, the latter showing the link standing out of the vertical. The brake face is automatically lubricated to a slight degree, receives a high polish and does not cut or rapidly wear. The brake is noiseless in its operation. Its crescent form accomplishes important technical functions and also eliminates the necessity of pulling off a wheel for its attachment, removal, or inspection. Its face is *solid unbroken metal*, with no grooves or interstices for catching grit or sand, which in part explains the absence of wear above referred to. The brake magnet is practically indestructible, a few turns of stout wire constituting its one coil entirely enclosed and sealed in metal. No harm nor moisture can reach it. As to moisture, it is immaterial, as the E.M.F. at which it works is extremely small, seldom reaching six volts. The lubricator for the brake surface is dry, not sticky or adhesive, and does not gather sand or dirt and retain it upon the braking face. No mechanical pressures whatever are employed to arrest the car, and hence no strain or shoulder-wear comes upon the journals. In constructing the brake magnets their proportions, and the arrangement of the magnetic circuits received considerable study. It was during some preliminary experiments that an unexpected phenomenon was noticed ; namely, that the retarding effect, when speed is an element, is very much more than would have been expected from the co-efficient of friction due to magnetic attraction or adhesion, this latter being a known and definite quantity. Further experiment, made to ascertain the cause, showed it to be due to Foucault or eddy currents set up in the masses. The conditions and structure of the brake magnet were, therefore, varied in a number of particulars, especially such as would be expected to give the greatest result in Foucault currents produced. The result was immediately successful. It was found that the retarding effect of the brake magnet is due very much more to the generation of these currents than to the direct effect of the coefficient of friction resulting from direct magnetic adhesion, the amount of which, I find, can be relied on accurately when employed by itself. Some of the forms of brake magnets experimented with were provided with numerous poles of opposite polarity, which were worked upon three different kinds of armature, two of which had radial teeth of different number relative to those in the magnet, and one being a plain disc armature. The toothed armature, while it causes a series of sudden jerks and is also unsatisfactory in the total retardation resulting from a given input is found also upon rupture of the magnetic circuit to impart to the magnet coil certain counter E.M.F.'s which materially cut down the current supply and thus the capacity of the device. A magnet formed of a continuous disc with an annular groove sunk in its face is found to give very satisfactory results, but is much heavier and requires an armature twice as heavy for a given number of lines as the double circuit magnet. Furthermore, the relative rotation between such a magnet and its armature affords no point in the masses where the lines are interrupted or changed, and the Foucault currents, or reactionary effect set up, is very much inferior to those in a magnet where a gap or cessation of magnetic stress is easily produced. As a result of these investigations the crescent form has been adopted, the opening in the crescent giving the effect referred to, as well as affording an excellent method of attachment and removal of the brake magnet, and at the same time supplying a gap for easily reaching the face for inspection and lubrication. The belief that the extra retarding phenomenon is that of Foucault or other eddy currents is borne out by the fact that a conducting lubricant, such as graphite, is found to considerably increase the effect ; also metal filling between the polar faces is almost indispensable for the best result, while at the same time effectually protecting the coil from all damage. These observations would seem to indicate that the eddy currents, however produced, circulate in both masses near the surface, and traverse back and forth across the air-gap whenever ample provision is made to allow them so to do. The practical value of the combined action of all these forces in increasing the retarding effect results in necessitating but a small magnet, and a smaller current expenditure considering the work performed.

By reference to Table III., the result in retardation gained through the eddy or other currents may be plainly seen, column A

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indicating the retarding effect which should be expected from a friction coefficient of 10 per cent. between the lubricated surfaces due to magnetic attraction of the lines actually circulating, and column B indicating the values of retardation actually obtained on the dynamometer.

Table III.

Amperes.	Volts.	"A." Pull due to magnetic adhesion or traction. Friction coefficient 10 per cent.	"B." Pull on brake chain obtained. Graphite lubrication.
		Lb.	Lb.
5·0	1·0	7·6	125
9·0	1·8	18·3	300
9·5	1·9	36·4	608
15·0	3·0	121·0	1,976
16·0	3·2	149·0	2,432
20·0	4·0	158·4	2,584
23·0	4·6	167·0	2,736
25·0	5·0	186·0	3,040
31·0	6·2	207·0	3,385
35·0	7·0	213·0	3,490
35·5	7·3	214·0	3,500
41·0	8·5	223·0	3,650

The assumed values are based on a traction of 28·26lb. per square inch for 45,000 lines per square inch, being the assumed values at the knee of the curve easily recognised as occurring between 16 and 20 amperes in the table.

As to the arrangement for application and control of the brake by the motorman, about a year ago the following appeared from the hand of the writer :—

"Considering the inexperience of the operator and the responsibility which at times well nigh overwhelms him, I think that, as engineers, we should be willing to set a very high mark to be attained in the ideal brake for electric street railway service, namely, the use of but a *single controlling handle for everything;* starting, accelerating, retarding and braking the trailer, or trailers and all. Let the motorman have nothing to think of except one handle, and two-thirds of the accidents now occurring will be prevented. Let this handle require no more exertion in its operation than the present controlling handle. Let the motor man fulfil his function with as little physical exertion as possible ; he will then have a greater reserve for mental application when necessary. A motorman required to exert an enormous amount of brute force, constantly grinding at the brake, has but little life left to apply in case of emergency. I agree with a prominent writer on this subject, where he says that a multiplicity of handles is fatal in time of emergency."

At the time the above was written, equipments controlled as therein set forth—namely, by the use of a *single controlling handle for everything*—had been in operation for upwards of a year. The methods employed for accomplishing this have been varied, but the form most in use at the present time is where the resistance contacts are employed in a two-fold manner ; the controller handle is made to operate back and forth over the same contacts for controlling both the application of the current to the motor and braking the car.

The smoothness of even a sudden stop by the electric brake is as though the car was running into an air cushion.

It will thus be seen that the brake is automatic and does its work without any special act or even the knowledge of the motorman. He simply "works a single handle" back and forth and electricity "does the rest." Suppose the motorman wishes to stop his car, he turns off the current by simply swinging the lever over to the right. This operation is made to automatically convert the motor into a special dynamo for generating currents at very low speeds, and also simultaneously to cut off all connection with the trolley current. The brakes are then applied by simply swinging the handle back over the path it has just traversed ; the farther it is swung to the left the stronger the brakes are applied. The act of releasing or letting off the brakes again automatically re-establishes connection with the trolley and reconverts the dynamo into a motor. The same rheostat and contacts are applied to control the motor while running the car, and also to control the slight amount of current generated by the transformed dynamo which is sufficient to brake the train.

The motorman cannot turn on the current before the brakes have been released, nor can he apply the brakes before the current has been turned off. This is a result of construction, and constitutes a feature of merit in the new electric brake, effecting an economy in current and a saving in wear and tear. Freeing the conductor of all care in this connection, and leaving the braking of the train—including trailer or trailers and all—solely in the hands of the motorman by placing at his command a power with which he may with the utmost ease accomplish his task, constitutes an important advance in the art of control of electric railway equipment.

It has been found that the electric brake is practically incapable of abuse by any motorman, an advantage which never before has been attained in any power brake, due to the fact above named, that no amount of over-application can cause flattening of the wheels, or any harm whatever to any part of the equipment through their locking and skidding.

Operating the brake in this manner, it will at once be seen that the system is one of the utmost certainty of operation, surer even than the hand brake, air or other power brake, from the fact that every time the car runs, the motor, which is depended on for the braking action, receives a test, and its fitness and capacity for the next brake application is constantly being demonstrated. On the other hand, the motorman never knows whether his hand brake is sure to operate when called upon for the next application. An accident came under the observation of the writer on Case Avenue hill, in Cleveland. Here the last hand brake application was successful in every way ; but before the brake was called into action again a nut dropped off from a brake rod upon the truck, rendering the brake useless. The motorman continued to wind on his brake staff, and before he realised what the trouble was, his car was going at a tremendous speed into a short curve at the foot of the hill. There were a number of casualties and also six demands for damages as a result. With the air or other power brake this liability to failure is increased in direct proportion to the complexity and number of parts.

The advantages found to result from the practical use of the electric brake as compared with former brake systems ; its qualities as an accident preventer, as well as its general commercial value, may be recapitulated as follows :

1. The certainty of its operation.
2. The enormous power at instant command and under perfect control.
3. The absence of all power absorption at moneyed cost from the central station.
4. Its high efficiency, being far superior to compressed air ; amply proven in numberless instances where electricity has replaced air. (The air requires a direct application of energy, amounting to an immense aggregate power-absorption during the day from the central station ; the working parts of the air machinery are attached to the car axles, and require a large quantity of energy, not only while compressing, but at other times as well.)
5. Its extreme simplicity.
6. Observe saving in wheels, two to three-fold.
7. Entire saving in brake shoes.
8. Lubrication of brake face ; very little wear of either wheel or magnet.
9. Absolute silence of operation and release. (No hissing to frighten horses in streets.)
10. The low E.M.F. at which it operates.
11. The ease of its application and control.
12. Conserving strength, and prolonging the usefulness and life of the motormen.
13. The smoothness of its operation.
14. Cannot cause flat wheels.

Electric Radiation.—In a recent number of *Wiedemann's Annalen*, Dr. Zehnder describes the results of some measurements made with the large prism lately described in our columns. He finds, by two methods which agree within narrow limits, that the index of refraction for the asphalt used is 1·93 for electric waves about 70 cm. long. Hertz found that of pitch to be 1·69. The tinplate shields which had to be used to cut off the rays passing by the prism had considerable influence on the angle of deflection. The reason is that two tinplate shields 80-100 cm. apart, with their plane perpendicular to the direction of the waves, themselves deflect the rays through an appreciable angle, and cause phenomena of diffraction. A diffraction-grating made of several strips of zinc sheet 200 cm. long and 33 cm. wide, enabled satisfactory determinations to be made of the angle of refraction δ; from which together with the width of grating $b = 80$ cm. the wave length λ could be calculated from the formula $\lambda = b \sin \delta$. The average value $\lambda = 69{\cdot}4$ thus found comes fairly near to the value determined by Boltzmann's method. The author also finds that the primary reflector emits a bundle of rays capable of being separated into an electric spectrum, but with his present means could only trace waves from 67·4—73·3 cm. long. He thinks, however, that Sarasin and De la Rive go too far in imagining the radiation contains rays of *every* wave length.

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The Electrician.

(The Oldest Electrical Journal, 1861—1878.)

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WATER-POWER IN GREAT BRITAIN.

The problem of the utilisation of the water-power of this country is one which has a great fascination for the minds of those who imagine they see in it a means of obtaining energy for nothing, and in the electric current a means of transmitting that more than cheap energy to an indefinite distance. But, before the steady arithmetical gaze of an engineer, these glorious qualities shrivel to a finite magnitude of very limited dimensions; and it is perceived that neither can water-power ever be obtained for nothing, nor can its useful effect be transmitted electrically to more than a certain distance without the serious and effective competition of other sources of power. Of the two sides of the water-power problem—namely, where to use it and how to use it—the former is by far the most difficult, though at the same time the one least recognised. Every babbling brook is the equivalent of so many 8-c.p. lamps, in the eyes of some people; and every out of the way waterfall is a thing whose energy is to be hurried as far as possible along a cable to the haunts of men. It is a very intricate matter, in these little British Isles, this question of where to utilise water power; and, if even half of the truth were known, it would be seen to be chiefly a matter of where *not* to use it. It may seem rank waste to let the foot-pounds of a stream do nothing but dissipate themselves in fruitless heat, degrading the universal energy and hastening the end of all things. But if, to appro-

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priate those same foot-pounds for the use and convenience of man, it is necessary, first of all, to go to a place more or less remote from the other place where the foot-pounds are really wanted; secondly, to undertake costly constructive and other works around and about the stream; and, lastly, to purchase, erect, and keep in working order an alternative plant which can be conveniently called into use when the water foot-pounds fail—as they mostly do—to supply the power which is needed; if all this, and more, is necessary, there is little wonder that some engineers are content to let the foot-pounds burble their natural way along the native brook bed. Seen in this light, the problem of where to utilise water power resolves itself into a comparison between the total cost of its adoption and the total costs of other possible schemes. The balance will generally be found to turn against the water power scheme with a very decisive kick. Not that hydraulic engineering is to be blamed; it is the fault of the geological and meteorological forces which moulded these little isles and apportions their rainfall. Still, there are localities in our country where geologic steepness or meteorologic prodigality, or both combined, enables a foot-pound to be obtained cheaper than in any other way, and where this boon is a fairly constant blessing. At these hydraulic oases the exception proves the general rule.

The question which the electrical fraternity will be asking itself this week will, in all likelihood, be: Is the Powick mill site at Worcester one of these hydraulic oases, where it is worth while trying to take the energy out of the water and to transmit it along three miles of cables? Without doubt, taking the advantages with the disadvantages, the Powick mill site is far better than the average in this country. And most of the still better ones are protected in the interests of navigation, and are thus hampered or rendered useless for power purposes. Yet, although this mill site is so superior to the available average, he would be a bold man who should now say that it has been better to utilise it than to leave it alone. Time alone will reveal the precise value of the water-power at Powick; but it is even now possible to discover some of the more serious limitations to its utility. Reference is made in an article which we publish this week, describing the Worcester station, to the two conditions under which water-power at Powick becomes unavailable. The first of these, arising from drought, will occur during the summer months, at a time when the maximum demand is not very large. It is comparatively unimportant, and is only significant in so far as it shows the need for steam plant. But the second occasion for the turbines being rendered *hors de combat* is one which, if it occurs at all, is likely to take place during the wintry months, when not only is the load heavy for a longer time, but when its maximum is very much in excess of the summer maximum. What does this mean? It means that the station must be so equipped with steam plant that, without the turbines working, the maximum possible demand on the station can be adequately met. In other words, the auxiliary plant at the Powick water-power station must "coincide with and be of the same magnitude as," as it were, the water-power plant itself! To this, then, has the problem reduced itself: that water at Powick is only of use as a means of avoiding the use of already existing steam plant, at a time when to use the steam plant would be uneconomical. The turbines are a mere go-between and stand-by for the steam engines. It is a very small game for such a big candle. Nevertheless, we wish every success may attend the Worcester scheme; nothing would please us better than that it should succeed. It is a heroic experiment to make in a country like ours; and, even on that account alone, the gods should prosper it.

THE BOARD OF TRADE ELECTRICAL STANDARDISING LABORATORY.

This laboratory was established in consequence of a deputation comprising most of the prominent members of the electrical profession, to the Board of Trade in 1889, for the purpose of urging the necessity of the establishment of such an institution. A scheme was submitted by this deputation for the establishment and working of a standardising laboratory, and this scheme has been kept in view as far as was consistent with the amount of money procurable from the Treasury.

The laboratory exists for three purposes: First, to obtain and preserve standards for the measurement of electrical quantities; second, for giving the standard measurements of those quantities; and, third, to enable the Electrical Adviser of the Board of Trade to make such tests of instruments and material as may be necessary in the performance of his duties. No scientific work outside these purposes can be undertaken.

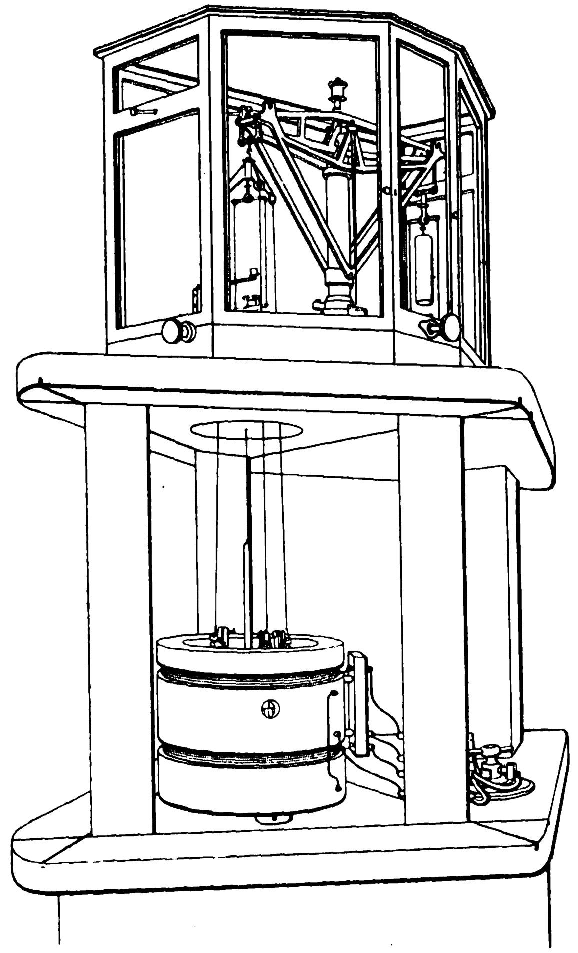

Fig. 1.—The Ampere Balance, showing the weight raised from the scale pan by the lifting gear.

Six rooms are in occupation in the basement of No. 8, Richmond-terrace, Whitehall. One of these is occupied by the gas engine and dynamos, used solely for charging accumulators; another by the accumulators, from which all the power used in making electrical measurements is obtained. These two rooms are outside the main building. The rooms within the main building are, first, the room containing the standards for current and pressure and the necessary adjuncts; second, the room containing the transforming machinery, where the power derived from the accumulators is transformed as required; third, the room occupied by the standards of resistance and the Clark cells used as sub-standards, this room being used exclusively for measurements connected with resistance and the comparison of electromotive forces; and, fourth, the verification room, where commercial instruments sent for the purpose are verified. Beyond the verification room is fitted a small chemical laboratory.

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The use of these rooms will be better understood, if we begin first by describing the important instruments which they contain, and the method of working with them. As in an observatory, the laboratory has been adapted to the instruments rather than the instruments to the laboratory, and it is better, therefore, to turn attention first to the two main pieces of apparatus, the Ampere Balance, and the Volt Standard.

STANDARD OF ELECTRICAL CURRENT.

Construction and Use of the Instrument for Determining the Standard of Electrical Current.

The complete instrument is shown in perspective in Fig. 1, and the details and connections in Figs. 2 and 3. It is constructed as follows :—

Balance and Supports.—A sensitive balance, suitable for the accurate determination of weights up to five kilogrammes, with a beam 16in. in length between the knife edges from which the scale pans are hung, is fixed on an upper horizontal platform of marble, supported on four marble columns at a height of 2ft. 3in. above a similar platform fixed on a suitable stone pier, bedded solidly in a mass of concrete, and kept clear from contact with the wooden floor of the laboratory.

Marble Cylinder.—On the lower platform is placed on three supports, details of which are given below, a cylinder of white statuary marble, partly hollow (*see* Fig. 2).

The cylinder is thoroughly impregnated with paraffin wax. A block of ebonite, *e* (Fig. 2), is fixed on one side of the cylinder, and serves as a terminal board.

Fixed Coils.—Two circular grooves are cut completely round the cylinder, in which are wound coils of No. 18 standard wire gauge (0·12cm. diameter), insulated with two coverings of white silk. The wire was passed through a bath of shellac and alcohol as it was wound on the marble, and each layer was well coated with the same material when in its place.

Each coil has 16 turns per layer and 16 layers of wire.

The coils are both wound in the same direction, and the outer ends are strained tight and secured to terminals *t t* (Fig. 2).

The inner ends are passed through the marble and secured to bolts in connection with terminals *i i* (Fig. 2).

Sighting Holes.—Between the grooves on the marble cylinder, at points equidistant from each other, are bored through the marble three sighting holes, one of which is shown at *h* (Fig. 2). These holes are closed on the inside by glass, the exact centres being indicated by the intersection of two straight lines engraved in the glass, and also by the angle of a quadrant of tinfoil affixed to the glass.

Suspended Coil, Suspending Wires, &c.—A circular coil, shown in sectional elevation at *c* (Fig. 2), and of the dimensions given, is suspended from one end of the beam of the balance by means of three gilded phosphor bronze wires 0·086cm. diameter, *w w w* (Fig. 2). These wires pass through an an aperture in the upper marble platform.

The wire in this coil is the same as in the fixed coils, and is similarly insulated and varnished. There are 18 turns of wire in each layer and 18 layers. Each complete layer was allowed 24 hours to dry after being coated with shellac varnish before the next layer was put on.

The coil is covered with a taping of silk ribbon, closely laid on to overlap, and varnished with shellac in alcohol, four coats, each being allowed to thoroughly dry before applying the next one.

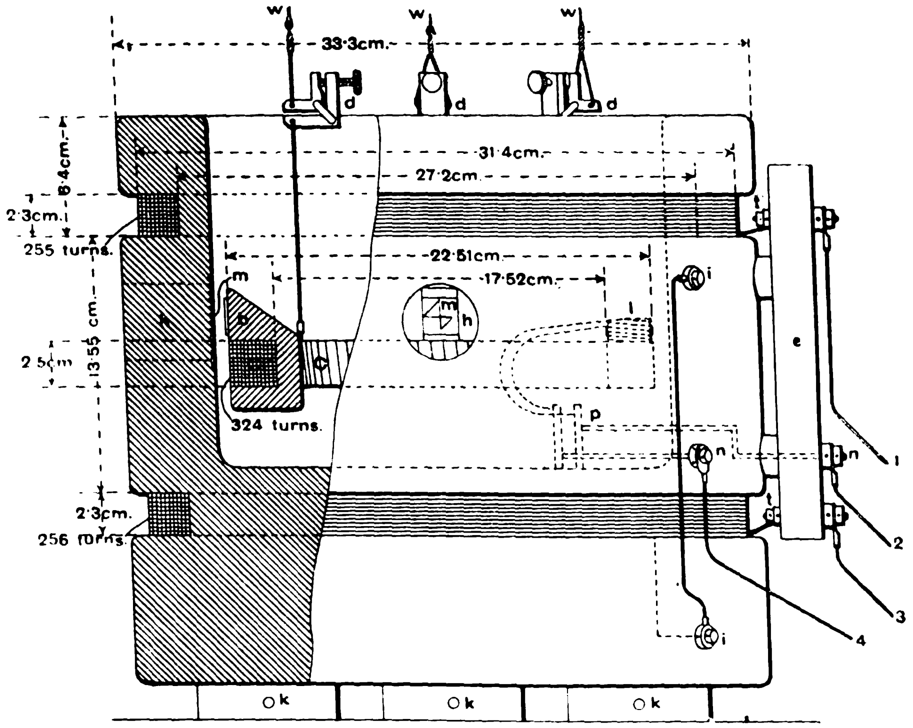

Fig. 2.—Elevation and Part Section of Marble Cylinder.

The ends of the coil are brought out near each other on the upper surface at *l* (Fig. 2). A considerable length of wire is left for each end, and is formed into a spiral, and then projected horizontally to the centre of the coil, where the stiff wires terminate, and flexible connections are made by three silk-covered silver wires, No. 40 S.W.G., from each to the posts *p* (Fig. 2), which are connected to terminals *n n*.

Three ebonite blocks *b* (Fig. 2) are fitted over the coil, as shown, and secured by a lashing of silk thread, the suspending wires being attached to brass eyelets screwed into the ebonite.

At *d d d* (Fig. 2) are shown ivory cranks for effecting the vertical adjustment of the suspended coil.

The attachment of the suspending wires to the balance is effected by ivory rings, which are hooked on to a three-legged fitting, this being hooked to the stirrup, hung on the knife edge of the beam (*see* Fig. 1).

The scale pan is also hung from this stirrup, as shown in Fig. 1.

On the upper part of each ebonite piece, *b*, facing the sighting hole *h*, is fixed a mirror, M, the centre being fixed by the intersection of cross lines and by the angle of a quadrant of tinfoil.

Adjustments.—The proper adjustment of position of the suspended coil is indicated by the coincidence of the angles of the

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tinfoil quadrants on the mirrors *m*, and the glass back of holes *h*, when the eye is so held that no reflected image can be observed.

Eccentric Movement for Horizontal Adjustment.—A means of fine horizontal adjustment is provided in the supports of the marble cylinder, which are three short slate cylinders, *k k k* (Fig. 2), having projections from their upper and lower surfaces, the upper projection being eccentric and fitting in a hole in the bottom of the marble cylinder, and the lower projection being concentric and fitting in a radial groove in the marble slab.

The Weight.—The iridio-platinum weight shown in Fig. 1 can be lowered into the scale pan, and released from the outside of the case by a system of levers.

The weight is accurately 33·55 grammes.

Enclosure.—The marble cylinder is enclosed by means of three sheets of plate glass, which slide in grooves cut in the marble platforms, and when in position are in contact with the sides of the three marble columns adjacent to the cylinder, these sides being coated with baize, the plan of this enclosure being an equilateral triangle with the axis of the marble cylinder at its centre. The planes of the three glass sheets are respectively parallel with those of the glass at the back of the sighting hole viewed through them.

The balance is enclosed within a case of mahogany and glass (*see* Fig. 1), and arrangements are made as indicated for manipulating the rider weights of the balance and the ampere weight from the outside of this case.

The whole enclosure is fairly dust-tight, and sufficiently air tight to prevent any disturbance of the weighing operations by currents of air.

Connections.—The connections to the reversing switch Z (Fig. 3) are brought outside the enclosure by means of rods passing through the marble column adjacent to the ebonite block. Fig. 3 shows these connections, and the direction of the current through the various parts of the apparatus, the lower arrows over the fixed coils showing the alteration of direction caused by operating the switch.

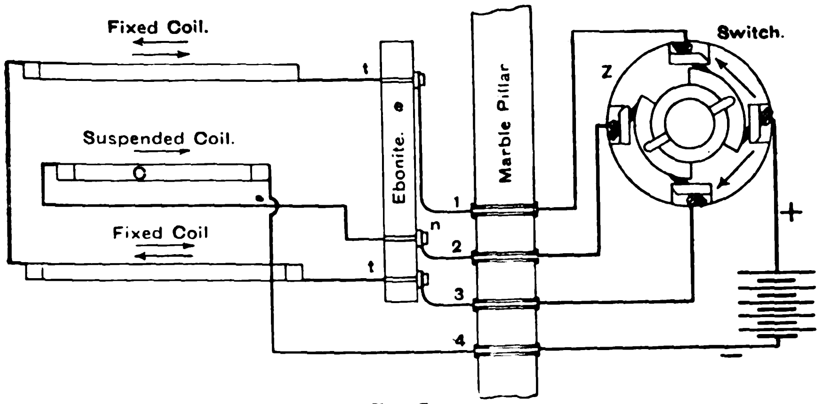

Fig. 3.

Auxiliary Current Balance.

In the construction of the standard ampere balance the chief object aimed at has been the securing of the greatest possible constancy and precision of determination.

On account of the slow period of vibration of the beam, however, the use of an auxiliary instrument has been found advantageous.

This is a special form of Lord Kelvin's current balance instrument arranged to balance with a current of one ampere passing through the coils when a certain weight is applied to one end of the beam, equilibrium being also maintained when, with no current passing, this same weight is applied to the other end of the beam.

Use of the Instrument.

The standard balance, auxiliary balance, and the instruments to be standardised, are connected in circuit with a sufficient number of accumulators, and an adjustable resistance, part of which is capable of continuous variation. The whole circuit is arranged so that a current of approximately one ampere will pass on completion of the circuit.

This current is allowed to pass continuously for at least one hour, being directed through the coils of the standard, so as to increase the force of gravity on the suspended coil, and the counterweight in the right hand pan being adjusted from time to time.

At the end of this preliminary period the current is stopped for a short time to take a reading of the zero of the auxiliary balance, and apply a correction by means of the rider weight, if necessary. The current is then again put on, and as rapidly as possible regulated by means of the adjustable resistance to exactly the value of one ampere, as indicated by the auxiliary balance.

The counterweight in the right hand pan, standard balance is also exactly adjusted.

The switch Z (Fig. 3) is then operated to reverse the current in the fixed coils, and at the same time the weight is lowered into the left-hand scale pan.

The balance should then still be maintained when the current, after adjustment, if requisite, is exactly one ampere by the auxiliary balance.

(To be continued.)

THE CONSTRUCTION OF RESISTANCES.*

BY D. K. MORRIS

(Concluded from page 629.)

Rheostats and Resistances for the Absorption of Power.

These can be divided into—those capable of perfectly gradual adjustment and step by step resistances.

The only way of having a perfectly gradual adjustment if the resistance material is in the form of wires, is to have a sliding or rolling contact. But the uncertainty of such contacts is a serious drawback to this form of resistance, especially when working with small currents; for a contact which would offer no appreciable resistance to the passage of two or three amperes might, nevertheless, measure a considerable fraction of an ohm on a Wheatstone's bridge.

The most common form of such resistance has two rollers, and the wire is rolled from one on to the other. One of the rollers is either made of slate, or is covered with an insulating material such as ebonite, asbestos, or varnished paper, while the other surface is usually nickel-plated, so as to present always an unoxidised surface.

The wire passes from one to the other over a kind of saddle, which travels along by a screw thread on the axis of the handle.

In the best forms there is, just behind the handle, a toothed wheel which gears into two identical toothed wheels at the end of each cylinder, and the tension of the wire is preserved by having a partially wound-up clock spring within one of the cylinders.

In the resistances for use with the Thomson-Houston traction motors, a rheostat cable is employed, consisting of 42 No. 20 steel wires twisted round a hemp centre.

Carbon Plate Rheostats.—This is a very useful form of resistance. The following is a description of one made by R. W. Paul, of Hatton-garden:—

Forty plates of ordinary gas carbon, $3\frac{1}{2}$in. square and $\frac{3}{8}$in. thick, are supported in, but insulated from, a metal frame, and by means of a cast-iron terminal plate and a screw these may be pressed together to any desired amount. Such a resistance carries, when compressed, 25 or more amperes without heating, and can be varied within fairly wide limits, which the makers state to be 25 ohms down to $\frac{1}{25}$th of an ohm.

Still lower resistances can be obtained by the use of an intermediate terminal plate.

Another handy form of carbon resistance is made by this firm; it is known as the Varley Carbon Rheostat, and consists of discs of flexible carbonised cloth strung on to an insulating

* A Paper read at a Student's Meeting of the Institution of Electrical Engineers, March 16, 1894.

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central rod between terminal plates; and, by a nut and screw, this column can be compressed.

Liquid Resistances.—A very simple form can be made by cutting two channels side by side in a wooden base, into which are screwed two terminals, one at the end of each channel; these can then be filled with mercury. Tinned copper lugs connect the mercury with the terminals. The resistance between the latter can then be continuously varied by sliding along a copper bridge piece, the ends of which are tinned. This may be rendered more portable by replacing the two channels by vertical glass tubes filled with mercury, connected at the bottom to two terminals, and bridged over at the top by a bent copper rod, the arms of which are capable of reaching right down the tubes. In the latter form the mercury can be replaced by a solution of zinc sulphate, or other conducting liquid.

The following is a method of absorbing a large quantity of power readily. Two large lead plates are fastened to a frame so that they can be raised out of, or lowered into an insulated tub containing water. The resistance thus obtained can be varied within wide limits, not only by raising or lowering the plates, but by adding more or less acid to the water.

Taking a common value for e (0·00025), and a permissible rise of temperature of 60°C., we get *watts which can be absorbed per metre* $= 20\,d$ *in centimetres*, or $50 \times$ *diameter in inches.*

You will notice that it does not depend on the material. This is as it should be. Of course the current required to produce a waste of 1 watt per metre is not independent of the material (it is easy to show that it is inversely proportional to the square root of the specific resistance); so it will require $3\frac{1}{2}$ times as much *current* to heat a copper wire to a given temperature as a similar iron wire; but, owing to the difference of resistance, the expenditure of energy will be the same. Hence, roughly speaking, a

No. 25 wire	will absorb	1	watt	per metre.
„ 19	„	„	2	„	„
„ 16	„	„	3	„	„
„ 14	„	„	4	„	„
„ 12	„	„	5	„	„

These results must not be regarded as being worth very much, as they are very considerably altered by the state of the surface, and by the amount of air convection; but, under ordinary circumstances, they give a rough idea of the energy which can conveniently be absorbed by wires of various gauges.

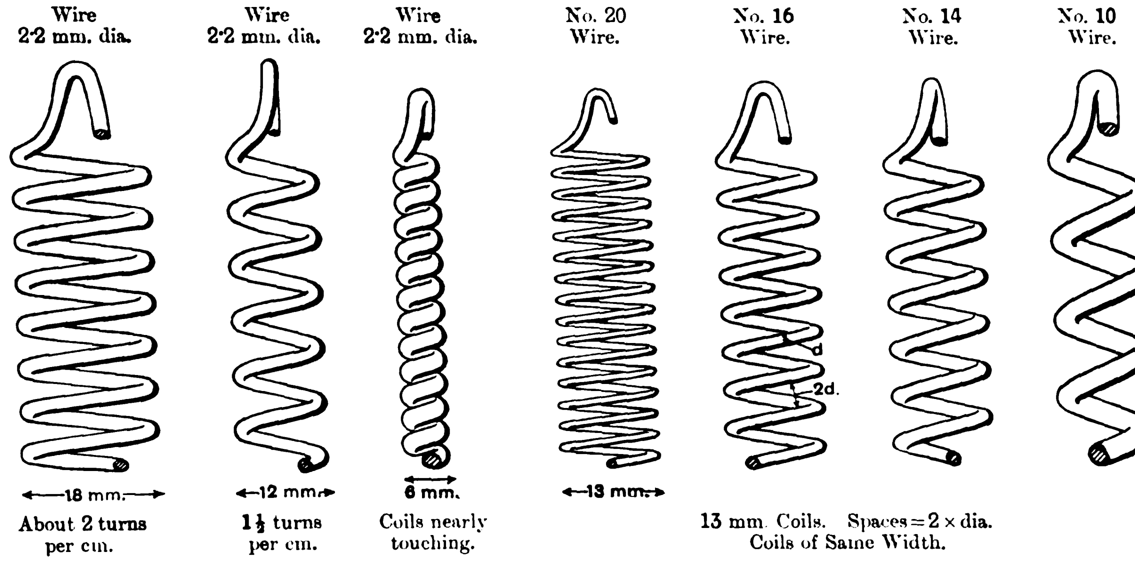

FIG. 14.—Resistance Coils. Spacing of Convolutions for most Rapid Cooling, absorbing maximum watts per metre of Wire (if same rise of temperature be allowed in all cases). From experiments by Herr Dettmar (see *Elektrotechnische Zeitschrift*, December 15th, 1893).

Step by Step Resistances.—These fall into two groups—series resistances and parallel resistances. Before proceeding to describe such resistances, some general considerations on the heating of wires in air will, perhaps, not be out of place.

To find a law connecting the diameter, d, of a conductor with that strength of current c which will raise its temperature $t$deg. above the surrounding air.

If there is equilibrium of temperature the wire must radiate heat as fast as it is generated, and this applies to any given portion of the wire; so the heat generated per second in 1cm. length of wire must be equal to that radiated and conducted away per second from the same piece. If e be the number of units of heat radiated and conducted from 1 sq. cm. of surface of the wire per second when the excess of temperature is 1°C., then $e\,t^{\circ}$ will be that, when this excess of temperature is t°C., and since the surface of 1cm. length of the wire is πd, we have—

$$\text{Heat radiated per second is } \pi\, d\, t^{\circ} e, \text{ or in ergs}$$

$$\pi\, d\, t\, e \times 42{,}000{,}000.$$

This must equal $C^2 R$, also expressed in ergs.

If C is in amperes, and R in ohms, then $\frac{C}{10}$ and $R \times 10^9$ are in absolute measure—

$$\pi\, d\, t^{\circ} e \times 42{,}000{,}000 = \left(\frac{C}{10}\right)^2 \times (R \times 10^9);$$

$$\therefore \pi\, d\, t^{\circ} e \times 4{\cdot}2 = C^2 R = \text{watts absorbed per cm. length.}$$

The above figures correspond to about 1 watt per 16 sq. cms. of surface.

[Dr. Fleming finds that, with rods made of plumbago and plaster-of-paris in various proportions, it is possible, without undue heating, to get rid of 1 watt with 6 sq. cm. of surface only.]

With wires wound in spirals, as is often done, the radiation on the inside is retarded; but the steady current of air which rises up the inside counteracts this in a measure.

According to some experiments by Herr Dettmar, of Frankfort (see *Elektrotechnische Zeitschrift*, December 15, 1893), there is a particular spacing of coils of a spiral of wire in air, for which the current is a maximum, which will cause a given rise of temperature. These are experimental results, and a definite law connecting them has not been given (*see* Fig. 14).

General Remarks on Resistance.—In series resistances it is important that the switch contact is fully large enough to bridge over the space between the points, for otherwise the circuit would be broken; and a stop must be placed so that the switch contact cannot pass beyond the point of least resistance, and so break the circuit when the maximum current was flowing.

Resistances for high-tension work should be very carefully insulated and placed out of reach of accidental contact. As a typical form of series resistance, the following, as made by Nalder Bros., may be given. Two blocks of slate in cast iron settings are fixed at a distance apart by two iron rods. Open

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coils of iron wire are stretched between them, 11 in front and 11 behind, and all connected in series. A twelve-point switch is connected, so that the first point gives no resistance, the next puts two coils in circuit, the third four coils, and so on.

For many purposes parallel resistances are more convenient; for instance, in making a dynamo test, it is desirable to increase the load by equal amounts, and if the energy is taken up wholly on such a parallel resistance, the load increases with uniform steps with the number of wires which are thrown into parallel—quite unlike a series resistance. Each element of a parallel resistance must be capable of standing the full pressure for which the resistance is intended.

As an example of a good form of such resistance, I have taken one of those designed by Dr. Fleming, which we have in the dynamo room at University College (Fig. 15). Each element of the resistance consists of a pair of No. 32 manganese steel wires connected at one end to a common brass bar, passing up the wall over a porcelain insulator 12ft. above, and down again to another small insulator, whence it is finally connected to one point of a suitable parallel switch. Such an element takes a current of 2 amperes at 100 volts. In order to keep the wires tightly stretched in spite of the increase in length due to heating, which amounts to a full

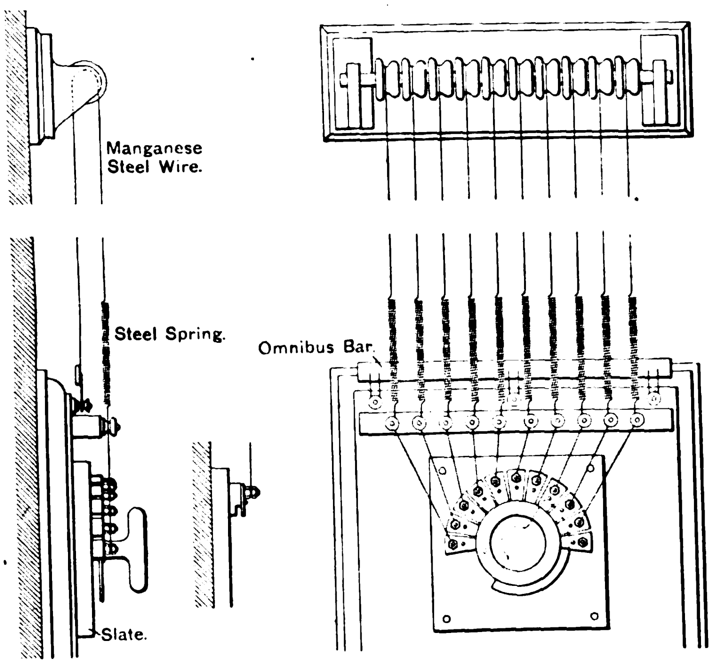

FIG. 15.—Parallel Resistance, Side and Front Elevations.

inch on this length of 24ft., a steel spring 7in. long is interposed as shown, and to avoid spoiling this spring by overheating it is shunted by a wire which carries most of the current.

Ten of these, connected with a ten-point switch, form a convenient resistance capable of absorbing nearly 3 H.P.

Wire resistances of this kind are capable of absorbing a much larger amount of power if immersed in water; but, of course, electrolysis occurs whenever a difference of potential of two or three volts is maintained in the same vessel of water. This can be obviated by using a liquid which is not an electrolyte, such as paraffin oil. The author has not had any experience of such resistances.

Incandescent lamps are extremely useful and convenient for absorbing power, especially in alternate-current work. One horse-power can be absorbed in 10 ordinary 16-c.p. lamps in a very small space compared with a wire resistance. Two groups (arranged in parallel) of 24 lamps in series will serve as load for the testing of a 5-H.P. 2,400-volt transformer. Such a resistance has *very* small inductance.

For many purposes, however, it is necessary to know the value of a non-inductive resistance in ohms; and, if this is required accurately, carbon, or any other material with a large temperature coefficient, is useless.

A form of resistance which has extremely low inductance and a large cooling surface, so as to avoid rise of temperature as much as possible, was described by Prof. Ayrton and Mr. Mather in a Paper read before the Physical Society in 1891. It is, I believe, still in use at the Central Institution.

Twelve platinoid strips, each 6m. long, 4cm. wide, and ¼mm. thick, were used. Each strip was doubled on itself, and kept separate by two layers of shellaced silk. This was bound together at intervals by a silk ribbon, and they were then arranged in a suitable frame.

WORCESTER ELECTRIC SUPPLY STATION.

Unless the unexpected happens, the forthcoming week will witness in one event the inauguration of the electric light for street and general purposes at Worcester, and the starting of the largest and most important water-power electric supply station in the United Kingdom. For many years the Worcester Corporation had been considering the advisability of acquiring control of the city lighting, and had contemplated the purchase of the gasworks. Early last year, however, these plans were modified by a suggestion that the Corporation might start an electric supply; and the utilisation of water power for the purpose was discussed. Whatever intention there may have been, at one time, to use the water of the Severn, it was quashed by the objections of the Severn Navigation Commissioners; and the timely offer of a mill-site at Powick, on the river Teme, a tributary to the Severn, at a point between two and three miles from Worcester, led definitely to the adoption of the scheme which has now almost reached practical completion. The then city surveyor and Mr. Thomas Caink, the present engineer and surveyor to the city, prepared plans involving the outlay of £23,500 on plant and apparatus, and £15,000 on the station buildings. Careful comparisons between the flow and fall of the stream at the mill site, and the probable demand for electric supply, for each month in the year, showed that it would be necessary largely to supplement the water power by steam power. The mill site at Powick suffers from two principal defects: firstly, in the drought, from an insufficient supply of water; secondly, in flood, from the partial or complete loss of head due to the tailing-up of the bottom water. As the chief causes of flood arise on the Severn, during the periods of heavy rains the entire mill site is converted into almost level backwater of the Severn, and the use of water motors is rendered impossible. The normal fall is 10ft., and the maximum possible—when the stream bed has been fully excavated—will not be more that 16ft. The turbines are worked on falls down to as low as 3ft., beyond which it is more economical to close the gate and use steam power. The normal power developed by the turbines is 350 H.P., but with exceptionally favourable conditions 500 H.P. may be utilised. No artificial mill-pond has been excavated, and the head race is far from capacious; so that the reservoir space entirely depends on the amplitude of the weir over the natural stream, and this, it need scarcely be observed, does not permit of very much storage, except during dry seasons. Consequently, the water cannot, as a rule, be conserved for use during the nightly period of maximum demand; but it serves the very useful purpose of taking the light day loads, enabling the steam plant to be shut down.

The supply station at Powick is built on arches over the mill stream, as will be seen by reference to the accompanying illustrations. We may call the attention of our readers to the expensive character of the foundation and structural work on a water-power station, as compared with an ordinary steam station. Fig. 1 shows the plan of the mill site, buildings, and generating plant. Water from the upper stream flows, by a deviation from the natural course just above the weir—which is not shown—along the head race H. A portion of this water may pass along the by-wash W to a neighbouring mill, M, or to waste; the remainder is strained by the gridiron gratings G, and passes through three passages into the wheel pits, or flumes, in which the turbines are set. These flumes are immediately below the engine house E, and are vertically above

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the three arches—shown in Fig. 2—from which the water motors discharge into the tail race T. Fig. 2 gives a transverse elevation of the turbines and their setting, looking down the stream. There are four turbines, each of the mixed flow type known as the "Victor" turbine. They are supported on stone rings built into the crowns of the brick arches. The four turbines, A, B, C, D, (Fig. 2) are geared to the three alternators, 2, 3, 4, (Fig. 1) in the following manner. Turbine A is a 54in. engine, capable of developing 160 H.P., and it drives a vertical shaft, upon the upper end of which is carried a large morticed wheel, the teeth of which are of Scotch fir. This horizontal wheel is geared to a vertical cast-iron bevel wheel on a countershaft which is in alignment with the spindle of a cast-iron rope pulley. On the other side of this pulley, and also in alignment with its spindle, is the extended crank shaft of a vertical steam-engine. The 100 H.P., and turbine D is a 30in. engine, capable of developing about 60 H.P. These two turbines will together develop about the same power as either A or B. The object in view in thus subdividing the engine power of one set is to enable a small amount of load to be met without working a turbine at less than full power. A turbine worked at very much below its normal load is far less efficient than at full load. The arrangement of the turbines with respect to the gearing and alternators is shown in the longitudinal section of the mill site and plant in Fig. 3. This illustration also shows the excavation and construction work which has been rendered necessary in developing the site, the natural bed of the stream being shown at the extreme right of the drawing.

The chief feature of interest in the Worcester electric supply station being the use of water power, we have written our descriptive account of this station almost entirely from this point of

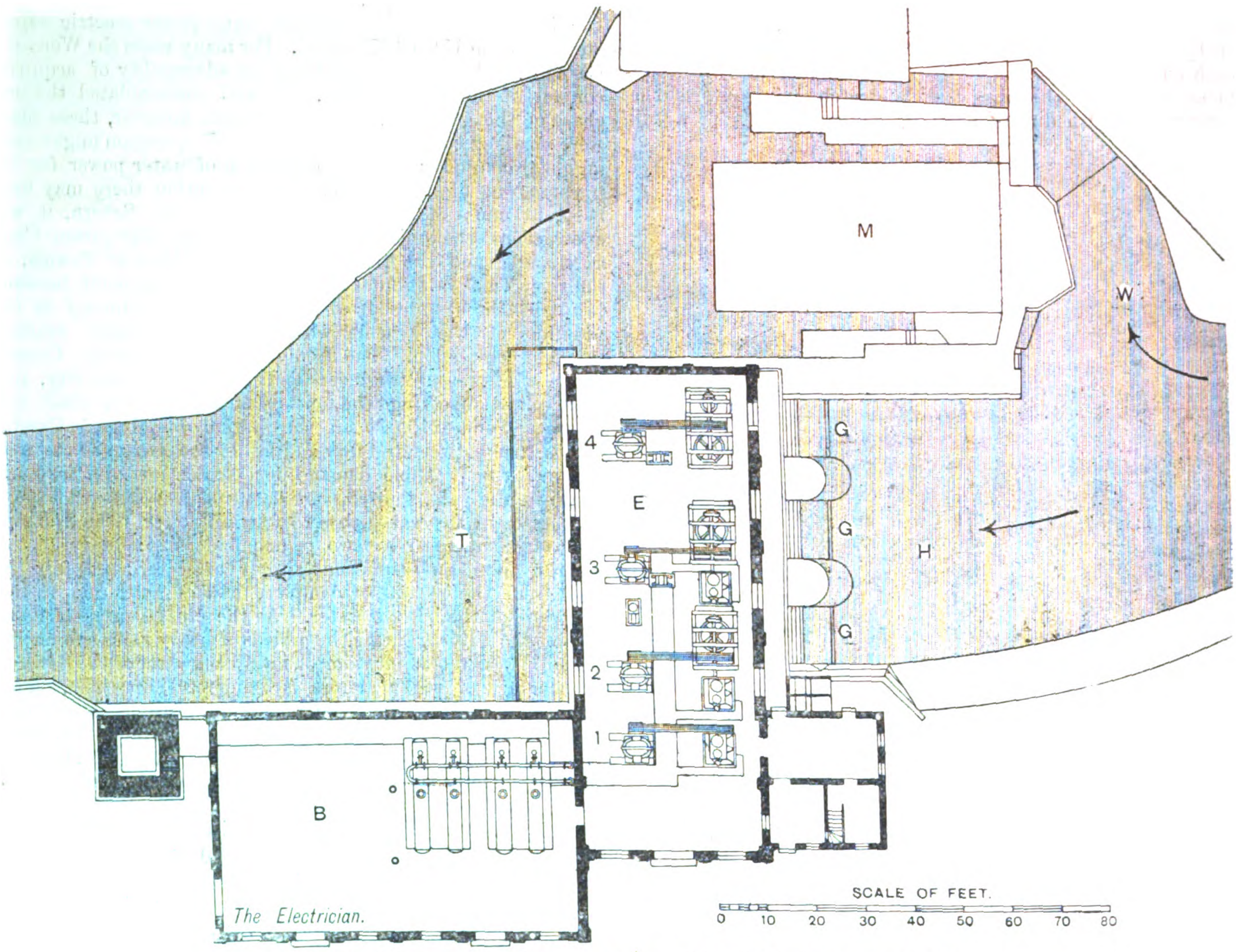

FIG. 1.—Worcester Electric Supply Station. Plan of Mill Site and Machinery.

pulley drives the 125-kilowatt alternator 2, by means of 10 ropes. By means of a four-jaw claw clutch, the turbine countershaft can be coupled to the pulley spindle; or, by means of a Snyers flexible coupling, the steam-engine can be coupled to it. When both couplings are fast, both steam and water-power may be used for driving the same alternator. Each of the alternators is constructed to develop 58 amperes at a pressure of 2,200 volts, with a frequency of alternation of 100 ∿ per second. Turbine B is geared to the alternator 3, and to a similar steam-engine, in the same manner as turbine A, the two sets being exactly similar in every respect. The end sets of plant, 1 and 4, however, are somewhat different. The alternator 1 is capable of being driven only by steam power; the alternator 4 is capable of being driven only by water power; namely, by the two smaller turbines, C and D. Turbine C is a 48in. engine, capable of developing a little over view. The electrical features of the system present nothing of novelty or special interest, with the exception of the system of mains which has been adopted, and reference to which will presently be made. Some further particulars of the utilisation of water power at Powick may, therefore, be interesting and instructive. We have said that a mixed flow type of turbine is in use. An illustration of the vanes in this turbine is shown in Fig. 4. The water passes from the wheel pit, through a number of guide blades, into the upper spaces between the vanes. Its course in then inwards, then downwards, and, finally, obliquely outwards, as it glides over the vane surfaces. After leaving the turbine the water enters the draught tube, the lower lip or orifice of which is immersed in the tail water. This tube is shown in both Figs. 2 and 3, and its object is to enable the engine to utilise the head down to the bottom level, however low or high the water may stand in

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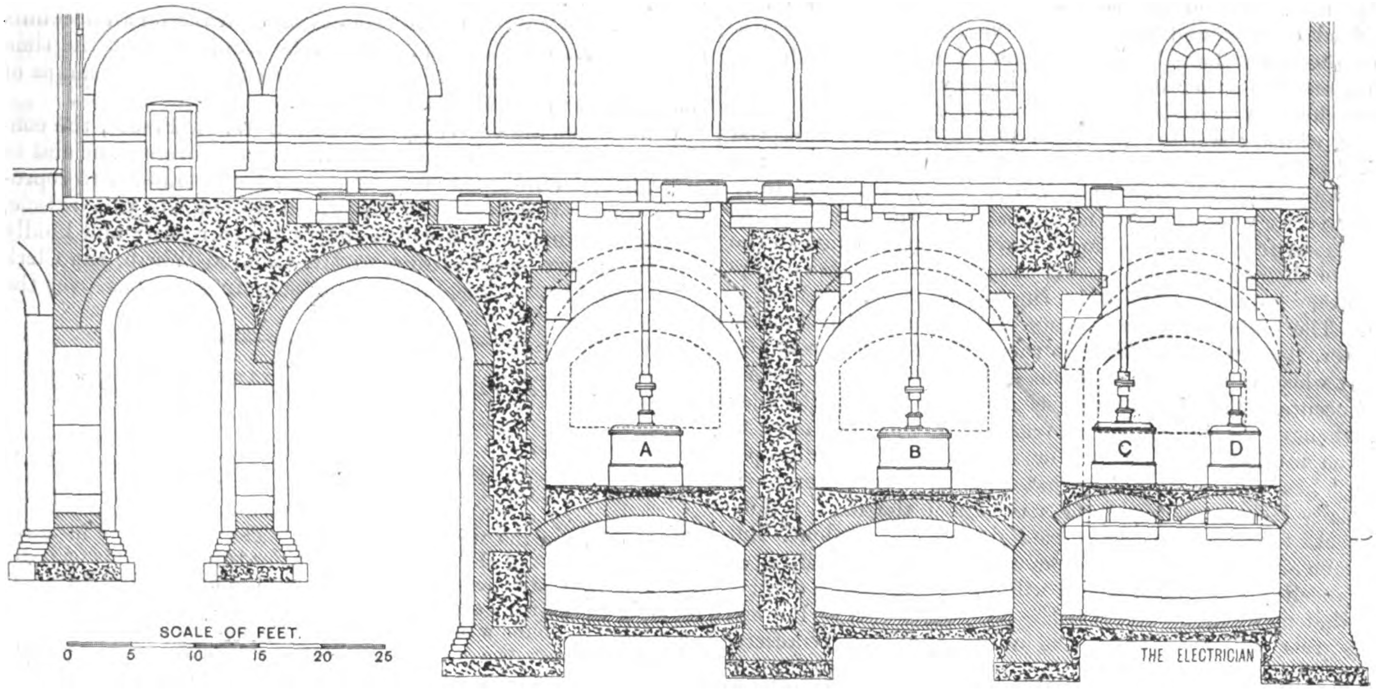

Fig. 2.—Worcester Electric Supply Station. Transverse Section of Wheel Pits and Foundations.

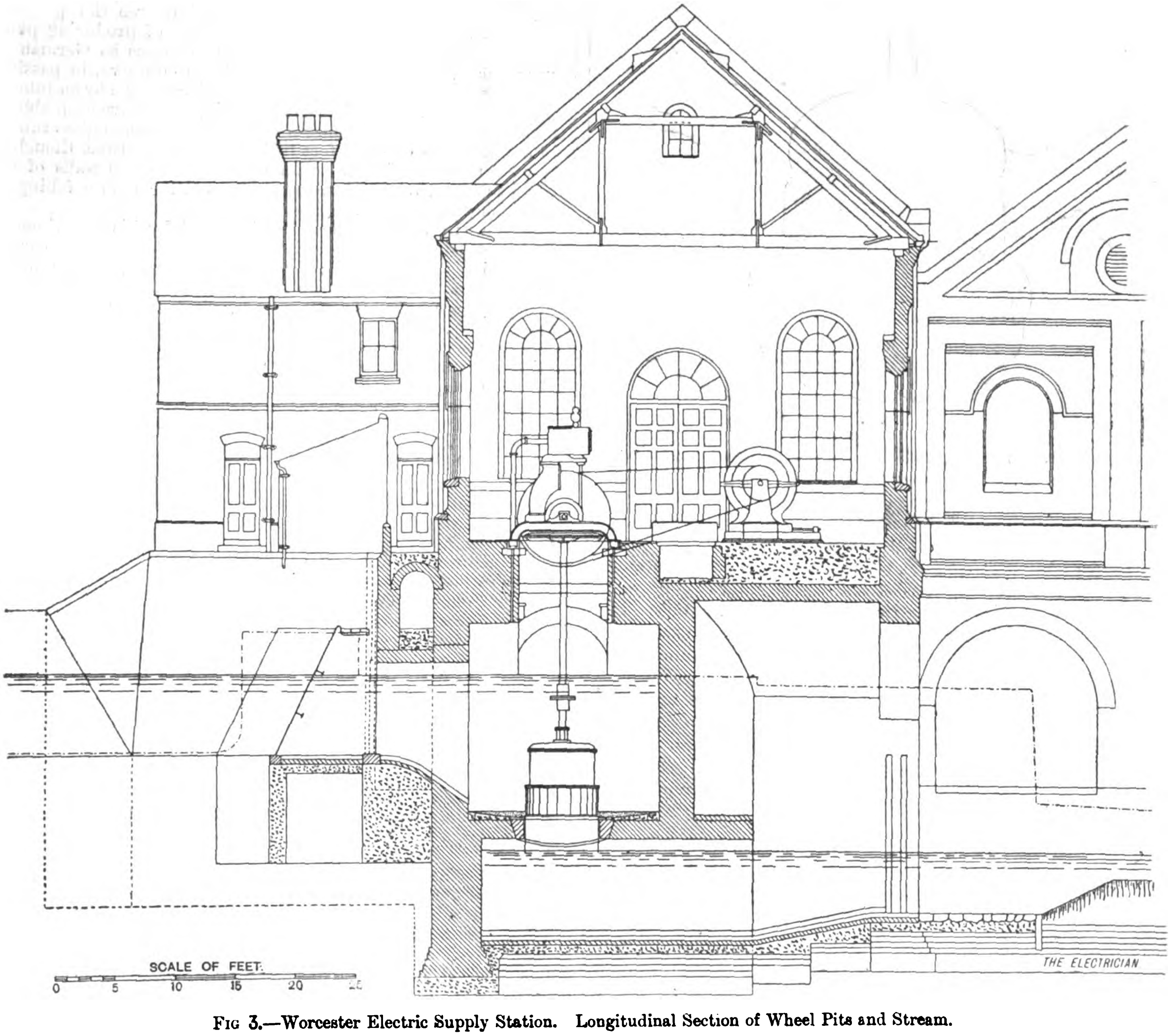

Fig 3.—Worcester Electric Supply Station. Longitudinal Section of Wheel Pits and Stream.

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the tail race. The guide blades of the turbine form an outer and fixed circle round the rotating vanes. By varying the orifice given by these blades, the flow of water through the engine, and the power developed by it, may be regulated. At Powick this regulation is effected by means of a cylinder gate or shutter, which envelops the guide blades. By adjusting the vertical position of this cylinder the flow of water between the guides may be varied from a maximum, when the gate is fully lifted, to zero, when the gate is quite shut down. This requires that the entire gate shall be moved over a range equal to the height of the guide passages; and to effect this purpose a supplementary governor, worked by the energy of the turbine, is used. The governor gear consists of an ordinary pendulum governor, the duty of which is to throw into action a pawl and ratchet wheel whenever any serious departure from the normal speed occurs. The ratchet gear is actuated by the turbine; and, whenever it is thrown into action, it will commence to feed the ratchet train onward or backward until the proper "gate" has been adjusted. That this form of governor is essentially lacking in promptness is one of the most serious drawbacks to its use where electric lighting is being done. But the problem of regulating water motors for electric lighting is by no means an easy one, and it will be instructive to observe with what measure of success it has been dealt with at Powick.

The great distance between the area of supply at Worcester and the generating station necessitated, of course, the employment of the high-pressure system; and a pressure of 2,000

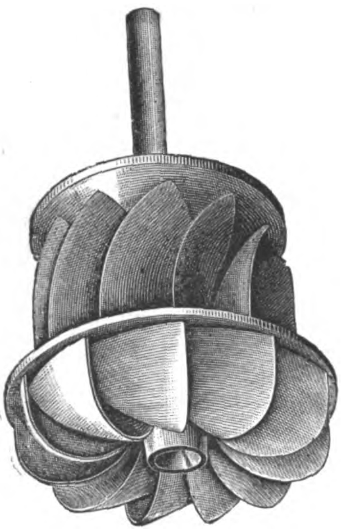

FIG. 4.

volts at the transformers, or 2,200 at the generator terminals, was decided upon. To minimise the loss of power by leakage, it was considered desirable to adopt the system of oil insulation known as the "Brooks" system. Our readers will find some account of this system in *The Electrician*, Vol. XXIV., p. 87. The head of oil necessary for the Worcester mains is obtained by means of an oil tower, situate about midway between Worcester and Powick on the rising ground of St. John's. The average head is about 30ft. of oil; but we understand that in some parts of the system a head of about 50ft. is attained. At a point but a few yards beyond the bridge over the Severn, by which the mains are led into the city, there is a large and well-appointed transformer pit, which is well lighted and faced with enamelled brick. This pit or cellar also serves the purpose of an arc switch room, the switches controlling the two street arc lamp circuits being placed here. Each of these circuits contains 13 small transformers, located in the lamp standards, each transformer supplying one street arc lamp.

In addition to supplying power for lighting purposes, the generating machinery at Powick is utilised for working the pumps at the waterworks. Two sets of electrically-driven pumps have already been provided, and it is probable that if this feature of the system should prove successful the Corporation will find further use for their electric power in sewage pumping and other mechanical work. Such duties as these, regular and steady as they will probably be, must prove very beneficial to the economy and successful working of the generating plant. For ordinary customers the power will be supplied at 5d. per unit, with discounts for cash and on all accounts exceeding £25 per annum. We understand that by the time the station is started there will have been some 3,850 lamps of 8 c.p. wired in the consumers' houses.

Our thanks are especially due to Mr. W. H. Preece, the consulting electrical engineer to the Worcester Corporation, and to Mr. Thomas Caink, the city engineer, for permission to reproduce some of the illustrations which accompany this article, and for the information which they have so readily and kindly supplied; they are also due to Mr. Leonard Wigan, the Clerk of the Works, for his kindness in accompanying us over the works.

ON THE VELOCITY OF CATHODE RAYS.*

BY J. J. THOMSON, M.A., F.R.S.

The phosphorescence shown by the glass of a discharge tube in the neighbourhood of the cathode has been ascribed by Crookes to the impact against the sides of the tube of charged molecules driven off from the negative electrode. The remarkably interesting experiments of Hertz and Lenard show that thin films of metal when interposed between the cathode and the walls of the discharge tube do not entirely stop the phosphorescence. This has led some physicists to doubt whether Crookes's explanation is the true one, and to support the view that the phosphorescence is due to ætherial waves of a very small wave length, these waves being so strongly absorbed by all substances that it is only when the film of the substance is extremely thin that any perceptible phosphorescence occurs behind it. Thus on this view the phosphorescence is due to the action of a kind of ultra-violet light, which possesses in an exaggerated degree the property possessed by the ultra-violet rays of the sun of producing phosphorescence when incident upon such substances as German or uranium glass. It is, perhaps, worth while to observe, in passing, that the light produced in an ordinary discharge-tube by an intense discharge is very rich in phosphorogenic rays. I have been able to detect phosphorescence in pieces of ordinary German-glass tubing held at a distance of some feet from the discharge tube, though in this case the light had to pass through the glass walls of the vacuum-tube and a considerable thickness of air before falling on the phosphorescent body.

The view, to which Lenard has been led by his experiments, that the cathode rays are ætherial waves demands the most careful consideration and attention; for if it is admitted, it follows that the æther must have a structure either in time or space. For these cathode rays are deflected by a magnet, which, so far as our knowledge extends, does not produce any effect on ultra-violet light unless this is passing through a refracting substance: thus, if the cathode rays are supposed to be ultra-violet light of excessively small wave-length, it follows that in the æther in a magnetic field there must either be some length with which the wave-length of the cathode rays is comparable, or else some time comparable with the period of vibration of these rays.

It might be objected that it is possible that the action of a magnet on the cathode rays is a secondary effect, and that the primary action of the magnet is to affect the main current of the discharge passing between the positive and negative electrodes, and thus to alter the distribution of the discharge entering the cathode; this would affect the distribution of the places of greatest intensity over the cathode, and thus indirectly the distribution of the waves emerging from it. To test this point I shielded the cathode from magnetic forces by means of a magnetic screen consisting of a ring made of soft iron wire; the length was about 1·5in., its thickness was about 0·75in. When this ring encircled the cathode a magnet was brought up to the tube; the phosphorescent patches inside the ring were not now affected by the magnet, but those on the parts of the tube farther away from the cathode and outside the iron ring were very much displaced by the magnet; thus proving that the magnet acts on the cathode rays through the whole of their course, and does not merely affect the place on the cathode at which they have their origin. There thus seems no escape from the conclusion that the establishment of the hypothesis that the cathode rays are ætherial rays would also prove the finiteness of the structure of the æther.

The following experiments were made with the view of determining the velocity with which the cathode rays travel, as it seemed that a knowledge of this velocity would enable us to discriminate between the two views held as to the nature of the cathode rays. If we take the view that the cathode rays are ætherial waves, we should expect them to travel with a velocity comparable with that of light; while if the rays consist of molecular streams, the velocity of these rays will be the velocity of the

* From the *Philosophical Magazine*.

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molecules, which we should expect to be very much smaller than that of light.

The method I employed is as follows:—The discharge tube was sealed on to the pump, and the two electrodes were placed at the neck of this tube. The discharge tube was covered with lampblack, with the exception of two thin strips in the same straight line from which the lampblack was scratched: these strips were about 10cm. apart; the one nearest to the negative electrode was about 15cm. from the electrode, the other was 25cm. from the electrode. They were chosen so as to phosphoresce with, as nearly as could be judged, equal brilliancy when the discharge passed through the tube.

The light from the phosphorescent strip fell upon a rotating mirror about 75cm. from the tube. This mirror is the one used by me in my experiments on "The Velocity of Propagation of the Electric Discharge through Gases" (*Proc.* Roy. Soc., 1890), and is described in that Paper. The only change made in the mirror was to replace the single plane strip of silvered glass which was used in the previous experiments by six strips of mirror fastened symmetrically round the axis. The mirror was driven by a large Gramme machine.

The images formed by reflection from the mirror were observed through a telescope, of which the object-glass was a large portrait photographic lens of 4in. aperture, the eye-piece a short-focus lens; when the mirror was at rest the two images of the phosphorescent strips were seen in the same straight line, and the adjacent ends of the two images were brought into coincidence by inserting between one of the phosphorescent strips and the mirror a very acute-angled prism. The point of the experiment was to see if the images of the two phosphorescent strips remained in the same straight line when the mirror was in rapid rotation. If, for example, the cathode rays travelled with the velocity of sound, they would take about $\frac{1}{3300}$th of a second to pass from one strip to the next; if the mirror were rotating 300 times a second it would, in the interval taken by sound to pass from one strip to the next, rotate through about 33deg.; the displacement of the image produced by a rotation one thousandth part of this could easily be detected.

When the phosphorescence was produced by the discharge of an ordinary induction-coil, the images seen in the telescope after reflection from the revolving mirror were drawn out into very faint ribands of light without definite beginnings or ends, so that it was impossible to say whether or not there was any displacement of one image relative to the other.

I tried a considerable number of phosphorescent substances in the hope of obtaining sharp images, but without success. The substances I tried were ordinary German-glass, uranium-glass, lead-glass, the cyanide of magnesium and platinum, asaron, æsculine, and Schuchardt's "Leuchtfarbe."

The gradual fading away of the phosphorescence after the exciting cause has been removed, is one reason why one of the edges of the image formed by the revolving mirror should be indistinct; this cannot be remedied unless some substance can be found which ceases to phosphoresce immediately the incidence of the negative rays ceases. I was unable to find any substance possessing this property; of the substances I tried, uranium-glass was the one whose phosphorescence died away most quickly.

I tried several experiments with a specimen of asaron. This substance was found by Lenard to cease to phosphoresce so quickly after the cessation of the phosphorogenic rays that he could not detect its duration in his very sensitive phosphoroscope. My specimen of asaron must, I think, have been impure, as it phosphoresced a coral-pink instead of violet, as described by Lenard, and its phosphorescence showed a very appreciable duration; in addition to this, it did not give out nearly enough light to be of any use in experiments of this kind.

But even though the images of the phosphorescent strips have one edge (that corresponding to the end of the phosphorescence) indistinct, we can get the information we require about the velocity of the cathode rays if we can get the image of the edge corresponding to the beginning of the phosphorescence sharp and distinct.

After unsuccessful attempts with several methods, I found that this could be done in the following way, using the oscillatory currents produced by the discharge of a Leyden jar: The electrodes of the discharge tube were connected with the ends of the secondary coil of a transformer, whose primary circuit consisted of a coil of wire with the ends connected to the outside coatings of two Leyden jars, the inside coatings of which were connected with the extremities of an induction-coil; the secondary coil of the transformer had about 30 turns for each turn of the primary coil. It was heavily insulated, and both primary and secondary were immersed in an oil-bath. This transformer easily gave sparks 7in. or 8in. long in air, and when connected to the terminals of a discharge-tube made of uranium-glass produced a very vivid phosphorescence. When the phosphorescence was produced in this way, the images after reflection in the rotating mirror had one edge sharp and distinct, though the other edge was indeterminate in consequence of the duration of the phosphorescence.

When the images of the two bright phosphorescent strips were observed in the telescope, after reflection from the rapidly revolving mirror, their bright edges were seen to be no longer in the same straight line; if the images came in the field of view from the bottom and went out at the top, then the sharp edge of the phosphorescent strip nearest the electrode was lower than the edge of the other image; if the direction of rotation of the mirror was reversed so that the images came in at the top of the field of view and disappeared at the bottom, then the bright edge of the image of the phosphorescent strip nearest the negative electrode was higher than the bright edge of the image of the other strip. This shows that the luminosity of the strip nearest the cathode begins to be visible before that at the strip more remote; and that the retardation is sufficiently large to be detected by the revolving mirror. This retardation might be explained, (1) by supposing it due to the time taken by the cathode rays to traverse the distance between the phosphorescent patches; or (2) we might suppose that, though the cathode rays reached the two phosphorescent patches almost simultaneously, it took longer for the rays falling on the patch at the greater distance from the cathode to raise the patch to luminosity. In other words, there may be an interval between the incidence of the cathode rays and the emission of the phosphorescent light, this interval being greater the further the phosphorescent patch is from the cathode. This latter supposition cannot, however, explain the displacement of the images for the following reasons: The sharpness and brightness of the edge of the image show that the phosphorescence, when once it is visible, must attain its maximum brilliancy in a time very small compared with the time taken by the mirror to rotate through an angle large enough to produce the observed displacement of the images. Again, the two phosphorescent patches are as nearly as possible of equal brightness, so that there can be very little difference in the intensity of the cathode rays falling upon them: it was for this reason that both the phosphorescent patches were taken some distance down the tube. Again, I took a tube which was bent so that the cathode rays fell more directly upon the patch farther from the cathode than upon the other patch, so that in this case the phosphorescence of the more remote patch was brighter. The displacement of the images with this tube was just the same as for the previous, *i.e.*, the phosphorescence commenced at the patch nearest the cathode sooner than at the other patch; whereas if the displacement of the images was due to the interval between the arrival of the rays and the beginning of the phosphorescence it should have commenced at the patch furthest from the cathode, as this was the most exposed to the cathode rays and phosphoresced with the greatest brilliancy.

I conclude, therefore, that the displacement of the images is due to the time taken by the rays to travel from one patch to the other. This displacement enables us to measure the velocity of the cathode rays. The amount of displacement observed through the telescope is not constant: even though the mirror is turning at a uniform rate, there are quite appreciable and apparently irregular variations in the amount of the displacement of the images seen in the course of a few minutes. I think these are due to irregularities in the sparks discharging the jar, and the consequent irregularities in the electromotive force acting on the discharge tube.

When the mirror was rotating 300 times a second, the bright edges of the two patches were on the average separated by the same distance as the image of two lines 1·5mm. from each other placed against the discharge tube. Since the distance of the discharge tube which contained hydrogen from the mirror is 75cm., the mirror must, in the time taken by the cathode rays to pass from one patch to the other, have turned through the angle whose circular measure is $\frac{1 \cdot 5}{2 \times 750}$.

Since the mirror makes 300 revolutions per second, the time it takes to rotate through this angle is

$$\frac{1 \cdot 5}{2 \times 750 \times 2\pi \times 300} = \frac{1}{6\pi \times 10^5};$$

and since the distance between the patches is 10cm. the velocity of the cathode rays is

$$6\pi \times 10^6 \text{cm./sec.},$$

or about $1 \cdot 9 \times 10^7$cm./sec.

This velocity is small compared with that with which the main discharge from the positive to the negative electrode travels between the electrodes (*see* J. J. Thomson, *Proc.* Roy. Soc. 1890). I verified this by inserting an electrode into the far end of the tube used in the previous experiment, and observing the images formed when a bright discharge passed down from the electrode at the beginning to the electrode at the end of the tube. The light from the luminous gas shines through the places where the lampblack has been scraped from the tube, and we get two images, which when the mirror is at rest coincide in position with the images of the two phophorescent patches in the previous experiment. These

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images, however, unlike the phosphorescent one, remained in the same straight line when the mirror was rotating rapidly, thus proving that the velocity of the main discharge is very large indeed compared with that of the cathode rays.

The velocity of the cathode rays is very much greater than the velocity of mean square of the molecules of gases at the temperature 0°C. Thus, for example, at 0°C. the velocity of mean square of the molecules of hydrogen is about $1{\cdot}8 \times 10^5$ centimetres per second: the velocity of the cathode rays is about one hundred times as great. The velocity of the cathode rays found from the preceding experiments agrees very nearly with the velocity which a negatively electrified atom of hydrogen would acquire under the influence of the potential fall which occurs at the cathode. For, let v be the velocity acquired by the hydrogen atom under these circumstances, m the mass of the hydrogen atom, V the fall in potential at the cathode, e the charge on the atom; then we have, by the conservation of energy,

$$m v^2 = 2 V e.$$

Now e has the same value as in electrolytic phenomena, so that $e/m = 10^4$.

Warburg's experiments show that V is about 200 volts, or 2×10^{10} in absolute measure. Substituting this value, we find

$$v^2 = 4 \times 10^{14},$$

or

$$v = 2 \times 10^7 \text{cm./sec};$$

a value almost identical with that found by experiment. The very small difference between the two is, of course, accidental, as the measurements of the displacement of the images on which the experimental value of v was founded could not be trusted to anything like 5 per cent.

The action of a magnetic force in deflecting these rays shows, assuming that the deflection is due to the action of a magnet on a moving electrified body, that the velocity of the atom must be at least of the order we have found.

Consider an atom projected parallel to the axis of the tube which is situated in a uniform field of magnetic force, the lines of magnetic force being at right angles to the axis of the tube. Let H be the intensity of the magnetic force. Then, if m is the mass of the atom, v its velocity, and ρ the radius of curvature of its path, we have

$$\frac{m v^2}{\rho} = H e v,$$

where e is the charge on the atom; since e/m for hydrogen is 10^4, we have

$$v = \rho H \times 10^4.$$

I cannot find any quantitative experiments on the deflexion of these rays by a magnet; but ordinary observation shows that it would require a strong magnetic field to make ρ as small as 10cm., which would mean clearing the tube of phosphorescence except within about 10cm. of the cathode. If v were 2×10^7, this would give H = 200, which is not extravagant.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *September* 21, 1894.

The Feeder and Main Patent.—The recent decision nullifying the Edison feeder and main patent marks the growing tendency of United States courts towards a more rational treatment of questions relating to patents. The opinion of the court below, whose decision has been reversed, dwelt much on technicalities which it was apparent from the language were little understood by the judge, and therefore liable to a wrong construction. The opinion was also remarkable for philosophical and scientific dissertations that had but a remote bearing on the facts of the case, and the admiration of the judge for the "Wizard of Menlo Park" received many fervid expressions. The recent decision, however, is strictly judicial in tone and confines itself to the subject matter of the claims and condemns the action of the lower court in introducing ulterior considerations extending the importance of the patent. The conclusion of the final court is that the feeder system had previously been used in electro-plating, was described in the Khotinsky patent of 1875, and is, besides, no invention, as the use of feeders as described involved at the date of the patent only the exercise of the common skill and knowledge of the electrician.

The American Institute of Electrical Engineers.—At the September meeting of the American Institute of Electrical Engineers, two Papers were presented, one by Dr. Bedell and Mr. Carl Kinsley, on "A Study of the Residual Charge of Condensers and their Dependence upon Temperature," and the other by Mr. E. A. Sperry on "The Electric Brake in Practice." The first-named Paper was merely read by title, and is a lengthy account of experiments as to the soaking-in effects of dielectrics. The conclusions are that the action of a condenser is dependent to such a marked degree upon its earlier history, that its previous charges may be of more importance in determining its action under certain circumstances than charges received later. It was found that the resistance of pure oils is constant at one temperature but falls off rapidly with the temperature, and that there are no absorption or residual effects to be met with in such oils. In solid dielectrics the effects of absorption are diminished as the temperature is increased. The Paper of Mr. Sperry is of a commercial character, but, although diffuse and disjointed, gives much information in regard to the subject of braking street cars. In the discussion that followed the reading of the Paper, it was pointed out that the combination of the brake ring and car wheel formed a dynamo brake, whose advantage over the car motor acting in the same capacity was that destructive wear on the gears was avoided. It should be added that the braking surfaces are kept lubricated by a graphite brush located in the gap, the inventor claiming that thereby the eddy currents are permitted to circulate more freely between the brake ring and the car wheel.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

NEW BOOKS AND EDITIONS.

The 1894 Edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK contains 1,000 closely-printed pages, and several new and useful features have been added. The price of the Directory and Handbook, from October 1st, is 6s. post free; abroad 5s. 6d. *The 1895 edition is in active preparation.*

"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell, with this title, will be ready in October. It will contain the latest information respecting the application of electric energy to mining purposes, in which the author has had much experience. The book is well printed, on good paper, and will contain nearly 250 illustrations, a large proportion of which have been specially made for the book. The price is 10s. 6d., post free 11s. (abroad 11s. 6d.). Orders can now be sent in.

"THE WORK OF HERTZ."—The lecture delivered by Dr. O. J. Lodge at the Royal Institution on June 1st is reprinted with corrections and additions, and many original illustrations, price 2s. 6d. net.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., will be ready early in October, handsomely bound, full of original illustrations, designs, initials, &c. Price 7s. 6d., post free.

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. (abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application to the Publisher.

"ELECTROMAGNETIC THEORY," by Oliver Heaviside, is now ready, price 12s. 6d. (abroad 13s.). Prospectus on application.

"THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application to the Publisher.

"DRUM ARMATURES AND COMMUTATORS."—This book, written by Mr. F. Marten Weymouth, is also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

TENDERS INVITED.—The Directors of the Lancashire and Yorkshire Railway invite tenders for the supply of the Company's ordinary requirements of various articles during the twelve months ending October 31, 1895. Full particulars and forms of tender can be obtained at the Stores Department, Osborne-street, Manchester, where samples can also be seen. Tenders have to be in by 10 a.m. on October 8th.

——— Mr. John Annan, manager for the liquidator in J. W. Hobbs and Co. (Limited), invites tenders for the supply and erection of boiler house plant, engine house plant, switchboard, instruments, &c., for the electric light and power installation at the large block of hotel buildings now erecting on the Salisbury Estate, Victoria Embankment, and Strand, London, W.C. Plans and specification, &c., can be obtained of Mr. R. Hammond, consulting engineer, Ormonde House, Great Trinity-lane, E.C., on and after October 5th; and tenders must be sent in before Friday, October 26th. Further particulars are given in our advertisement columns.

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Tenders Invited.—The Edinburgh Corporation require tenders for providing and erecting the cast-iron battery standards in the Torphichen-street electric lighting central station. The plans may be obtained from the borough engineer, 1, Parliament-square, Edinburgh, to whom tenders must be sent by 10 a.m. on the 8th inst.

Tenders Accepted.—The Cheltenham Town Council have accepted the tender of Messrs. Humpidge and Co., of Stroud, for the supply of an overhead travelling crane for the electric lighting station at £82; 21 tenders were received. Twenty-two tenders were sent in for the supply of casings for street boxes, and the lowest, that of Messrs. T. Spittle and Co., at £6. 10s. per ton was accepted.

Liquidations.—A petition has been presented for the winding up of Messrs. R. C. Cutting, Douglass and Co. (Limited), and is down for hearing at the Royal Courts of Justice, London, on the 24th inst.

——— Claims against the estate of Messrs. Newington, Priddle and Co. (Limited) must be sent in to Mr. C. J. Stewart, the Official Receiver, 33, Carey-street, W.C., by the 9th inst.

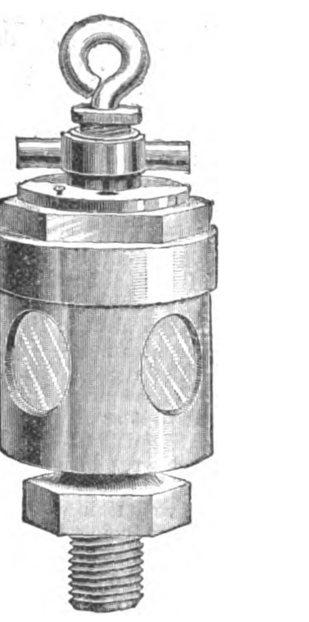
——— A meeting of the shareholders of the Halifax Mutual Electric Light and Power Company (Limited) is to be held at the Townhall Buildings, Halifax, on the 25th inst., at noon, for the purpose of receiving an account of the winding up.

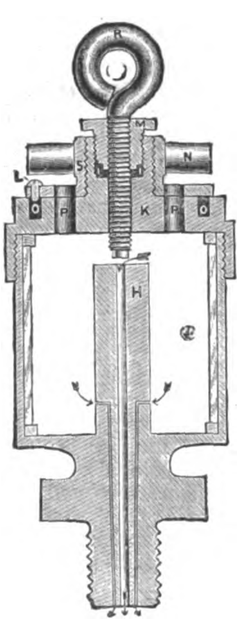
Sales by Auction.—Messrs. Wheatley Kirk, Price, and Goulty will, on Wednesday the 17th inst., at York-street Works, Lambeth, S.E., dispose of a quantity of modern engines, boilers, machine tools, and other plant and machinery, the property of Messrs. W. H. Allen and Co. The sale is necessitated owing to the removal of the firm to their new works at Bedford. The sale includes an electric lighting installation. Catalogues can now be had from the auctioneers, at 49, Queen Victoria-street, E.C., or Albert Chambers, Albert-square, Manchester.

Removal.—Messrs. Gilbert and Co. have removed from Hanway-street to more extensive works at 142a, Oxford-street, London, W. The Kensington offices remain as hitherto.

"L'Industrie Électrique."—The new address of our Paris contemporary is 12, Rue de Chantilly, Paris, to which all communications should in future be addressed.

Safety Lubricators.—Messrs. W. H. Willcox and Co., of Southwark-street, S.E., have recently placed on the market the Willcox safety automatic double-feed crank-pin lubricator, which is illustrated herewith. This is claimed to be the only lubricator





specially made for the crank pins of engines, pumps, &c. The feed can be regulated to the one-thousandth part of an inch to suit the exact speed at which the crank is running, only the absolutely required quantity of oil being supplied. This regulation is effected by giving the piston H more or less play, as circumstances require. By this means waste is avoided, as no oil can run away when the crank is at rest, the piston coming down on to its seating, and thus closing the outlet. The adjustment is simple when once the screw is set, and refilling is effected by turning the handle N to the left and pouring the oil in the holes opened on the top of the cover. By turning the handle hard to the right the cover is closed, and the lubricator is ready for use again. The body of the lubricator is of glass, and is enclosed in a strong gunmetal casing. By this means the quantity of oil in the lubricator is always on view. This is undoubtedly a strong recommendation, as the need for an effective sight-feed lubricator has long been felt. It is stated that considerable success has attended the introduction of this lubricator, as many of the largest engine builders are now adopting it. Makers of fixed engines for electric lighting plant are amongst those for whom the lubricator is specially adapted.

Fire.—Messrs. J. D. F. Andrews and Co. inform us that their works at Marsham-street, Westminster, S.W., have been completely burnt out. Temporary arrangements have been made with Messrs. Sharp and Kent, by which work will be carried on as usual. Temporary offices have been opened at 34, Victoria-street, S.W.

Aberdeen.—At a meeting of the Gas and Electric Lighting Committee of the Aberdeen Town Council held on Wednesday, 26th ult., the City Electrical Engineer (Mr. Ruthven-Murray) reported that, in consequence of the large and increasing demand for electric energy, an extension of plant would be immediately required. He stated that there were now 80 consumers, having in all 7,000 lamps connected to the mains. It will be remembered that the station was opened on February 28th last, and the fact that an extension is required in less than seven months shows with what popularity the light has been received. The progress of electric lighting in Aberdeen has been exceptionally rapid and successful. The supply was commenced at a most disadvantageous time, as the city is so far north that in summer there is practically no night. A large proportion of the load is for shop lighting; but it also includes three hotels, a few private houses, Robert Gordon's College, and the School of Art. The committee resolved that Prof. Kennedy should be requested to report as to what additional plant he would recommend to be provided.

Aberystwith.—On Tuesday last the Mayor and Corporation inaugurated the installation of the electric light at the marine front and main portion of the town by a banquet; 2,000-c.p. arcs are used for the front and the main thoroughfares. These are placed about 45 yards apart.

Antwerp Exhibition Awards.—Diplomas and medals of honour have been awarded to the following firms associated with the British exhibits at the Antwerp Exhibition: Tangyes (Limited) and Chance Brothers. Gold medals have been awarded to Dowson's Economic Gas Power Company and Messrs. Crompton and Co.; and grand prizes to Messrs. Johnson, Matthey and Co., Babcock and Wilcox (Limited) and Galloways (Limited), and awards have also been offered to Messrs. Musgrave and Co. and Messrs. Siebe, Gorman and Co. The whole of the exhibitors at the Exhibition were, on Wednesday evening last, entertained at a banquet in the Festival Hall by the members of the Executive Committee of the Exhibition.

Bacup.—The first business premises in the Rossendale district lighted are those of Messrs. Holden and Co., tea and coffee merchants, Union-street, Bacup. The generating plant is on the premises.

Bristol.—The Electrical Committee of the Corporation, at their last meeting estimated that £3,250 would be required for their purposes from the next general district rate, which is £1,500 less than the demand made last year. There is a hitch in the proposal to extend the mains to Redcliffe so that St. Mary's Church could have the electric light, and the Committee have determined to ascertain definitely whether the church authorities propose to proceed with the scheme, as otherwise the amount proposed to be spent on the extension can be otherwise utilised. Applications for current have been received from Highbury Chapel and Old King-street Baptist Chapel, but the Committee will not be able to accede to the requests unless a sufficient number of other consumers can be found on the route. The laying of the Clifton extension will shortly be commenced, and, it is hoped, will be completed by the end of the month, so that the current can be supplied by November 1st.

Cardiff.—The local authorities have issued an explanatory pamphlet of their electric lighting undertaking. It is announced that the supply of current will be ready in a week or two.

Chatsworth.—The electric lighting work at this beautiful residence of the Duke of Devonshire is now practically complete. About 1,000 incandescents are used, and the fittings include a magnificent chandelier for 48 lights in the drawing room. A duplicate service is provided.

Cheltenham.—On Wednesday Mrs. Wethered, the Mayoress, laid the memorial stone of the new electric lighting station at the refuse destructor near the Midland railway station.——The gas company have announced the reduction of 2d. per 1,000 in the price of gas. The inhabitants are now only awaiting an increase in the illuminating power of that product, when they will rest satisfied until the electric lighting installation is complete.——The Town Council have instructed their electrical engineer to procure the testing apparatus required at the central station, at a cost of about £300. Out of the sum of £16,000 to be borrowed for electric lighting purposes, £5,000 was borrowed at $3\frac{1}{2}$ per cent. from Messrs. D. Migley and Sons, of Manchester.

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THE COMMERCIAL CABLES.—The Commercial Cable Company announce that the cable landing at Pier A, North River, New York City, is completed, and is in perfect working order. The Company now have three complete submarine telegraph lines between the United States and Europe, which are connected with the landlines of the Postal Telegraph Company and the Canadian Pacific Telegraphs.

DERRY.—A request from the Port and Harbour Commissioners, requesting that a supply of electric current be provided for the cattle pens to enable veterinary inspection to be performed at night, has been referred by the Town Council to the solicitor. At the last meeting of the Electric Lighting Committee, Mr. Christie presented his report, and referred to the breakages in the electric light cables. Mr. Councillor Thompson brought serious allegations against the Council's electrical engineer, which the Mayor said it would be necessary for Mr. Blake to be present to answer. A special meeting was subsequently held to discuss this, the latest phase of the vexed question of the electric cables at Derry.

EDINBURGH.—On Tuesday the Town Council remitted to the Lighting Committee to consider and report on the proposed lighting by electricity a number of the leading thoroughfares of the town.

ELECTRIC TRAMWAY IN DUBLIN.—It is understood that the work in connection with the construction of the electric tramway between Kingstown and Dalkey will shortly be commenced. The system to be adopted is the Thomson-Houston overhead, and the cost of laying the line, rearranging the Balls Bridge depôt as a power station, and the equipment of the line with electric cars, is estimated at about £70,000.

FACTORY AND OFFICE LIGHTING.—Messrs. Tickner and Partington have just completed the re-installation of the electric light throughout the extensive offices and mills of Spratts Patent (Limited) at Bermondsey, S.E. Incandescents are used throughout the mills, offices, and factory, and the plant also supplies current to a number of magnetic separators and a motor fan for ventilating the offices.——Messrs. Tickner and Partington are also fitting the new offices of *The Queen*, *Field*, and *Law Times* at Bream's-buildings, Chancery-lane, W.C., for electric lighting, and arrangements have been made for taking the current either from the City of London Company's mains or from the existing steam plant. When completed, nearly 1,500 16 and 32-c.p. incandescents and 17 arcs will be used.

FERMOY.—Communications from a number of electric lighting firms were read at the last meeting of the Town Commissioners, and it was decided to accept the offer of a conference with the representatives of the Electrical Installation Company on the subject of the electric light supply for the Fermoy district. The Commissioners also decided to accept the services of Mr. T. Tomlinson, engineer to the Bray Electric Lighting Company, to advise the Board on the subject.

FOLKESTONE.—The Corporation, at their meeting last week, had under consideration the scheme of electric lighting furnished by Mr. Medhurst, which he estimated would cost about £12,000. The scheme was explained at length, and, it was said, would embrace almost the same area as that previously submitted by Mr. Parker, but which was to cost £35,000. After a lengthy debate a new committee was appointed, with power to employ Mr. Medhurst to prepare plans, &c.

GLASGOW.—As a result of a friendly conference between representatives of the Watching and Lighting Committee of the Glasgow Police Commissioners and representatives of the Corporation Gas and Electric Lighting Committee, it has been agreed by the first-named body to pay the sum of £26 per lamp for arc lamps in use for lighting certain of the principal thoroughfares—George-square, and a temporary bridge over the Clyde near the harbour. There are, in all, about 130 of these lamps.

HEREFORD.—At the usual monthly meeting of the Town Council, on Tuesday, the Gas Committee recommended that having received a notice from the Great Western Electric Light and Power Company to apply for a Provisional Order to supply electric current within the Council's district, it was desirable that the Corporation should themselves undertake the electric lighting. The recommendation was referred to the Committee for consideration, with power to call a special meeting of the Council.

HULL.—Dr. Holder, Chairman of the Electric Lighting Committee, announced at its last meeting that the number of additional users of the electric light were more numerous than was at any time anticipated. He also announced that it might happen that the tramways would come into the Corporation's hands, and in that case it would be a question as to what power should be used, whether overhead or storage. He understood there was a new storage battery, which, from information he had received, was working satisfactorily in Paris. They were in a position to give such a battery a fair test on their own premises, and so form an opinion whether the cell was worth their consideration, and the Committee adopted his suggestion that their engineer should obtain a cell for the purpose of testing it.

KEIGHLEY.—A resolution in favour of an application to the Board of Trade for a Provisional Order to supply electric current within the borough has been referred to the Gas Committee of the Town Council.

KILLARNEY.—The Commissioners of Control of Public Lunatic Asylums, Dublin, have, owing to a report from their electrical engineering inspector (Mr. Walter Leake), made material alterations in the machinery at the Flesk water mills, which have been supplying the township of Killarney with electric current for the past six months. The wires, leading from the machinery in the mills across a field, then over the Flesk river across another field to the opposite road, where the connections are made, have been altered by a novel change. The wires, extending as above mentioned at a height of about 15ft. from the ground, have been put underground under the course of the river. These wires have been put into earthenware and under the river in metal pipes, and a telephone wire runs parallel with them, connecting up the works and offices in College-street.

LANCASTER.—It has been resolved to use 2,000-c.p. arcs for the street lighting.

LEEDS.—At the meeting of the City Council on Wednesday a resolution was adopted, by which arrangements are entered into with the Yorkshire House-to-House Company for the supply of electric light for the Town Hall and municipal buildings for a period of two years. It was pointed out that the installation at present in use at the Municipal Buildings constitute a nuisance to the neighbourhood, and that the vibration of the engines was objectionable. The cost per unit was 6·70d., whereas the House-to-House Company had undertaken to supply current at 6·57d. In moving the resolution Sir E. Gaunt said that the Council had spent a lot of money already, and that there was no doubt that if they had the work done by the Company for two years they would be in a position at the end of that time to tell whether it would be more advantageous for the Council to undertake the work themselves. Other speakers pointed out that the whole of the Council's plant was obsolete. Mr. Alderman Hepworth asked the Council to pause before it passed the resolution. He had had a great deal of experience in putting down the light in various parts of the country, and in no instance had a company supplied the electric light at the price originally given, not even within a considerable sum. The resolution was ultimately adopted.——Associated with the festivities to be held in connection with the Royal visit to Leeds, a 150,000-c.p. search light, manufactured by Mr. F. J. Boorland, of Leeds, is to be used, and preliminary experiments as to its power were made last night. The lens is 12in. in diameter. The chief interest in this lamp is in its capabilities as a means of conveying signals for the use of an army in the field, and the object of the preliminary tests is to show its capacity in this respect. In the tests last night a shaft of light was thrown across to Goole, where members of the Leeds Volunteer Corps were stationed, and signals were exchanged. The arrangements at Leeds were under the superintence of Mr. Nicholls, of the City Engineer's office.

LIVERPOOL.—At the weekly meeting of the Finance Committee a suggestion was made that the electric light should be substituted for gas at the St. George's Hall and the Municipal buildings; but the Committee did not think it desirable, "considering the great improvements continually being made in the electric light," to enter into any large expenditure at the present time.——The City Council at their last meeting considered the recommendation of the Watch Committee for the adoption of a new arrangement for lighting the city, by which it was proposed that at 11 p.m. a considerable number of lamps should be extinguished. Sir W. B. Forwood pointed out that the passing of such a resolution would be a most dangerous and hazardous step. They were asked to reduce the lighting of the town by one-half at the very time when all the great corporations of the country were introducing the electric light in order to provide better illumination, and at a time of night when it was most required, when the lights of the shops had been put out. Notwithstanding the opposition of many important members of the Council the Watch Committee's recommendation was adopted. It is estimated that a saving of £7,000 per annum will be effected.

LONDON GAS CHARGES.—Some time back we announced that a conference of delegates of vestries and various district boards in the London district was to be convened by the Hammersmith Vestry to consider the means of obtaining uniformity in the price of gas throughout the metropolis. This conference was held at Hammersmith this week, and representatives from Battersea, Fulham, Hackney, Hampstead, Islington, Kensington, Lambeth, Paddington, St. George's (Hanover-square), St. George's (Southwark), and Westminster were present. After some discussion a resolution was carried, that "the time had arrived when the anomalies in the charges for gas and the use of meters by the various gas supply companies should be removed, and that gas should be supplied at a uniform rate per thousand feet, with the free use of

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meters." It was further resolved "that a Parliamentary inquiry should be held to inquire into the present management and working of the various gas undertakings, especially in regard to the question of the sliding scale of price and dividend."

MANCHESTER.—Mr. Alderman Gibson, at the last meeting of the City Council, in reply to questions put to him as Chairman of the Gas Committee, stated that the electric light installation was now being increased, and eventually, no doubt, the area would be extended, not only to Oxford-street, as suggested by a member, but to all the main roads in the city.

MIDDLETON (NEAR LEEDS).—This village is the property of the Middleton Estate and Colliery Company (Limited), and is composed of two mansions, a colliery, church, schools, chapel, and workshops necessary for the maintenance of the collieries and a population of about 1,200 persons. Mr. T. Harding Churton, of Leeds, has been called in by the owners to prepare a scheme for lighting the greater part of the estate by electricity, the generating plant to be situate at the colliery. The necessary work is now being carried out. A constant supply of current is to be provided for, the power being derived from a steam engine which is also used for ventilating the main. An underground concentric cable, designed by Mr. Churton and made by Messrs. W. T. Glover and Co., 2,300 yards in length, is to be used, and the dynamo is being made by Messrs. John Fowler and Co., of Leeds. The workwill be completed about the middle of November.

MOTHERWELL.—On Tuesday last the Police Commissioners discussed a report by Mr. Mavor, of Glasgow, dealing with the subject of the lighting of this district by electricity, which Mr. Mavor thinks could be introduced with good prospects of success. He estimates the initial outlay at £12,500, which would include the cost of obtaining a Provisional Order. As the Commissioners have been notified of the intention of a private company to apply for a Provisional Order, it was decided to adopt Mr. Mavor's report, and to take the necessary steps to carry out the scheme.

MUSIC HALL LIGHTING.—A sum of £550 was spent on electric lighting at the Canterbury Music Hall during the past year, and a further larger sum has been expended in lighting the Paragon Music Hall. These halls belong to the Canterbury and Paragon (Limited). The Chairman, at a recent meeting of the shareholders, stated that the Directors considered that the satisfactory result of the past year's working, in spite of the general falling off in music hall receipts, was largely owing to the policy adopted of brilliantly lighting the halls under the Company's management, and otherwise beautifying their property.

NEWCASTLE-ON-TYNE.—On Monday last a formal reopening was made of the Literary and Philosophical Society's premises after the lengthy closing for repairs and alterations consequent upon the disastrous fire which occurred at the centenary celebration. Mr. James Swinburne delivered a lecture on "Some Modern Electrical Experiments," which is the first of a series of twenty-one miscellaneous lectures to be given during the session. Lord Armstrong who, as President of the Society, took the chair, referred to the fact that on the previous occasion of his addressing the members the conflagaration referred to followed, and this was fancifully ascribed by some people to the pyrotechnic electrical experiments given on that occasion. In the course of Mr. Swinburne's lecture reference was made to the experiments of Mr. Nikola Tesla, and Mr. Swinburne was able to show a large Tesla coil lent by Mr. Mavor, of the Fowler-Waring Company, and which had been carefully and scientificially worked out by Messrs. Ionides and O'Gorman. This coil is by far the most powerful Tesla coil in this country, and enables a number of very striking experiments to be made. A cordial vote of thanks was awarded Mr. Swinburne at the conclusion of his lecture.

MILL LIGHTING.—The extensive Vulcan Mill, Bury, Lancashire, has just been fitted throughout for the electric light by Messrs. J. H. Holmes and Co. A trial recently made proved thoroughly satisfactory. A "Castle" dynamo of the latest type is used with a capacity for 1,160 16-c.p. lamps, and a second machine is used for the pilot circuit capable of supplying 230 16-c.p. incandescents. Two Marshall's engines are used.

THE NEW MAYORS.—Mr. Alderman B. A. Dobson, of the firm of Barlow and Dobson, machinists and engineers, and President of the Iron Trades Employers' Association, has been unanimously invited by the Bolton Town Council to accept the Mayoralty of that city for the ensuing year.

NEW SWINDON.—It has been decided to apply for a Provisional Order for lighting the district of New Swindon by the electric light.

THE "PATENT SOLICITOR."—Charles S. Hulser, trading as a "patent solicitor" at Temple Chambers, London, E.C., was convicted at the Mansion House, London, last week, for failing to carry out an undertaking to destroy a quantity of stationery containing untrue statements. Defendant claimed to be a patent solicitor, whereas he is not upon the rolls of the Incorporated Law Society. A fine of £4. 2s. was inflicted, or imprisonment for fourteen days. A distress warrant was issued.

PENRITH.—The extensive premises of Messrs. Hetherington Bros., general merchants, Corn Market, Penrith, have been lighted throughout by electricity. The outside lighting is effected by arc lamps, and 116 16-c.p. incandescents are used for the interior lighting. The generating plant consists of a 14 H.P. Stockport gas-engine, and an 80-ampere dynamo, supplied by Mr. Nawton, of Taunton.

PHOTO-PROCESS BLOCK MAKING BY THE ELECTRIC LIGHT.—Some very high candle-power Harp arc lamps are now being fitted by Messrs. Tickner and Partington, in Furnival-street, Holborn, W.C., for photo-process block work.

PORTSMOUTH.—The overseers have assessed the electric lighting works at £3,500, which means a payment in rates of nearly £1,200.

REDDITCH.—The Electric Lighting Committee some time back engaged the services of Mr. J. A. McMullen to prepare a scheme for, and to report upon the probable cost of, lighting the town by electricity. Mr. McMullen has prepared two schemes, one which would entail an outlay of from £7,000 to £8,000, and another which would cost from £13,000 to £14,000. The Committee have carefully considered these schemes, and believe that by making an equivalent charge for electric current to that now being paid for gas the smaller scheme would more than pay expenses, and that by the adoption of the second or larger scheme a profit of more than £1,000 per annum would result. The Committee, therefore, suggest that as soon as premises are obtained for from 1,500 to 2,000 lights a Provisional Order should be applied for, but that the whole question should be deferred until the election of the new Council.

SHIP LIGHTING.—The "Arundel Castle," a powerful steamer of 4,700 tons, now being built by the Fairfield Company, for the South African service of the Castle Line, is being fitted throughout with electricity.

ST. HELENS.—The Electric Lighting Committee of the Corporation have instructed Mr. Robert Hammond to report as to the best scheme to be adopted for the supply of electric current within the borough.

STRAND (LONDON).—The application by the Charing Cross and Strand Electricity Supply Corporation for leave to lay mains in the parish of St. Paul, Covent Garden, for the purpose of supplying electric current to Drury-lane Theatre, was discussed by the Strand Board of Works and refused.

SUNDERLAND.—A proposal to light the Museum and Library by electricity was before the electric lighting Committee of the Town Council at its last meeting. No definite decision was come to, the question being adjourned for further information as to probable cost, &c.

TAPE TELEGRAPH MACHINES.—The London Stock Exchange has recently decided to prohibit the use of the Exchange Company's tape machine by outside brokers, so far as the supplying of Stock Exchange prices is concerned. This has given rise to much discontent on the part of the fraternity affected by this decision, and an action was brought in the High Court, on Wednesday, for an injunction against the Exchange Company to restrain them until the trial of an action from disconnecting the plaintiffs with their Stock Exchange centre. Several points in the evidence were subsequently dealt with by the Lord Chief Justice, who ultimately declined to grant the injunction, but stated that the motion raised a question of very wide importance as to the liability of the Exchange Company to supply information to all members of the public without distinction or preference, as the Company were under licence from the Postmaster-General. No order was made as to costs, which were reserved till the trial of the main action.

TECHNICAL EDUCATION.—The London County Council have adopted a motion referring to the Parliamentary Committee and the Technical Education Board the preparation of a Parliamentary Bill, providing that a portion of the City Livery Companies' incomes should be allotted to the Council for the purposes of technical education in the Metropolis.

WELLS.—At the meeting of the Town Council, on Monday, the Lighting Committee reported that, in their opinion, it was desirable in the interests of the ratepayers to adopt the electric light for the city, and that a claim should be adopted and carried out by the Urban Sanitary Authority. It was decided to ascertain from other towns using the electric light the name of a competent expert to advise on the subject, and to report at the next meeting.

WOKING.—The Lighting Committee report that Messrs. New and Mayne anticipate lighting the streets by electricity according to their contract on October 8th.

WORKS LIGHTING.—The Aston Hall Brick and Tile Works, near Hawarden, and the iron and steel foundry works of Messrs. Maurice Donne and Morice, at Stevenson, N.B., are to be lighted by electricity.

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WORCESTER.—The Electric Lighting Sub-Committee have recommended that the charge for electric current for motive power be fixed at 3d. per unit, and that a separate meter be used. It was explained by the Mayor that users of the electric current for motive-power purposes would then be supplied with power at a much cheaper rate than the gas company was able to supply them. The electric lighting mains are to be extended in order to supply current to applicants in College-street and Sidbury. It was stated that the equivalent number of 8-c.p. lamps at present wired was equal to 3,850, this, of course, being independent of the Waterworks pumping and street lighting. The churches of St. Michael and St. George, the Union Club, the Shire Hall, and other important public buildings were now lighted by electricity, and further extensions will be necessary in the immediate future.

LATIMER CLARK, MUIRHEAD AND CO. (LIMITED)

(*In Liquidation*).

The report of the receiver and liquidator in this winding up has just been issued, and discloses a most unsatisfactory condition of affairs. On the January 18th last, the date of the appointment of Mr. J. Worley as receiver and manager on behalf of the debenture holders, no funds have come into his hands as liquidator, as the whole of the assets are claimed by the debenture holders and other secured creditors. The Company's books had to be written up, and owing to complications that existed a long time was occupied in this work. Contracts had been entered into to the extent of fully £100,000 which still required to be completed, involving a considerable outlay for materials and labour, and it was necessary to finish them to prevent heavy claims for damages and loss of sums deducted as retention money. These contracts have now been completed, so far as they can be; but it will be some time before the balances outstanding in respect of them can be got in. The report gives an account of the formation of the Company in 1883, and the steps which were taken to obtain capital from time to time. In all about £19,300 was brought into the business up to 1886 in the form of debentures. In March, 1888, a second issue of debentures was resolved upon, and up to December, 1891, sums amounting to £10,900 were received in respect of the same. In February, 1889, other debentures for £12,000 were issued as security for loans, making the second issue £22,900 in all. The total due in respect of debentures and interest at the date of the stoppage was :—

1st issue.	Principal	£25,000 0 0	
	Interest	6,824 11 10	
			£31,824 11 10
2nd issue.	Principal	22,900 0 0	
	Interest	5,867 17 3	
			28,767 17 3
			£60,592 9 1

The turnover up to the end of last year appears to have been about £437,000. Some of the contracts seem to have been fairly profitable, but others showed disastrous results. The last balance-sheet was made up to June 30, 1893, and covered a period of eight months. It showed a gross profit of £3,501. 12s. on operations amounting to £38,600; but the net result was a deficit of £2,575. 11s. 10d.; after debiting establishment charges and £2,400 for interest on debentures and loans. The deficiency shown in the statement of affairs is £47,022. 9s. 10d. Adding the share capital £47,020, the total is £94,042. 9s. 10d., which is accounted for as follows :—

Losses on contracts, bad debts, &c., &c.......	£24,361 0 0	
" shares in various companies	4,027 1 4	
" patents	795 1 5	
		£29,183 2 9
Interest on debentures and loans, in excess of profits		24,638 2 4
Difference in valuation of plant, &c	13,467 16 10	
" " stock in trade	5,057 13 5	
" " premises, Regency-street	5,781 1 4	
Difference in valuation of furniture, &c. ...	914 13 2	
		25,221 4 9
Goodwill		15,000 0 0
		£94,042 9 10

No dividend has ever been paid on the shares. The Directors of the Company at the date of the stoppage were Mr. J. Latimer Clark, Mr. John Muirhead, Mr. E. Clapham and Mr. D. B. Hall. Mr. Clark and Mr. Muirhead had been on the Board since the formation of the Company, Mr. Clapham joined it in 1886, and Mr. Hall in May, 1890.

It was deemed desirable to sell the entire business and property, as a going concern, by private treaty if possible; but although special efforts were made no offer could be obtained. It was, therefore, decided to offer the plant, machinery, and stock in trade for sale by auction, which was done early this month, notice of the sale having been given to all the creditors. The net proceeds of the sale will not be more than £5,000. For the sub-leases of the premises in Regency-street there were no offers.

The gross liabilities of the Company are £101,728. 4s. 7d., of which £81,697. 10s. is expected to rank for dividend. The estimated assets amount to £34,675. 0s. 2d., of which a considerable portion is payable in debentures and shares of uncertain value, leaving a total estimated deficiency of £47,697. 10s.

A meeting of all the creditors is called for Thursday, the 11th inst., at three o'clock, at Winchester House, London, E.C., to consider the above report and statement of accounts, and to receive from Mr. Worley such further information as he is able to give as to the present position and past transactions of the Company. Mr. Worley adds that there does not appear to be any prospect of the unsecured creditors receiving any dividend.

COMPANIES' MEETINGS AND REPORTS.

Brush Electrical Engineering Company (Limited).

The fifth annual general meeting of this Company was held at Cannon-street Hotel on Monday, October 1st, under the presidency of Mr. J. B. Braithwaite, jun.

The SECRETARY (Mr. B. Broadhurst) read the notice calling the meeting, and the report of the Directors was taken as read.

The CHAIRMAN: In moving the adoption of the report I do not think I need detain you more than a very few minutes on this occasion, as the past year with the Brush Company has been one of continuous employment in our factory and one of great commercial prosperity, considering the very keen competition we have had to meet with in our business during the period under review. I will deal first with the balance-sheet, and then with one or two matters which will, I think, interest you with regard to our present position as a manufacturing company. If you turn to the balance-sheet you will see that there has been no change in the capital issued in the past year, and the shares and Debenture Stock issued remain the same. There is an increase in the item of creditors which is balanced by a corresponding increase in the item of debtors, both of which increases are due to the extended business which the Company has done during the past year, an increase amounting to about 50 per cent. The next item is loan from bankers on security, £25,000. You may ask how it is we have arranged for this overdraft instead of issuing further capital in view of the fact that our Debenture Stock is at a good premium, and that our Preference Stock is also at a premium. The answer is that we do not require any additional working capital. The reasons which made it desirable for us to arrange an advance from our bankers are reasons of a temporary character only. There are three reasons. One is the increased overturn of the business, another is the large amount of money that we have locked up at the present moment in retention funds connected with the municipal contracts we are executing. I do not know whether the shareholders are aware of it, but in undertaking these municipal contracts it is usual for a provision to be inserted that a considerable sum of the total amount of the contract shall be retained in the hands of the Municipality until the plant has been set to work, and been running to the satisfaction of the Borough Engineer for a period of three months or six months as the case may be. The same retention clause exists in respect to the large contract we have with the City of London Electric Lighting Company. Therefore, when you see on the credit side of the balance-sheet that we are owed £158,000, I may say that something like £50,000 or £60,000 of that is represented by this retention money, all of which will come in, and a good deal of it very shortly. When it comes in there will be no further necessity for us to have credit from our bankers, so that to issue capital for a purpose like this would be only unduly burdening ourselves. We also hold nearly £43,000 of shares and debentures in other companies. It is probable that during the present year at least half of that amount, and possibly more, will be turned into cash, which would again, by itself, enable us to repay this loan and also have working capital in hand. I think the shareholders will agree with me that under the circumstances it is much better to arrange for the accommodation we require temporarily from our bankers rather than to permanently increase the charges on the Company by issuing fresh capital, and I hope that the shareholders will endorse the action we have taken in this matter. The next item requires a little explanation. If you look on the credit side of the balance sheet you will see an amount of £9,000. Shareholders who have been in this Company for some years will probably remember that for two or three years in succession we wrote off a lump sum of £3,000 out of our profits from the item of property, patents, and goodwill. This was written off in a general way, without reference to any particular item, and appeared in our books as a sort of inner reserve fund. I had a conversation with Messrs. Cooper Brothers, our auditors, this year on this subject, and I pointed out how undesirable it was that this inner reserve fund should exist in our books unknown to our shareholders, and I said that, personally, I should prefer that our balance-sheet should show our position to the shareholders to the fullest possible extent. I therefore suggested that we should bring that £9,000 back on one side, and show it as a reserve against depreciation on the other. You will therefore see that we have brought that figure of £9,000 back, and in the past year we have deducted from it the balance of the cost of the Manchester and Cardiff stations closed during the year, amounting to £3,614, leaving us with an available reserve for depreciation of property, patents, and goodwill of £5,385, in addition to the other reserve, which now amounts to a little over £1,000. The shareholders will therefore see exactly our position with respect to that item. With reference to the closing of the Manchester and Cardiff stations, I suppose we must say that that is the fortune of war. In both those cases the Brush Company pioneered the electric light. At Cardiff we had a station running for a considerable number of years, and we did the work so well that the Corporation there said that it was a good sound business, and that they would do it themselves. When, therefore, we applied for a Provisional Order, we found that our supply had been so excellent

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that we could not get the Corporation to consent to our having an Order. The same thing occurred at Manchester, where we had a small supply station which had been furnishing current for some years to hotels, &c., in the neighbourhood. When we applied for a Provisional Order the Corporation said, "No, you have done the work well; and shown us that it is quite easy, so we intend to do it ourselves, and keep the profit." There was therefore nothing for it under the circumstances but to close down those stations, sell our property, and write the thing off; and the difference between the cost of these stations, as it stood in our books, and what we realised for them has been this sum of £3,614, which we have written off our depreciation reserve fund. Those two matters are now cleared up, and I need not state that in the present condition of the electric lighting industry there is no necessity for us to pioneer any further stations. We have set the example and done the pioneering work, and municipalities throughout the country are now convinced that it is to their interest to do the work themselves; and I am glad to say that in many cases they are coming to the Brush Company, as the people who are most competent to supply them with the plant they require. On the credit side of the balance-sheet you will see that the item of property, patents, and goodwill is increased by this sum of £9,000, and it is further increased by the additions which have been made during the year to plant, amounting to £3,710. This represents virtually the additional capital expenditure we have incurred in the past year, and it has been almost entirely incurred for additional tools in order to enable us to deal with the large amount of central station plant that we now have orders for. It has also been partly incurred for additional shops at Loughborough, where we have, I suppose I may say, the finest electrical works in the United Kingdom. If any shareholders would like to have an opportunity of visiting our works at Loughborough, we should be happy to give them every facility for seeing the property in which they have invested their money if they will drop a line to the Manager. We have deducted for property and plant disposed of during the year, £5,237, and the usual sum for amortisation of lease, £733; and we bring out then our property, patents, and goodwill at the figure of £287,084. Then we have our stock—goods in hand in process of manufacture, work in progress, and materials in London, at Loughborough, and other places, £114,681. I am very happy to be able to say, as I think I said the same at our meeting last year, that none of the plant represented by that £114,681 as in course of manufacture is being manufactured for stock simply to keep the men employed and our works going. All of this work is in execution of orders that we have received. With regard to the item of debtors, I have mentioned the large sum that we are now owed of £158,691; and then we have our cash at bankers and in hand amounting to about £13,000; share and debentures in other companies about £43,000; and liquidators' balances and suspense accounts £2,110. The balance of foreign and colonial branches accounts stands at £76,258. That gives us a net result, after paying our interim dividends and charging the interest on our Debenture Stock, for the whole year of £15,938, out of which we shall propose, if you approve this report and balance-sheet, that £12,150 be appropriated to paying the second half-year's dividend on the Preference shares, and a dividend on the Ordinary shares at the rate of 5 per cent. per annum, carrying forward £3,788. Probably someone will ask why we do not propose the same dividend as we paid last year, as we have earned it. It is quite true that we have earned it; and paying 7 per cent. per annum instead of 5 per cent. would absorb £2,700, and we could pay that and still carry forward £1,088. It is not unreasonable, therefore, for you to ask whether we have any special reason for not doing so. We have no special reason except that the balance-sheets published by some of our competitors—two of whom, not having even earned their Preference dividends out of trading profit, were of such a character that we thought the present was the psychological moment to increase the amount carried forward. We thought that this was an opportunity which might never occur again, and I hope you will approve of this course, because in an industrial concern like ours you cannot be in too strong a financial position. I believe you will find that the fact that we are in such a solid financial position as to enable us to carry forward so large a sum will do the Company not harm but good. We do not, however, intend to pile up the amount carried forward in this way. If we have another year like this, I hope that we shall be able to pay a dividend of 5 per cent., which I think we will settle on as our regular dividend, and a handsome bonus besides; but I cannot prophecy until the end of the financial year. If you turn to the profit and loss account you will find that our gross profit this year was £57,157, as compared with £49,405 in the previous year. You will therefore see that during the past year our gross profit has improved by £8,000, which, in view of the fact I have mentioned before of the exceedingly keen competition which there has been for these tenders for Municipal stations, cannot, I think, but be considered extremely satisfactory; and in my view it reflects very great credit on our managers, officers, and staff generally, all of whom have worked so loyally and heartily in the interests of the Brush Company in the past year. On the other side of the account the standing charges show an increase of about £2,000. You cannot do 50 per cent. more business without some additional expense. You are aware that last year we wrote off £1,300, the bulk of the cost of the removal to Loughborough. The final concentration of our work there has taken place at an expense of £632, which we propose to write off out of revenue, the same as we propose to do with the cost of removing from the Hammersmith works. We have spent nearly £4,000 more on buildings and plant. This expenditure assures us that our engineers and other officers keep our property in first-rate condition. The net result of the profit and loss account is that there is a profit, after paying the Debenture interest, for the shareholders of £27,280. There is nothing calling for special attention in our foreign business. In Australia the business during the past year has been very much reduced and hampered, owing to the crisis through which the Australian Colonies have passed; but I think the shareholders will be well satisfied with the gentlemen who are managing our business out there in view of the fact that, notwithstanding all this financial depression, the amount of bad debts they have made is less than £50. With respect to our Vienna business, that has made satisfactory progress in the last year. The quality of the work turned out from there is extremely high. Our engineer, Mr. Kremenezky, is a very energetic and talented gentleman, and I think your interests are well served by him in Austria and on the Continent generally. All the plant he turns out is of first-class quality, and the arrangements we have made for the financial management of the business between London and Vienna have proved satisfactory. During the past year the Vienna business has shown us a fair return on the amount of capital invested in it, and I think it is a business that is steadily improving. There is a new item in our balance sheet—namely, the Bonus Fund "Trustees' a/c" in connection with the employés' bonus scheme. The shareholders who have attended these meetings for some years are aware that in 1887 we thought it right to adopt some scheme between the Company and its employés, by which the latter should have some share in the prosperity of the Company, believing that such a course was in their interest as well as in our interest, as attaching them more firmly to us, and encouraging that strong feeling of loyalty and *esprit de corps* which, in such an undertaking as this is of very special value. This scheme has very much extended since it was established. In 1887 the number of participants was only 13, and the amount distributed was £250. We began by making our highest officers participants, but we have gradually extended the scheme downwards. In 1890 there were 25 participants, and the amount distributed was £730; in 1891 55 participants, and the amount distributed was £1,313; in 1892, 67, and amount distributed £1,961; and last year we felt that we must make a stride forward, and include a much larger number of the men in our employ. In doing that it became necessary to draw up a trust deed and appoint trustees, and in 1893 the number of our employés who participated in the scheme was 163, and the sum distributed was £2,488. The trustees consist of the Chairman of the Company from time to time, the two managers, and our works manager at Loughborough. The sum we have had to deal with has been £2,190, out of which we have paid out £872. We have invested £1,196 in the purchase of £889 Four per Cent. Midland Railway Preference Stock, which forms the provident and reserve fund provided by the scheme. I think this disposes of all the points which arise with respect to the balance-sheet, but I shall be very happy to answer any questions which the shareholders may wish to put respecting it. With regard to the general prospects of the Company, it may interest the shareholders to know that during the year the stations we have erected for the municipalities of Lancaster, Huddersfield, and Hanley, have been opened for work. We have also completed the installation for the Duke of Norfolk at Arundel Castle. We have now in hand the fitting up of the Central Station at Worcester, and the works are also in hand for the municipality of Leicester, and these works will be opened before the end of the year. We have also work in hand for the Dover Company. With respect to our City of London contract, you will remember that when we took that contract the largest size of dynamo machine we had made was one of 100 kilowatts, capable of supplying about 3,000 lights. The contract provided for our manufacturing machines of four times that size, and at our meeting the year before last I said that we had successfully manufactured a machine of 200 kilowatts, which proved to be capable of supplying, not 6,000 lights, but nearly 7,500. I told you last year that the first two of the larger machines had been built and erected in the City Station. Those machines were specified for 400 kilowatts, and turned out equal to 500 kilowatts. Each of the machines which we have furnished to the City of London Company is capable of supplying current for 15,000 lights, and the City of London Company has now six of these 15,000 light machines. Three more are on order, and are now in course of manufacture. Each machine supplied by us has exceeded the specification, as proved by the tests taken. The specification stipulated that the combined efficiency of the engines and dynamos should not be less than 80 per cent., and the tests made by Professors Kennedy and Thompson gave a result of 83 per cent. The regulation of the machinery was to be within 10 per cent., and the result was well within that figure. In every case our work has not only come up to, but has exceeded, the requirements of the specification. I think these facts deserve a word of praise from me as Chairman of the Company (and I hope that the shareholders will endorse them) in recognition of the abilities of the technical officers by whom these results have been attained. Our engineer, Mr. Raworth, is responsible for the design of the engines; and our electrician, Mr. Mordey, is responsible for the dynamos; and the fact that these gentlemen should have made designs of machines four times larger than anything previously built, and that those machines should have been built from those designs, practically without modification, is very high testimony to the capabilities of those gentlemen. Although we have had some very large orders from the City of London Company, we are still expecting further orders for another £100,000, and judging from the progress made we shall not have to wait long, for the applications for lighting in the City continue to increase. I do not think it will be a breach of faith to mention that the applications received for the light last week alone exceeded 4,000 in number. Then, with respect to the County of London Company, which we have formed during the past year, we were careful to send a prospectus to every one of the Brush shareholders, wishing to give them an interest in a company which we believe will turn out as successful in its way as the City of London Company. They, however, only responded to a very small extent. I do not think the prospects of the County of London Company are one whit less favourable than those of the City of London Company. The County of London Company hold the district of St. Luke's, joining on to the City boundary, and running up to the Angel, Islington, and the districts of Clerkenwell and Wandsworth. The Bournemouth station is theirs, which already supplies 18,000 lamps, and they also have a station at Dover. In addition to these the Company has secured the outfall o

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Lake Windermere, which is the finest piece of water-power in the kingdom, equal to 40,000 H.P. The Company is taking the necessary steps to acquire powers to supply an area of ten miles from Lake Windermere, and the Brush Company expect from the County of London Company orders to the extent of something like £1,000,000 in the next few years, and therefore we feel a beneficial interest in their progress. It is impossible to prophesy the financial results of the current year, but so far we have every reason to be satisfied. Our works are employed to their utmost capacity, and we have orders in hand that will keep us employed to the end of the year, while additional orders continue to come in at a satisfactory rate. I think, therefore, that we shall not have a less satisfactory balance-sheet next year than we have this. I now propose

"*That the report of the Directors and statement of accounts to June 30, 1894, now presented to the shareholders, be received, and that the same be hereby adopted.*"

Mr. B. H. VAN TROMP seconded the motion.

Mr. BOYS thought there was a middle course between paying a dividend of 5 per cent. and 7 per cent. on the Ordinary shares, and that was 6 per cent. He had every confidence in the Company as he had always had, and he had been very pleased to hear the remarks of the Chairman.

The CHAIRMAN said there was no reason why they should not pay a dividend of 7 per cent. per annum for the past half-year on the Ordinary shares; but at the same time he thought the shareholders would agree that the present was an opportunity of strengthening their position which they ought not to lose sight of.

Mr. SEWARD asked if the reserve fund was invested separately, or whether it was in the business.

The CHAIRMAN: The reserve stands in our books against our property patents, and goodwill.

The resolution was unanimously carried, as were also resolutions for confirming the payment of the interim dividend at the rate of 6 per cent. per annum and 5 per cent. per annum respectively on the Preference and Ordinary shares for the six months to December 31st last, and for the dividend on the Preference shares at the rate of 6 per cent. per annum, and on the Ordinary shares at the rate of 5 per cent. per annum for the six months ended June 30th.

Mr. Sanderson and Col. F. G. Steuart were re-elected as Directors, and Messrs. Cooper Bros. and Co were re-appointed auditors, and, after a vote of thanks to the Chairman for presiding, the proceedings terminated.

The Fusion of French Cable Companies.

Extraordinary general meetings were held last week of the two French Cable Companies it is proposed to amalgamate—that of the Société Française des Télégraphes Sousmarins on Thursday, and that of the Compagnie Française du Télégraphe de Paris à New York on Saturday. The meeting of the former Company was under the Presidency of Admiral Caubet, the Chairman of the Company, and the resolutions approving the fusion, subject to the Government authorisation, were carried.

The Directors of the Compagnie Française du Télégraphe de Paris à New York, previous to the meeting forwarded to the shareholders a report, of which the following is a translation:—

"The Board of Directors you elected last year would have ill comprehended its mission if it had contented itself with following in the steps of its predecessors and with prolonging indefinitely a situation which for fifteen years has meant for you not only the absence of dividends, but (being without a reserve fund) a diminution, each year more marked, of the value of the property which represents your capital. Naturally, our first duty was to re-establish order on the Board, reduce expenditure, increase as much as possible the traffic, and watch the course of litigation in progress. But we know well that with the best administration a cable placed in conditions like ours—a single cable, without feeding lines, without return traffic—could not possibly realise profits sufficient to lay up a reserve and to distribute a dividend to the shareholders. You have had the situation under consideration at your meetings of 1890, 1891, and 1892—your opinion in 1891 being unmistakable, when, in view of the establishment of a cable from Puerto Plata to New York, you passed a resolution that an issue of debentures sufficient to produce the sum of 12,000,000fr. should be made; and so the junction of our cable with the French system of the Antilles, and the search for a strong and durable support, became rightly the chief object in view. This result, which your isolated efforts were unable to realise, an understanding with the Société Française des Télégraphes Sousmarins might one day permit you to realise; we have, therefore, thought it our duty to pursue the realisation of this object, which appeared to us to be of very great importance for both Companies.

"Separated as they are to-day, left to their own traffic resources in the face of a very powerful combination, they can neither increase nor prosper. The Compagnie Française du Télégraphe de Paris à New York connects France and America without possessing in the latter country any interest capable of bringing traffic to it; while the Société Française des Télégraphes Sousmarins, although owning a system extending over nearly 7,000 kilometres in a region of the New World where it has important monopolies which have a long period yet to run, can only communicate with France and Europe through cables belonging to foreign companies, which have the greatest possible interest in preventing the development of its traffic. To form of these two companies, each of which would be so well the complement of the other if they were combined, one great French Telegraph Company, capable of giving to the correspondence between France and the three Americas the independence and security which it calls for, is the aim of the project now submitted to you.

"In considering this project it is not only a question of the pure and simple union of the present receipts of the two companies, but of the effective junction of the two systems, which, once combined, should lead to an important increase in receipts. This consolidation of the two systems could be effected by the laying of a cable between the Antilles and North America, as in the scheme which you have approved at former meetings. This connecting link once laid, the Company would transmit its traffic by its own cable, and would thus retain the receipts from correspondence exchanged with the countries served by the Société Française des Télégraphes Sousmarins which have now to be divided with the intermediary companies. On the other hand, messages for Europe originating on the system of the Société Française des Télégraphes Sousmarins cross the Atlantic by Anglo-American cables, and not by the Pouyer-Quertier cable. This traffic, which is now taken to Cuba by an English Company whose interests are bound up with those of the Anglo-American lines, will be sent by the P.-Q. cable as soon as a connecting line has made the system of the Sousmarins Company independent of foreign companies. Besides the traffic now existing, which it is essential should go over our lines, the amalgamation of the two systems should lead to a very important augmentation of income, the principal sources of which would be: (1) The traffic between Brazil and the whole Atlantic coast of South America and North America, which now goes *viâ* Europe, crossing the Atlantic twice; (2) The traffic between Europe, Cuba, and the greater part of the Antilles, which would find in the new line a much quicker and cheaper route. Under these new conditions, it will be necessary to consider the question of laying a second transatlantic line between France and the United States, which would not only give security, but would be required for the increased traffic. It is not necessary to say that the laying of a second cable would, even in the conditions which now exist, ensure our line from interruption; but it would not bring any increase of traffic to return the capital which would have to be expended. No project of this kind will stand serious examination in view of the actual condition of our Company's finances.

"We have every reason to believe that the constitution of a grand French system such as we have indicated would be viewed with favour by those in authority, and that the great Company of which you will form a part, if you approve the proposals we make, will receive from the Government support which will permit the realisation of the programme laid before you. The progress of the negotiations has not permitted us to bring this question before you since your last meeting; besides, the litigation with the Anglo-American Company had not then been concluded, and we were precluded from touching on that subject. You are aware of the result of that litigation. The principal demands of our opponents have been rejected, and we wait with confidence the result of the expert inquiry, which is limited to the period 1886-1891. We have to bear the costs. But, since the month of May, the question occupying our attention has made a decided advance, and we find ourselves in presence of solid proposals, which it was our duty to submit to you at the earliest moment.

"You have been furnished with the terms of the provisional agreement between the Boards of Directors of the two Companies, the Compagnie Française du Télégraphe de Paris à New York and the Société Française des Télégraphes Sousmarins, now submitted for your ratification; this will have given you the financial side of the project, and we here give an analysis:—The reconstituted Company will have a capital of 24 million francs, composed thus: Reduction of the capital of the Société Française des Télégraphes Sousmarins from 11 million francs to 7,300,000fr.; capital representing our Company, 14,000,000fr.; shares subscribed for at par by a group of financiers to the amount of 2,700,000fr., which sum would be utilised for carrying out the scheme. To effect this, you will have to vote the liquidation of your Company, and its liquidators must have authority to transfer its property to the Société des Télégraphes Sousmarins at a total value of 14 million francs, which it will receive in fully-paid shares of the Société Française des Télégraphes Sousmarins, reconstructed with a capital of 24 million francs. The number of share warrants will agree with the value of the ceded property, and the exchange for the shares of our Company will be effected by the liquidators after the liabilities are disposed of.

"The estimates of the value of the property of the two Companies appear to us to be reasonable and fair. The American system of the Société des Télégraphes Sousmarins will be represented in the new amalgamation by 14,300,000fr.—7,300,000fr. in shares, and 7,000,000fr. in debentures. This valuation does not appear to us to be excessive. The Company's system in the Antilles and in South America extends over 6,754 kilometres. Its total cost has been 10 million francs, including the concessions, the greater part of which, as we have said before, ensure for many years an exclusive monopoly. In addition, the Société des Télégraphes Sousmarins possesses, by contracts, subventions, and traffic guarantees, a sum of 355,000fr., which will be sufficient to pay the interest on the debentures. We have, therefore, had to consider whether this amount of 14,300,000fr., the estimated value of the system of the Société des Télégraphes Sousmarins in the new amalgamation, corresponded with that of our own property. The system of the Société des Télégraphes Sousmarins, of whose value we had to make a comparative estimate, comprises a group of cables, the first of which was only laid in 1888, their average existence not exceeding four years. If we suppose, following accepted calculations, that they should last 25 years, it is evident that they are almost as good as new. The amount of 14,300,000fr., which represents their estimated value, gives them an average worth of 2,117fr. per kilometre. The same calculations respecting our cables gives an average of 2,163fr. per kilometre for lines which have been laid more than 14 years, and whose initial value has evidently suffered a sensible depreciation. We have also had to recognise the fact that the Société des Télégraphes Sousmarins holds in certain countries privileges which relieves it from all danger of opposition, while with us rivalry is a permanent menace.

"Our property, consisting of our submarine and land lines, our steamer, cable in store, material—everything constituting our assets—has been estimated at 14,000,000fr. Giving our cables an original life of 25 years, and reckoning its initial value at 34,000,000fr., its present worth comes out at about 13,600,000fr.

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"In valuing the property of the Société Française des Télégraphes Sousmarins, we have left entirely out of the calculation the New Caledonia cable, which was recently laid and is worked by that Company under the law of March 23, 1893. This cable, which is 1,500 kilometres in length, is the outcome of an absolutely distinct operation, and was provided for by the issue of special debentures, the interest on which is guaranteed by the French and the Australian Governments. Receipts are guaranteed of 300,000fr. after deduction of 60,000fr. for cost of working. It is anticipated that the investment of these debentures will exceed the charges they were issued to meet. The two companies have also had to take into account, in making this estimate of value, the appreciation of the new shares taken at par for the sum of 2,700,000fr.

"The meeting of shareholders of the Société Française des Télégraphes Sousmarins will take place before yours. The resolutions passed by them will be communicated to you, and it will then be for you, in your turn, to vote on the preliminary agreement, which we ask you to confirm, relying on your wisdom to take care of your own interests."

The *Bulletin de l'Electricité et de la Télégraphie* has voiced the opposition offered by some of the shareholders to the proposed fusion, and its last issue contained a long reply to the above report, dealing *seriatim* with the points raised, and stating that the Minister of Posts and Telegraph had been petitioned to withhold his consent to the amalgamation. The *Bulletin* also accused the Directors of a desire to take no action in obtaining from Messrs. Siemens Bros. and Co. an amount of nearly 11 million francs, which (according to the *Bulletin*) is due to the Company under the following circumstances:—By the terms of an agreement made in 1878 between M. Pouyer-Quertier and Messrs. Siemens Brothers, the latter were to establish two telegraphic communications between Europe and North America—one from France to the United States, and the other from England to Canada—and to provide a fully-equipped cable steamer; the total cost to be $44\frac{1}{2}$ million francs. The first cable and a portion only of the second (St. Pierre-Cape Cod) have been completed, and the cable steamer provided, of a total value of 12,465,500fr.; but Messrs. Siemens Bros. having received from the Company 33,334,000fr., it is claimed by the dissentient shareholders that the balance should be refunded by them to the Company.

At the meeting on Saturday, M. Etard, a Director, presided, in the absence of M. Lefaivre, the Chairman of the Company, and proposed the resolutions approving the winding up of the Company and the transfer of its assets to the Société Française des Télégraphes Sousmarins. He said that the Government had intimated that the necessary authorisation would probably be granted if the shareholders of both companies voted the amalgamation; and that, with reference to Messrs. Siemens Brothers, negotiations were pending with that firm, and that any sums recovered from them would be expressly reserved for the shareholders of the P.-Q. Company. A lengthy discussion ensued, but in the end the resolutions were passed almost unanimously.

CITY NOTES.

AFRICAN GOLD RECOVERY COMPANY (LIMITED).—At the meeting of the shareholders of this Company held last week, the Chairman said that the results obtained from the MacArthur-Forrest process, of which they are the owners, were eminently satisfactory, and resulted in the production of from 30 to 50 per cent. more gold than was obtainable before the discovery of the process. With respect to the Siemens and Halske process now being adopted to some extent in South Africa, this was, he believed, a process based upon the MacArthur-Forrest discoveries, and was being worked with some trifling addition.

ALUMINIUM COMPANY (LIMITED).—The profit for the year ended June 30th enabled the Directors of this Company, after providing for fixed charges, and allowing for depreciation in plant and buildings, to declare a dividend of 5 per cent. for the year on the "A" shares, carrying forward £1,475.

BIRMINGHAM CENTRAL TRAMWAYS COMPANY (LIMITED).—A meeting is to be held on the 10th inst. at the Queen's Hotel, Birmingham, to discuss a resolution to reduce the capital of this Company from £500,000 to £300,000. A circular accompanies the Directors' notice of the meeting, pointing out that very large sums of money have been spent, some of them most improvidently, which are no longer represented by the assets of the undertaking. A portion of the large sums referred to was spent in the provision of locomotive steam power for working a portion of the Company's system; but the Directors' report that the economies which were anticipated by many eminent engineers have not been attained.

BRITISH THOMSON-HOUSTON (LIMITED).—Mr. Ernst Thurnauer, General Manager in Europe of the General Electric Company of the United States, and a Director of the Compagnie Française pour l'Exploitation des Procédés Thomson-Houston at Paris, and of the Union Elektricitäts Gesellschaft at Berlin, has joined the Board of this Company.

CITY AND SOUTH LONDON RAILWAY.—The traffic returns of this Company for the week ended September 30th, were £881, as against £798 in the corresponding period of 1893, being an increase of £83. The total receipts for the half-year amount to £11,118, as against £10,479 for the corresponding period of 1893, an increase of £639.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the month of September, are £2,700, as compared with £2,880 in the corresponding month of last year.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the month of September, 1894, amounted to £1,898, as against £1,865 in the corresponding period of last year.

DIRECT UNITED STATES CABLE COMPANY (LIMITED).—The Directors of this Company have declared an interim dividend of 2s. per share free of income tax, being at the rate of 2 per cent. per annum, for the quarter ended September 30th, such divided to be payable on and after the 24th instant.

EASTERN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the month of September, 1894, amounted to £57,368, as against £55,997 in the corresponding period last year, an increase of £1,371.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of September, 1894, amounted to £40,178 and to £39,339 in the corresponding period of last year, being an increase of £839.

ENGINEERING AND GENERAL CONTRACT CORPORATION (LIMITED).—At the adjourned meeting of the shareholders of this Company, on Wednesday, the report of the Committee of Investigation, referred to in our last issue, was adopted, but a poll was demanded by the Directors.

W. T. HENLEY'S TELEGRAPH WORKS COMPANY (LIMITED).—Warrants were on Saturday posted for a dividend on the Preference shares of this Company for the half-year ended June 30, 1894, at the rate of 7 per cent. per annum.

MILDE TELEPHONES.—This week the public have been invited to subscribe for a first issue of 5,000 Seven per Cent. Cumulative Preference Shares of £1 each in the Mildé Telephones and Electric Supply Company (Limited), which has a capital of £20,000 in 15,000 Preference and 5,000 Deferred shares of £1 each. The prospectus states that the Company is formed with the object of acquiring the sole right granted to Mr. M. Kotyra by Messrs. Mildé, Sons and Co., of Paris, to all their improved telephones in Great Britain and Ireland and the English Colonies, and to establish local, provincial, and private telephone exchanges, &c., &c. Many claims are made for the Mildé telephones, one being that they are more simple in construction than any other telephones in the market. No date is given for the closing of the lists, and those requiring prospectuses will doubtless obtain copies at their leisure. The Deferred shares will not be entitled to any dividend until these Seven per Cent. Preference Shares have received their full dividend, and any surplus is to be divided between the Preferred and Deferred.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The traffic receipts for this Company for the two weeks ending September 30th were £1,647, as compared with £1,769 for the corresponding period of last year. The receipts for June, estimated at £4,460, realised £4,530.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended September 28th (after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited), were £3,395.

WESTERN UNION TELEGRAPH COMPANY.—The following is the report of this Company for the quarter ended September 31, 1894:—The condition of the Company at the close of the quarter ended June 30, 1894, was as under:—

Surplus April 1, 1894, as per last quarterly report		$6,937,992 68
Net revenues, quarter ended June 30, 1894		1,455,073 86
		$8,393,066 54
From which, deducting for dividend of $1\frac{1}{4}$ per cent. paid July 16th	$1,185,037 50	
Interest on bonded debt	220,404 50	
Sinking funds	19,991 00	
		$1,425,433 00
Less—Portion of Sinking Fund for the bonds of 1900 (which was set aside previously) returned to the Company by the Sinking Fund Trustees, because of the drawn bonds not being presented for redemption	40,000 00	
		$1,385,433 00
Left a surplus July 1, 1894, of		$7,007,633 54
The net revenues of the quarter ended September 30th based upon nearly completed returns for July, partial returns for August, and estimating the business for September, will be about		1,800,000 00
From which, appropriating for—		$8,807,633 54
Interest on bonds	$223,500 00	
Sinking funds	20,000 00	
Purchase of the telegraph lines and property of the American Rapid Telegraph Company, with 5,500 shares of capital stock, issued out of the increased stock authorised by the stockholders on October 12, 1892	550,000 00	
		793,500 00
		$8,014,133 54
It requires for a dividend of $1\frac{1}{4}$ per cent. on the capital stock issued		$1,192,000 00
Deducting which leaves a surplus, after paying dividend, of		$6,822,133 54

In view of the preceding statements, the Committee recommend the payment of a dividend of $1\frac{1}{4}$ per cent. on the capital stock of the Company on October 15th.—The dividend may be collected through any bank on or after the 15th inst.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share	Last Dividend.	Name.	Previous Week's Price, Sept. 26.	Price Wednesday, Oct. 3.	Rate per Cent. Yielded. £ s. d.	Dividend Due.	Business Done During Week Ending Oct. 3. Highest	Lowest
			TELEGRAPHS.						
£1,012,850	Stock	10/0	Anglo-American	39 42	39 42	5 7 2	Jan., Apr., July, Oct.	39	..
£2,993,560	Stock	20/0	Do. Preferred	74 76	74 76	5 18 5	" "	76⅛	75⅝
£2,993,560	Stock	5/0	Do. Deferred	6¾ 7½	6¾ 7½	..	..	..	..
£184,500	100	4%	*African Direct Teleg. 4% Deb. (Reg. & Bearer)	102 105	102 105	3 16 11	January and July	..	..
130,000	£10	3/0	Brazilian Submarine	12¾ 13¼	12¾ 13¼	4 18 1	Mar., June, Oct., Dec.	13⅛	12⅞
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1906)	109 113	110 114	4 8 8	June and December	..	–
10,000,000	$100	$1¾	Commercial Cable Capital Stock ... xd	140 145	135 145	4 17 9	Jan., Apr., July, Oct.	–	..
16,000	10	8/0	Cuba Submarine	12 13	12½ 13½	5 18 6	February and August	..	..
6,000	10	10%	Do. Preference 10 per Cent.	19 20	19 20	5 0 0	" "	..	..
12,931	5	1/8	Direct Spanish (£4 paid) ... xd	4¼ 4¾	4¼ 4¾	4 4 3	April and October	..	..
6,000	5	10%	Do. Preference 10 per Cent. ... xd	9½ 10	9½ 9¾	5 2 7	" "	..	–
£30,000	Stock	4½%	* Do. 4½% Debentures of £50 each	105% 108%	105% 108%	..	..	..	..
60,710	20	2/0	Direct United States Cable, 1877	8¾ 9½	8¾ 9½	5 12 4	Jan., Apr., July, Oct.	9⅛	8⅞
400,000	10	5/6	Eastern	15¾ 16	15¾ 16½	4 0 6	" "	16 1/16	15⅞
70,000	10	6%	Do. 6 per Cent. Preference	16¾ 17¼	16¾ 17¼	3 9 7	" "	..	..
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	118 121	118 121	3 6 2	May and November	119¾	..
£102,100	100	5%	* Do. 5 per Cent. Debentures, 1899	106 110	106 110	4 11 6	February & August	..	..
250,000	10	2/6	Eastern Extension	15¾ 16½	16 16½	4 6 3	Jan., Apr., July, Oct.	16¼	16 1/16
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	116 120	116 120	3 6 8	February & August	117	..
£62,700	100	5%	* Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103 106	103 106	4 15 6	January and July	..	–
£95,100	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb., 1900	103 106	103 106	4 15 6	" "	..	..
£300,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.)	103 106	104 107	3 15 4	February & August	..	..
£200,000	£25	4%	* Do. 4% Mauritius Sub. Debs.	103% 111%	109% 112%	3 13 3	May and November	108½	..
180,227	10	3/9	Globe Telegraph and Trust	8¾ 9	8¾ 9½	4 15 0	Jan., Apr., July, Oct.	9⅛	8⅞
180,042	10	6%	Do. 6 per Cent. Preference	15¾ 16½	16¾ 16½	8 13 10	" "	15 13/16	15⅞
150,000	10	5/0	Great Northern	20½ 21½	20½ 21½	3 19 1	Jan., April, and July	..	..
£190,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	103 105	103 106	4 14 4	March & September	104	–
17,000	25	37/6	Indo-European	46 48	46 48	5 4 2	May and November	47½	..
37,548	10	5/0	London Platino-Brazilian	5 7	5 7	..	" "	–	..
£100,000	100	6%	* Do. 6 per Cent. Debentures	106 109	107 110	5 9 7	March & September	..	..
£100,000	£100	4%	*Pacific European Tel. 4% Guar. Debs. "Red" 1942	104 107	101 107	3 15 6	..	..	..
11,839	8	4/0	Reuter's	3 5	3 5	..	April and October	..	..
3,381	£100 Cert.	25/0	*Submarine Cables Trust 6 per Cent.	105 110	106 111	5 9 1	" "	..	..
15,609	10	5/0	West African Telegraph	8 6	3 5	..	January and July	..	..
£249,900	100	5%	* Do. 5 per Cent. Debentures	100 103	100 103	4 17 7	March & September	101	..
30,000	10	2/0	West Coast of America	2 3	2 3	..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	101 106	101 106	7 10 11	June and December	..	..
88,321	10	9d.	West India and Panama	1¾ 1⅞	1⅝ 1⅞	..	..	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10¾ 11¼	10¾ 11¼	5 6 8	May and November	11	10⅞
4,669	10	6%	Do. 6 per Cent. 2nd Preference	9 10	9 10	6 0 0	" "	9¾	..
£80,000	100	5%	* Do. 5 per Cent. Debentures, 1917	108 111	108 111	4 11 1	June and December	110½	110
64,242	15	7/6	Western and Brazilian	8¾ 9½	8¾ 9½	..	May and November	9¼	9
33,129	7½	7/6	Do. 5 per Cent. Cumulative Preferred	6¾ 7½	6¾ 7½	..	..	7	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	2¾ 3¼	2¾ 3¼	..	..	3¼	3
£171,900	100	6%	* Do. 6 per Cent. Debs., Series "A" 1910	106 109	106 109	5 11 1	February & August	..	..
£214,800	100	6%	* Do. 6% Mort. Debs., Series "B" 1910	103 109	106 109	5 11 1	" "	..	..
$1,211,000	$1,000	7%	*Western Union 7% 1st Mort. (Building) Bonds	115 120	115 120	5 19 8	May and November	–	..
£166,900	£100	6%	* Do. 6 per Cent. Sterling Bonds	100 103	102 104	5 15 11	March & September	..	..
			TELEPHONES.						
44,000	5	10/0	Chili Telephone (fully paid)	1¼ 2¼	2 3	..	..	..	..
224,850	10/0	2½d.	Consolidated Telephone Const. & Maintenance	¼ ½	¼ ½	..	May and November	..	..
171,504	£1	6d.	Oriental Telephone and Electric (fully paid)	¼ ⅜	7/16 9/16	..	Yearly	..	..
484,597	5	3/4	National	4⅞ 5⅛	4⅞ 5⅜	4 17 7	June and December	5⅛	5
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	15 15½	15 15½	3 17 5	" "	15⅝	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	14 15	14 15	4 0 0	" "	..	..
119,234	5	3/4	Do. 5% Non-Cumulative 3rd Pref.	5½ 5¾	5½ 5¾	4 6 11	..	[illegible]	..
1,000,000	Stock	4½%	* Do. Debenture Stock, 4½%	109 112	109 112	4 1 8	January and July	..	..
58,000	5	1/0	United River Plate	2 3	2 3	..	" "	..	..
£146,733	Stock	5%	Do. 5 per Cent. Debenture Stock	88 94	88 94	5 6 5	" "	..	–
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	..	City of London Electric Lighting (fully paid)	13 14	13 14	..	..	..	..
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	14 15	14¼ 15¼	3 18 8	..	14⅝	14⅛
19,900	£5	..	Electricity Supply Co. for Spain	..	..	.	..	..	..
£30,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	4 5½	4½ 5½	3 12 7	..	4⅜	..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	..	..	..	..	..	..
8,322	£5	..	House-to-House Electric	..	..	–	..	..	–
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	..	..	–	..	..	–
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..	..	–	January and July	..	–
45,000	£5	..	Liverpool Electric Supply (fully paid)	6¾ 7	6¾ 7	–	..	..	–
111,000	5	..	London Electric Supply	½ ¾	½ ½	–	..	..	–
49,900	£10	5/0	Metropolitan Electric Supply (fully paid)	9½ 10	9½ 10¼	2 8 9	..	10	9¾
£150,000	Stock	4½%	* Do. 4½% Debs. (Bonds of £10, £20, and £10)	113 114	113 114	..	June and December	..	..
6,452	£10	..	Notting Hill Electric	5 6	5½ 6¼	–	..	5¾	..
19,980	£5	2/0	St. James and Pall Mall	7 7¼	7 7½	..	..	7⅛	7
20,000	£5	7%	Do. 7 per Cent. Preference	8½ 9	8½ 9	3 17 9	–	8¾	–
59,900	5	2/0	Westminster Electric Supply (fully paid)	6½ 6¾	6¼ 6¾	3 6 8	–	6¼	6 1/16
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
90,000	3	1/6	Brush Electrical Engineering	2⅜ 2⅞	2¾ 3	5 0 0	..	2 13/16	2 11/16
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	2¼ 2⅝	2½ 2¾	4 7 3	March & September	2 11/16	2⅝
£125,000	Stock	4½%	* Do. 4½ per Cent. Debentures	109 112	109 112	4 0 6	January and July	..	..
20,000	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref	1¼ 2½	2 2½	–	..	2⅛	1⅞
12,139	5	..	Edison and Swan United	–	–	..	..	–	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	..	..	..	–	–	..
120,000	2	..	Electric Construction	¾ ¾	¾ ¾	..	–	..	..
12,845	2	2/9	Do. 7 per Cent. Cumulative Pref. ... xd	1¾ 2¼	1¼ 2	..	..	1⅞	–
91,195	2	10/0	Elmore's Patent Copper Depositing	1⅝ 1⅝	1⅝ 1⅞	..	..	..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	¾ 1¼	¾ 1¼	.	..	..	..
50,000	10	10/0	India Rubber, Gutta Percha, &c., Works	23½ 24½	24 25	5 0 0	February & August	24½	24 1/16
£200,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	102 104	102 104	4 6 7	March & September	..	–
15,995	£10	6/4	International Okonite Ordinary	..	..	..	.	..	..
16,000	£10	..	Do. 8 per Cent. Preference	–	..	–	December and June	–	–
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid)	— ½	— ½	–	..	–	..
78,949	5	3/3	Swan United (£3 10s. paid)	..	..	..	May and November	..	..
37,350	12	12/0	Telegraph Construction and Maintenance	41 43	41 43	4 3 9	March and July	42½	41⅝
£150,000	100	5%	Do. 5 per Cent. Bonds	102 106	105 106	4 14 4	January and July	105	–
37,514	£5	–	Woodhouse and Rawson Ordinary (£3 15s. paid)	–	–	..	..	..	–
41,098	£5	–	Do. Preference (fully paid)	–	–	..	..	..	–
£63,870	10	10/0	W. T. Henley's Telegraph Works Ordinary	7½ 8½	8 8½	5 17 8	..	..	..
£30,000	10	..	Do. Preference	..	..	..	..	..	..
			RAILWAYS AND TRAMWAYS.						
£630,000	Stock	1%	City and South London Railway	36 38	36 38	1 16 2	May and November	37½	..
7,000	10	5%	Do. 5% Perpetual Preference	12½ 13½	13 14	3 11 5	May and November	..	..
£67,130	Stock	4%	Do. 4% Perpetual Debenture	121 123	121 123	3 5 1	..	123	..
37,500	£10	1%	Liverpool Overhead Railway	7¾ 8¼	8 8½	1 4 3	..	..	..
6,295	10	5%	Do. 5% Preference	12¾ 13	13 13½	3 15 6	..	..	..
£125,000	Stock	4%	Do. 4% Debenture	111 113	111 113	3 10 10	January and July	..	..

* In calculating the yield on this security, allowance has been made for accrued interest, but not for redemption.

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

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NOTES.

Owing to an unlucky breakdown of some of the switching machinery at the Bankside station, the whole of the supply, with the exception of that for the street arc lamps, had to be stopped for several minutes between two and three o'clock on Tuesday afternoon. The circumstance was rendered all the more unfortunate by the fact that the City was plunged in a fog at the time, and every available artificial light was in use. It seems that the cause of the breakdown was primarily due to the earthing of the switch connections of some of the exciter dynamos. This caused two of the Brush alternators to lose their field, and thus to short-circuit the mains, crippling the armatures by the mechanical displacement of some of their coils. It was considered advisable to shut down the whole station, with the exception of the arc machines, and to overhaul the plant. The trouble was quickly localised and remedied, and the station was in full swing again by a quarter to three o'clock. We understood that an improved switching gear had been invented by Mr. Mordey, for the express purpose of preventing accidents from arising when an alternator, in parallel with others, loses its field. This apparatus was described in *The Electrician*, Vol. XXXII., page 457. We do not know if it was in use at the Bankside station at the time of the accident just referred to; but we remember that it was to have been introduced there immediately after a similar accident which took place some months ago. Mischief must inevitably result from this mishap to other supply companies who have never had a hitch of any sort, and with whom even a flicker is extremely rare, and even to the whole industry, by shaking the confidence of the public in electric lighting.

A correspondent this week calls attention to one of the causes of flood in rivers which might be used for water-power purposes, and advocates as a remedy the construction of reservoirs, in which the storm water might be stored instead of flowing in a swollen and destructive torrent to the sea. We quite agree with our correspondent that "the whole question of conserving our water is fast becoming a national one." But, in the first place, we do not think the question is becoming a national one on account of hydraulic power; but because of the far more vital question of town water supply for domestic use. Nor do we think there is any practical value in the idea that the reservoirs might be built on the capital saved from destruction by floods. The problem would be to get the owners of property to see the matter in this light, especially if they were to have no direct interest in the water-power conserved. To the whole of the proposition put forward by our correspondent it may be urged, that if the civic and municipal authorities of the present day find such great difficulty in adequately meeting the reservoir problem for ordinary water supply, how much more difficult must it be to attack that problem solely in the interests of hydraulic power?

We reprint in our columns this week some remarks which have been made by our esteemed contemporary the *Engineer* on the governing of electric light engines. We do so, not because we are in complete agreement with the conclusions there expressed; but because we feel that this is a matter to which the special attention of electric light engineers ought to be called. Our contemporary sums up the difficulty very clearly; but we doubt whether the remedy it proposes would entirely meet the case. That there does exist the need for more prompt arrangements for keeping the electric pressure steady, every blink in the lights of non-storage systems amply shows. These blinks are, unfortunately, too frequent to admit of being called "accidental"; they are contingent upon the present modes of governing and regulation. It must not be overlooked, however, that only a part of the fault lies in the engine. There is the instantaneous change in the feeder-drop, which also tends to cause a blink whenever a sudden change of load occurs. It is impossible to make the engine governor responsible for an absolutely constant and non-fluctuating pressure on the lamps, if there is a drop of several volts between the lamps and the machines. The regulation to meet this is essentially electrical; and, in alternate-current systems, it is effected by hand in a manner which cannot possibly eliminate blinks.

As regards the part of the problem which may fairly be set down to the engine itself, the solution is to be divided between the governor and the flywheel. Indeed, in those cases where the speed is to be constant at all loads, it is the flywheel which must first encounter the sudden change of load; no mere valve-governor, however sensitive, can do so satisfactorily. Where the speed has to vary slightly as the load varies, the case is different; the flywheel is then rather a hindrance than a help, but the governor is powerless unless aided by electrical regulation of some kind. It is mechanically impossible for any engine instantaneously to change from one speed to a considerably different one; so that,

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in this case, the engine itself is powerless to prevent a blink in the lights, when a large instantaneous change takes place in the load. Fortunately, we do not, in our electric supply stations, expect the engines to meet sudden loads by sudden changes of speed. The flywheel, therefore, performs the useful duty of combating the sharpness or shock of the change in load. It tides over the difficulty during the brief interval which the valve-governor requires for its re-adjustment. On this account it is impossible to make the governor more sensitive than the flywheel, without introducing serious elements of instability, and causing the governor to hunt. As to the want of isochronism, to which our contemporary refers, inasmuch as it is not a matter of sudden change but of final equilibrium, electrical engineers are not likely to be worried by it; for, even if the governor is a little out of isochronism, it is very easy to compensate for it electrically.

There are few things better calculated to thoroughly arouse the unregenerate savage latent within us than the failure of any one of the much-vaunted mechanical contrivances of modern civilisation to come up to the expectations formed of it. An express train which can be overtaken by a hansom cab, a telegraphic despatch which can be beaten by a cyclist, a "constant" supply of electric energy which justifies its name only from being constantly found wanting, an alternating system which alternates between light and darkness during the busiest hours of a foggy day, are instances. This being so, it is not perhaps so surprising as it might at first sight appear to find that even the natives are unable any longer to put up with the so-called telegraphic service of Spain. The telegraph system of the Peninsula is reported to be in "a most deplorable condition"; the normal time required for a telegram to reach Barcelona from Madrid is said to be of the order of five hours, whilst a day or a day and a half are on occasion needed. Meanwhile, cyclists and pigeons are carrying all before them. It is dangerous to generalise from a single experiment, but the following trial of the efficacy of Spanish telegraphy may at any rate be taken as corroborative of the above. At two p.m. one day last autumn a message was started from Ronda on its weary way to Granada, about one hundred miles distant, and, so far as our informant is aware, it is still *en route*; at any rate, the telegram had certainly not reached its destination three days after its despatch. How it comes about that, with so little apparent capacity present anywhere, the retardation should attain such enormous dimensions is somewhat of a mystery.

Cable Interruption:

	Date of Interruption.
Zanzibar-Mombasa	September 4th.
Macao-Hong Kong	September 25th.

The Vienna Underground Electric Railway.—The concession for an underground electric railway across Vienna, referred to in our issue of July 20th, has been granted by the Minister of Commerce to the Austrian Landbank.

Durham College of Science.—At Newcastle-on-Tyne, on Tuesday, the south-east and south-west wings of the Durham College of Science were inaugurated by the Mayor. A sum of about £90,000 is needed to complete the buildings and to relieve the council of their liabilities.

Niagara.—According to some calculations made by Prof. J. W. Spencer, the human race has for 31,000 years been neglecting the dynamical possibilities of the Niagara falls, and will have only another meagre 5,000 years in which to make up for lost time.

Military Telephony.—The Austro-Hungarian financial statement contains a demand for £2,500 to be devoted to the purchase of 14 complete telephonic equipments to be used for enabling officers commanding army corps to communicate with those in charge of the train.

Institution of Civil Engineers.—We are requested to repeat that the rebuilding of the Institution of Civil Engineers will not affect the place of meeting, as such arrangements have been made as will allow of the theatre and reception rooms under it being retained for use during the approaching session.

Hotly Pursued.—In the last act of a melodrama which was recently produced at a New York theatre, the villain of the piece jumps through a window to escape from his pursuers and lands himself on the live wires of a high-pressure electric supply, where he is roasted to death. In this *fin-de-siècle* manner is virtue triumphant.

An Electric Ambulance.—According to the *Electrical Engineer* of New York, the City of St. Louis has adopted a plan of conveying patients from the Dispensary to the City Hospital by means of an electric car fitted up as an ambulance. It is intended to run the car to all parts of the city in response to ambulance calls, and an average speed of twelve miles an hour will be permitted.

New Books.—The Cambridge University Press will shortly bring out a volume on "Mechanics and Hydrostatics," by Mr. R. T. Glazebrook, and another on "Electricity and Magnetism," by the same author.——"The Electrician" Company will publish next week "Electric Lamps and Electric Lighting," by Dr. J. A. Fleming, and will shortly issue "Electric Motive Power," by Mr. A. T. Snell.

The Hermite Electrical Sanitation Process.—The Ipswich Town Council decided, at their meeting on Wednesday, to adopt the Hermite process. This decision was unanimous, and resulted from the exceedingly favourable report submitted by the Sewerage Committee on the trials which have been made on the main sewers of the town during the last three months. We understand the permanent plant is to be proceeded with as rapidly as possible.

A 7,000-Ampere Switch.—Probably the largest switch, as regards current-carrying power, which has yet been made is the one recently supplied to the Electric Traction Company of Philadelphia. The switch is constructed to operate 7,000 amperes at 500 volts, and is of the "Ajax" pattern. Except the carrier and the stand, the entire switch is built of commercially pure copper; it occupies a space of 14in. by 13in. on the switchboard.

Electric Shocks.—We have received from Mr. W. Langdon, the well-known Superintendent of the Telegraph Department of the Midland Railway Company, a copy of some instructions issued by him in relation to the avoidance of electric shocks, and to the treatment of those who are suffering from the effects of electric shocks. In such instances, as in drowning, time is everything, and a few simple, easily learnt, easily remembered rules very desirable.

Fatal Accident at Boston.—A double fatality through electricity occurred in Boston (Mass.) last week. While a man was employed cleaning an electric light on the top of a high pole he received a shock and was killed. His body was suspended from the wires for half an hour. When men were put to work to remove it one of them came in contact with it, and was thrown head foremost on the sidewalk, and died shortly afterwards.

Institution of Mechanical Engineers.—The next ordinary general meeting of this Institution will be held on Wednesday evening, October 24th, and Thursday evening, October 25th, at 25, Great George-street. The chair will be taken at half-past 7 p.m. on each evening by the President, Prof. Alexander B. W. Kennedy. The following Papers will be read and discussed, as

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far as time permits:—"The Manufacture of Standard Screws for Machine-made Watches," by C. J. Hewitt, of Prescot; "Drilling Machines for Cylindrical Boiler Shells," by S. Dixon, of Manchester.

Military Telephony.—Passing to non-personal equipment, a novelty, says *The Times* correspondent, speaking of the recent French army manœuvres, was this year presented by the French infantry in the matter of telephone equipment. Each regiment is supplied with two portable telephone instruments, three kilomètres of wire carried on bobbins by men, a light bamboo ladder, and two forked poles. With this material communication can be rapidly established in billets between regimental and brigade headquarters, or from a fraction of the outposts to the rear.

Interurban Telephony.—The Hungarian Minister of Commerce is at present occupied with the elaboration of an extensive plan of interurban telephony, which will shortly be laid before the Hungarian Parliament for approval. Within three years it is hoped that all the large towns in Hungary will be placed in telephonic communication with one another, and with the capital. The first object of this scheme is, it is said, to facilitate interurban communication for administrative purposes, although, of course, it is the commercial community which will have to pay the piper, and will, it is presumed, reap the main benefit.

"Science Progress."—The October number of *Science Progress*, a monthly review of current scientific investigation, contains the first of a series of articles on "Continuous Current Dynamos," by Mr. C. C. Hawkins. The article is admirably and clearly written, and reviews the stages of the development of the dynamo, from the empirical stage in which the Drs. Hopkinson found it, through the generalised mathematical theory which these investigators gave it, to the present complete theory upon which its design and use are based. The writer attaches high but not undue importance to the influence which the publication, in 1886, of the researches of the Drs. Hopkinson exerted upon the progress and evolution of the dynamo; and the article is, in many respects, a tribute to the work of these two men.

Arc Lamp Carbons.—Some tests which have recently been made on the comparative life and efficiency of the "Union" carbon, and some American makes of arc lamp carbon, may be interesting to our readers. The carbons tested were uniformly $\frac{7}{16}$in. diameter, and they were all burned in the same lamp. The longest life attained with a positive cored carbon was 18 hr. 53 min., the horizontal candle-power being 159, and the consumption 361 watts; the shortest life was 9 hr. 14 min., with a positive solid carbon, the horizontal candle-power being 359, and the consumption 445 watts. The former of these was a "Union" carbon, the latter a Washington make. The shortest life of a "Union" carbon appeared to be about 12 hours, when the lamp was giving 316 horizontal candle-power, and absorbing 424 watts.

A Municipal Lighting Plant Investigation.—In its issue of September 5th, the *Electrical Engineer* of New York publishes an elaborate analysis by Mr. Horatio Foster, of the financial position of some 49 American municipal electric lighting plants, about which it may be said that they are mostly small and mainly street lighting plants. "In no respect," says our contemporary, "do these figures justify the statements that have been made as to the superior economy of municipal plants. On the contrary, the private lighting companies operate more cheaply, and when placed on a parity with the municipal plants as to taxation, &c., are able to supply a town with light as cheaply as it can supply itself. The conclusion might be stated even more strongly, but our readers can study the figures for themselves, and draw their own conclusions."

A Chimney Struck by Lightning.—We have received from a Russian correspondent an interesting photograph showing the curious effect of a lightning discharge upon an unprotected factory chimney. The chimney, which is about 180ft. high and a little over 6ft. diameter at the top, was finished on August 17th, and on the 19th of that same month it was struck by a lightning flash, which rent open the brickwork in a vertical line from top to bottom. The width of the gap was in some places as great as two feet; yet the chimney preserved its erect position and remained intact during the subsequent repairs. The photograph shows the lower portion of the rent filled in with new brickwork, and we understand that the structure is now in a perfectly stable condition. The chimney is at the sugar works of Count Branitski, in the province of Kiew.

The "Elektrotechnische Zeitschrift."—The issue of the *Elektrotechnische Zeitschrift* for the 27th ult. contains the farewell statement of Herr F. Uppenborn, who has occupied the editorial chair since the electrically Dark Ages—that is to say, for nearly 13 years—and who has been succeeded by Herren G. Kapp and J. H. West, the journal under their ægis becoming also the official organ of the Verband Deutscher Elektrotechniker. In the issue of October 4th the new editors make their editorial bow. The first number under the new management contains amongst other contributions a well-illustrated nine-column description of the electric lighting of Arundel Castle, six columns on the telegraph service of the United Kingdom, a description of the Duncan alternate-current meter, and a review of Mr. Oliver Heaviside's new book, "Electromagnetic Theory."

Electric Cars and Moving Houses by Trolley.—A novel and successful application of the trolley, says the *Electrical Engineer* of New York, was recently seen in Hoboken, N.J. A good-sized frame house was being moved, and *en route* to its final destination had to cross the electric railway tracks. As the wires, of course, had to be cut and traffic suspended during the passage of the building, it was desirable that this should occupy as little time as possible. A car was therefore put at the disposal of the movers, and when the house had been brought as near the track as possible tackle was rigged about blocks across the street and attached to the rear coupling. The wires were then cut and cleared away, and the car moved off, drawing the house quickly across the tracks and out of the way. The wires were reconnected and traffic was resumed, the whole operation occupying but a few minutes.

Alternate Currents and Fuses.—Some experiments, with a view to determine if an alternating current has any influence on the resistance and fusing point of fusible cut-outs, have recently been made by Prof. D. C. Jackson and Mr. Ochsner, and the results are embodied in the Paper in the *Transactions* of the American Institute of Electrical Engineers, Vol. XI., p. 455. Samples of a number of commercial fuses and wires of various metals were tested; but in no case was any evidence found that an alternating current has any direct effect on the resistance or the fusing temperature of the material. The influence of the alternating current was found to be always the same as that of an equal continuous current; except in so far as secondary actions, such as mechanical shaking, might arise from the alternations of current. The limit of time up to which results are true is 550 hours for the resistance tests, but the limit is not stated in the case of the fusing temperature tests.

Secondary Batteries.—In a Paper read before the American Institute of Electrical Engineers by Mr. W. W. Griscom, "On Some Storage Battery Phenomena," the author arrives at the following conclusions: 1. That the chemical reactions in a storage battery cell must be complex, in order to account for the curves of electromotive force, temperature, and internal resistance. 2. That the current and the electromotive force of the component plates of a cell, and of each part of each plate, are constantly fluctuating, in spite of the fact that no source of electricity can compare with a storage battery for steadiness and constancy. 3. That by reducing the normal output of a battery by about 30 or 40 per cent. the discharge can be mainly confined to one set of chemical reactions, thus prolonging the life of the battery. 4. That the negative and positive plates are apt to get out of step, therefore the battery should be given an occasional overcharge when necessary, but only when necessary to get them in line again.

Transforming Frequencies.—For the laboratory and for experimental purposes a method, by means of which an alternating current of any frequency may be obtained, is of obvious

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value. Lieut. Patten, in an article in the *Electrical World* of New York, shows how this may be done. The method consists in turning an armature in a rotary field in a direction opposite to that in which the field rotates. If the two speeds are equal there will be a frequency of double the fundamental one, while with the armature at rest it merely acts as a transformer, and gives the fundamental frequency. By means of another combination, any desired frequency below the fundamental one may be obtained, even as low as a single period per second. We may note in this connection that a patent was recently granted in America to Mr. C. S. Bradley for a method of transforming frequencies of alternating currents, which consists in creating an alternating magnetic field and rotating in it a circuit so as to pass the poles at a fractional part of the rate of the alternating current itself. This seems to be somewhat similar to one of the methods described by Lieut. Patten.

High-Pressure Feeders at Worcester.—As we announced last week, the main feeders from the generating station at Powick to the high-pressure distributing sub-station at All Hallows are laid on the Brooks system of oil insulation, which system has proved itself so satisfactory at Chatham, Rochester, Keswick, and numerous other places where it has been in use for some few years. These feeders consist of three heavy wrought iron tubes, the metal having a minimum thickness of 0·25 of an inch, and an internal diameter of 2 inches. The conductors drawn into two of these tubes are made up of two 19/14 and two pilot wires laid up together into one cable, the remaining tube being left spare. Special joint and junction boxes are placed at various points along the line, from which branch connections may be taken as required. Midway along the line an oil pressure tower has been erected, allowing for expansion and contraction (due to variations in temperature) of the thick heavy, insulation oil. During the laying a very careful test was kept on the cable, and they were finally flashed with double the working pressure, namely 5,000 volts. The contract for the supply and laying of these feeders was given to Messrs. Johnson and Phillips, who are the sole makers of this system.

Operating Guns by Electricity.—The Ordnance Department of the United States Navy, says the *Army and Navy Journal*, has practically determined to operate the guns and turrets of some of its ships by means of electricity for the future. "It is not yet intended to actually displace steam by the new motive power; but to so place it that in case of accident it may be switched on, and thus prevent the gun being thrown out of action. It is a wise step to make electricity at first only accessory to steam; but that, on the whole, electric motors are a preferable means of working guns has been determined after a series of experiments, the stringency of which was intended to bring out weak points if such existed. The advantages of the system are considered to lie in the greater simplicity of electric conductors compared with steam pipes, both as regards the ease of carrying them round bulkheads, and the smaller surface exposed to injury, together with the facility with which they can be repaired. Chief of all advantages is considered the greater simplicity of manipulating the controlling switch as against steam valves. A single lever, according to the system devised by Capt. Samson, effects the operations of training and elevating."

"Punch" on the Galvanic Ring.—All persons afflicted with imaginary diseases are earnestly recommended by *Punch*, Vol. VIII., 1845, page 167, to try the galvanic ring. It signifies not whose ring out of the large variety advertised they may select, since the virtues of all are equal. These rings consist of a thin wire of zinc, soldered to a similar wire of copper; hence the quantity of galvanism they generate is next to nothing; certainly much less than that produced by a sixpence and a half-sovereign lying in contact in a gentleman's waistcoat pocket. Its exact amount it would be difficult to compute, as the galvanic fluid has no weight; but, giving a rough guess, we should say that it may be about the decillionth part of a suspicion. The tremendous effects on the system of this strong homœpathic amount of galvanism passing through the little finger may be conceived. But to quiet alarm, we may state that none whatever of this frightful torrent of galvanism developed by the ring passes through the finger at all. To be affected by galvanism, it is necessary that the part to be galvanised should lie between two opposite galvanic poles or extremities; now, as the finger is inside the ring, the galvanism is outside the finger. Thus, the finger is to the galvanic fluid as a person standing on the Isle of Dogs is to the fluid in the Thames. With what power an inappreciable force, ineffectually applied to the extremity of the body, must act in the cure of such a complaint as rheumatism is obvious. In all positive diseases the galvanic ring will afford a negative relief; and those who have nothing the matter with them may confidently depend on being cured by it.

Electric Motors in Workshops.—On the 9th inst. a visit was paid by the Society of Engineers to Messrs. Siemens Brothers and Co.'s works at Charlton. All the machinery in these shops is driven by electric motors. The plant at the electric generating station comprises three tubular boilers of gunboat type (two more in course of erection), each 18ft. long by 9ft. diameter, 400 I.H.P. each, 140lb. steam pressure. Steam is largely used for heating purposes, as well as for the engines. There are four engines. One Belliss compound vertical enclosed, 300 I.H.P., running at 350 revolutions per minute. Cylinders, 15in. and 23in. by 10in. stroke. Three Willans' compound condensing, 300 I.H.P. each, running at 350 revolutions per minute. Cylinders 14in. and 20in. by 9in. stroke. Four dynamos are coupled direct to the above engines, for 120 volts, 2,000 amperes. The distribution of the electrical energy is by means of underground lead-cased cables. Over the boilers are the condensers, consisting of 27 double-concentric cylinders; the steam passes through the annular space, while cooling water runs down inside and out. This water is used over and over again. There are in all 54 electric motors in the works, namely, 13 of 40 H.P. each, four of these in the rubber shop are directly connected by spur gear in the rolls; seven of 20 H.P. each; two of 15 H.P. each: these are directly coupled to a worm shaft driving the calendering rolls in the rubber shop, and are constructed to run at two different speeds; eight of 10 H.P. each, one of these is directly coupled to a cable machine, another works the lift in the rubber shop; 24 of various powers, from 10 H.P. to ½ H.P., mostly directly coupled to lathes and other machine tools.

Inductance and Capacity.—The neutralisation of the inductance of a line by means of a capacity, or *vice versa*, has been the subject of much mathematical writing, says the *Electrical World* of New York. What the average student of electrical phenomena wishes is first an idea of the mechanism of a phenomenon, as without this preliminary knowledge mathematical and graphical references to it will be likely to convey little information. For these the following may convey in a simple manner the idea of the respective action of a condenser and an inductance coil in series in an alternating circuit. Imagine the electromotive force of the circuit to be rising; the result on the one hand will be that the condenser will be unbalanced, and consequently will create a draught, so to speak, for enough current to again balance it; on the other hand, the increasing flow of current due to the increasing electromotive force will introduce into the inductance coil lines of force opposing the flow of the current, or, in other words, lines of force generating a current in the opposite direction to the main current, and in the direction of the draught of the condenser. If now, the condenser and inductance coil are so proportioned to each other that these two effects are equal, the result will be that the flow of current in the circuit will follow the simple form of Ohm's law, the factors in the impedance formula for inductance and capacity cancelling each other. The relative effects of inductance and capacity may also be illustrated roughly by an analogue from steam engineering. In the exhaust pipe of a marine engine there is often a throttle valve, automatically actuated and used to prevent the engine from racing in a rough sea. In this case the throttle corresponds to an inductance and the steam condenser to a capacity. By opening the throttle wider (decreasing the inductance) or increasing the vacuum in the condenser (increasing the capacity) the flow of steam is facilitated; or, by increasing the vacuum and throttling at the same time, one effect will nullify the other.

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ELECTRIC MOTIVE POWER.*

BY ALBION T. SNELL.

(*Continued from page 660.*)

A bar cutter has been patented quite recently by Messrs. T. Heppell and Patterson, which embodies some novel features. One of the special points is the endless chain used to clear away the cuttings. This is shielded by a strong guard. The gearing consists of cast steel bevelled

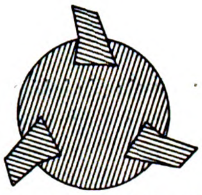

Fig. 121.—Section of Birtley Cutter Bar.

wheels and pinions. The machine is propelled by means of a steel rope which passes round a drum geared to the armature shaft by worm gearing, an eccentric, rod, pawl and ratchet. The design is very compact and appears to be capable of being worked into a less height than the type of bar cutter adopted by other makers; but this remains to be proved, for many alterations may be required before the machine gets

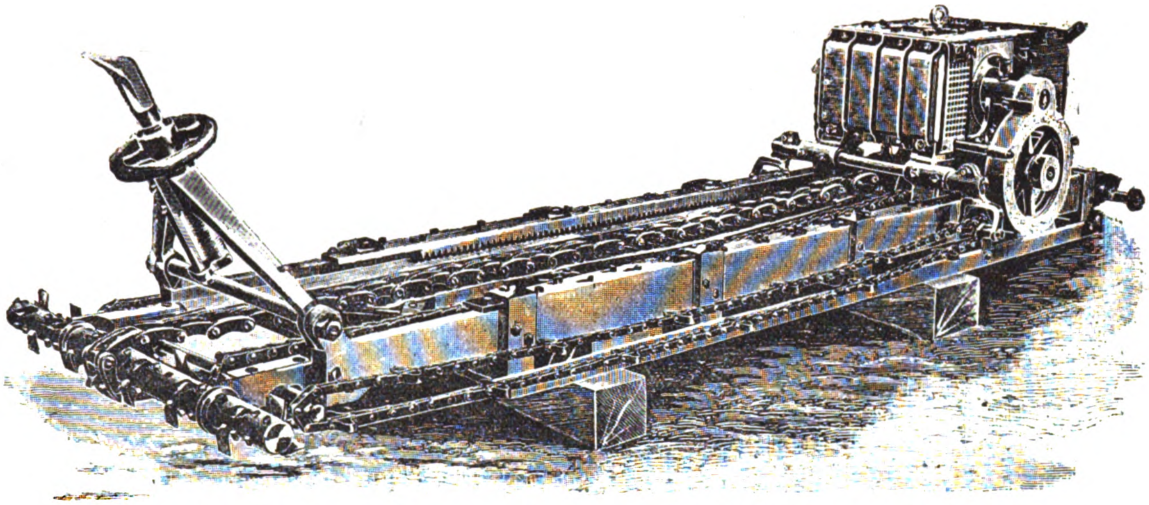

Fig. 122.—Jeffrey Electric Coal Cutter, showing cutter bar and jack for fixing the machine.

into regular work. At present the writer believes that one of these machines is at work in the Cannock Chase district. Mr. Heppell says that one at the Pilner Main Collieries is doing good work, cutting at the rate of about 20 yards per hour, 3ft. under. A sectional view of the cutter bar is shown in Fig. 121. It is arranged to swing about the centre of supports, which permits of the cutters being readily examined and also facilitates the moving of the machine about a coal pit. It has three dovetailed grooves cut along its length. The cutters have corresponding dovetails, and are distanced by suitable pieces of steel. The cutters can obviously be arranged spirally or otherwise, as may be required.

The Jeffrey bar cutter is of different construction from any machine of English origin, and was, no doubt, first designed to meet the conditions of the American coal seams. Special machines are built to suit the conditions obtaining in British mines. The details of construction are shown in Fig. 122.

It will be seen that the bar lies parallel to the coal face when in the cutting position. It is designed to hole as deep as 7ft. Deep undercutting is an especial advantage in pillar and stall working with an average roof. The machine consists of a bed-frame, occupying a space 3ft. wide by 7ft. 2in. long, built up of two steel channel bars firmly braced, the top plates on each forming racks with the teeth downwards. Mounted upon and engaging with this bed-frame is the sliding frame, consisting mainly of two steel bars, well braced, upon which are mounted at the rear end an electric motor. Upon the front end of this sliding frame is mounted the cutter bar, held firmly by two solid steel shoes with brass bearings. The cutter bar receives motion through an endless steel or bronze chain from the driving shaft, and as it revolves is fed forward by means of straight-cut gear and a worm and wheel. The bar is usually 36in. wide. In America the seams are generally much thicker than those here, and the roofs are sufficiently good to enable the face to be kept open for the distance necessary with a 6ft. or 7ft. holing, and pillar and stall working is chiefly practised. But in England the conditions of long-wall working do not, as a rule, permit of such deep undercutting, and from 4ft. to 5ft. is, as a rule, the deepest cut advisable. At the Cannock and Rugeley Collieries, where two of the Jeffrey machines are at work, one holes 4ft. and the other 7ft.

The electric motor occupies a space of about 20 inches square. It is designed to absorb a maximum of 15 E.H.P., and in some veins of coal does not require more than 7·5 H.P. The American standard pressure is 220 volts, but this can be altered to suit circumstances. The armature is designed to run at 1,000 revolutions per minute, and the cutter bar at 200. The momentum of the moving parts is such that the machine overcomes ordinary obstacles without difficulty, and since the motor is not coupled rigidly to the bar the vibrations are not transmitted to it, and the machine runs steadily and comparatively quietly. Two men are required to work the machine, one at the switch at the back and the other as helper to clear the debris and to assist in shifting. The machine is taken from stall to stall on a special truck. When at work it is slid on to two boards or bars of iron in front of the coal, and fastened firmly by means of the front and rear jacks against the face and roof of the coal, which is thus supported to some extent during the under-cutting. When the full depth of the cut is reached the feed is thrown off, and the cutter bar is returned to the starting position by means of reversing gear. The machine is then moved sideways for a distance equal to the length of the cutter bar, and another cut is made in the same manner. Each cut is made in ordinary working in from three to six minutes. The output depends to a great extent upon the skill of the men in moving and jacking the machine, and also upon the hardness of the coal, and whether the cut is made in coal or "dirt." In some seams these machines are said to cut from 40 to 66 linear yards of face to a depth of 6ft. in a shift of 10 hours. Since the depth of the undercut is roughly twice as great as that usually made with a bar machine of the Goolden-Atkinson type, this is equal to a length of face of from 80 to 130 yards, in comparison with the performance of the latter. Assuming these figures to be correct, it would appear that although the Jeffrey machine has to be shifted after every cut, yet it can cut a

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greater area of coal than the Goolden-Atkinson machine in the same time.

In comparing the two types stress must be laid on the relative suitability for different kinds of work. The Goolden-Atkinson machine requires a space between the face and the props at the goaf of not more than four feet at the outside, whereas the Jeffrey machine cannot be worked in a smaller space than six feet; but with the latter the depth of undercut may be nearly double that with the formes, though, of course, the total length of roof unsupported is then nearly twice as great. It is, therefore, obvious that the side cutter bar can be used in places where the front cutter bar cannot possibly be. It must be remembered also that the Jeffrey coal cutter makes a capital heading machine, while the side cutter cannot be used for this purpose. The two machines are not, therefore, rivals for the same work in all cases. They cost in the first instance about the same. The motors are of the same rated capacity, and the actual power required in practice appears to be about the same. Hence there does not seem to be much to choose between them as regards the question of cost, but it is rather a matter of suitability for any particular case.

Mr. Williamson, of Cannock and Rugeley Collieries, who is using one of these machines with a 36in. bar, holing 4ft. in a 5ft. seam, says that the output of round coal is increased 15 per cent. That is to say, hand cutting makes 75 per cent. of round coal and the Jeffrey cutter 90. And that one machine, working single shifts, has increased the output by at least 60 tons per day.

A number of patents have been taken out for machines with rotary wheels. In a few the wheels have been designed to cut vertically, or even at any angle, but in the majority the aim has been simply to make a horizontal cut as near the bottom as possible. The depth of the undercut determines the diameter of the wheel, and is limited in practice to from 39 to 55 inches, the latter being found to be as deep a cut as is desirable. If this depth be exceeded there is a strong probability of the coal shearing at the back, and fouling the wheel before it is clear of the cut, and if the cut be shallower the coal will not break readily by its own weight, but requires wedging down.

Passing by the early inventors of these machines and coming to modern history, the name of Messrs. Gillot and Copley stands in the front rank; but from some cause, which is not very apparent, this firm has not shown a disposition to apply electric motors to their machines, preferring to continue the use of compressed air.

The Yorkshire Engine Company have also built some excellent machines of this type embodying several improvements on those of the former firm. They also have confined themselves to compressed air, although they have built to order a few electrically driven machines. An illustration of one of their machines is given in Fig. 123, in order to show the general requirements of this type of plant, and also because the writer has found from actual experience that they do excellent work.

Fig. 124 is an enlarged view of the cutter wheel, showing the method of supporting it in bearings. The design is arranged to hole at a few inches above the rail tops. Owing to the success which this class of coal cutter has obtained when driven by compressed air no radical change has been attempted by inventors when applying electricity. They have accepted the main principle and have simply changed the motive power.

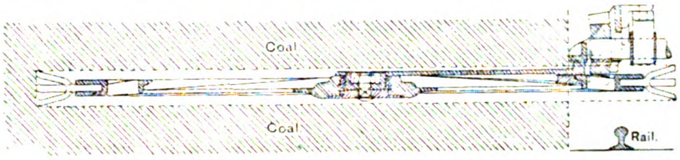

Fig. 124.—Cutter Wheel: Yorkshire Engine Company.

On referring to Fig. 124 it will be seen that the side wheel is fitted with two kinds of cutters. Every alternate one has Y-shaped teeth, while the remainder are straight. The function of the latter is to tear out the centre of the cut, while the former clears it out to the desired width, usually about 3in. In air-driven machines the speed of the wheel varies from 15 to 30 revolutions per minute, according to the kind of dirt and its resistance. This speed is found to be too slow for the electric motor, since the reducing gear is costly and cumbersome. Therefore all who have tried to apply electricity have endeavoured to raise the cutter wheel speed as much as possible. This has necessitated strengthening the machine as a whole, and has increased the dead weight from about 25cwt. to about 35cwt. The increased speed has caused no trouble in working however. In fact, the momentum of the moving parts is so great that obstacles which caused serious shocks at the slower speed are scarcely felt at the higher speed of from 70 to 100 revolutions per minute. And the increased weight tends to prevent derailment.

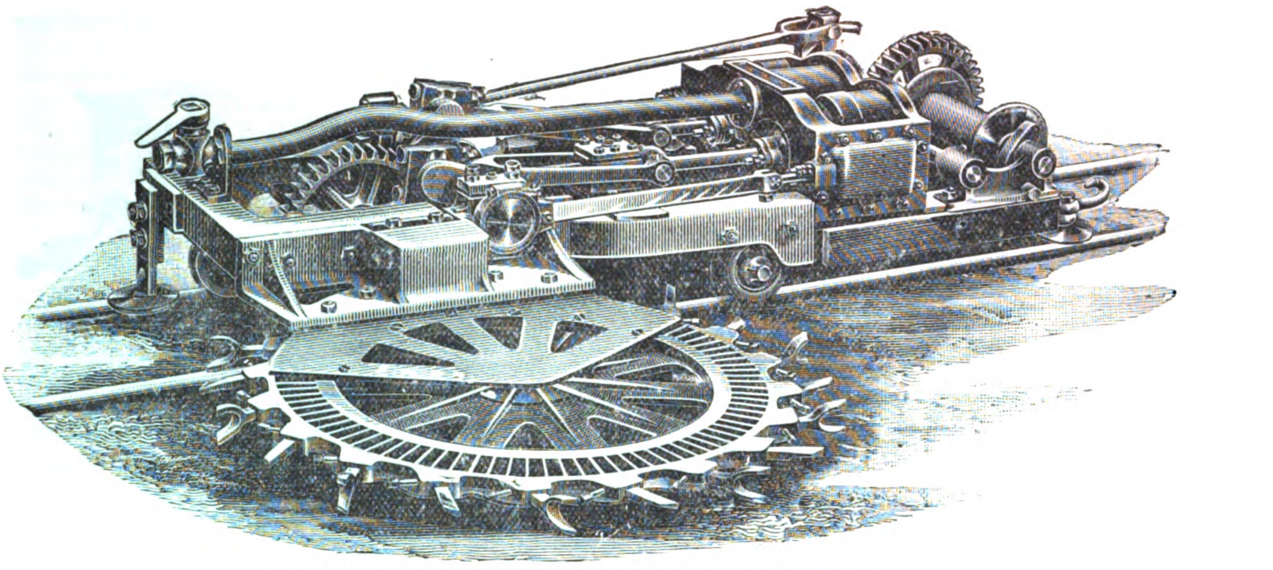

Fig. 123.—Yorkshire Engine Company's Side Wheel Coal Cutter.

(To be concluded.)

THE CHEMICAL THEORY OF ACCUMULATORS.—IV.

BY E. J. WADE.

The only theory that now remains to be examined thermochemically is the generally accepted one of the direct formation of lead sulphate at both electrodes by the abstraction of two molecules of sulphuric acid, which are replaced by two molecules of water. The chemical equation for the ultimate products of this reaction is

$$PbO^2 + 2H^2SO^4 + Pb = PbSO^4 + 2H^2O + PbSO^4.$$

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It is a little difficult to express these changes in an electrolytic equation, but the following, perhaps, illustrates what apparently occurs

$$\begin{array}{l|l|l} SO^4H^2 & & \\ PbOO & H^2SO^4 & Pb \end{array} = \begin{array}{l|l|l|l} & SO^4 & H^2 & \\ Pb & O & OH^2 & SO^4Pb. \end{array}$$

It will be noticed that the second molecule of sulphuric acid (placed above PbO^2) does not appear to undergo ordinary electrolytic decomposition, but combines what is usually termed a *secondary* reaction, and one which is so often supposed not to contribute anything to the electrical activity of the cell.

The usual form of the thermo-chemical equation for the above reactions is as follows,

$$\left.\begin{array}{l} [2Pb,SO^4] + [2H^2,O] - [2H^2,SO^4,Aq] - [Pb,O^2] \\ 225940 + 136720 - 215060 - 62300 \end{array}\right\} \begin{array}{l} = 85300 \\ = 1{\cdot}855 \text{ volts.} \end{array}$$

This figure, while considerably higher than those obtained from any of the previous equations, and approaching nearer to the observed E.M.F., yet falls short of it by a very appreciable amount, the discrepancy being quite sufficient to suggest that it does not fully represent what actually occurs. It will be noticed, however, that it is assumed that the acid is diluted with an infinite or very large quantity of water; practically speaking, that a very dilute solution of acid is employed. Now Messrs. Armstrong and Robertson and others have suggested that the real electrolyte is either pure sulphuric acid or one of its simplest hydrates, and that the energy absorbed in abstracting this from the solution during discharge is supplied by the cooling of the cell which then takes place. If this is so, it obviously must not be taken into account when calculating the E.M.F., which will be entirely independent of the degree of dilution of the acid.

On this assumption the thermo-chemical equation for pure sulphuric acid is :—

$$\left.\begin{array}{l} [2Pb,SO^4] + [2H^2,O] - [2H^2,SO^4] - [Pb,O^2] \\ 225940 + 136720 - 179360 - 62300 \end{array}\right\} \begin{array}{l} = 121000 \\ = 2{\cdot}63 \text{ volts.} \end{array}$$

This result is of course simply that given by the previous equation, plus the energy liberated by the complete hydration of two molecules of sulphuric acid (2×35700 calories = 0·775 volt), and is about twice as much too high as the preceding value was too low; which seems to indicate that the explanation of the discrepancy does not lie in that direction. Besides this, the researches of Messrs. Gladstone and Hibbert have proved conclusively that, in some way or another, the of E.M.F. of a cell does depend on the strength of acid employed. Their observations included measurements of the E.M.F. in all strengths of acid, from water containing the merest trace up to the very strongest acid that could be procured, and the mean result of the whole of them is embodied in curve *c*, Fig. 1. Most of their values for the higher percentages of acid were obtained with only the peroxide plate in the strong acid on account of the excessive local action that took place at the spongy lead plate under similar conditions, and these figures have therefore had to be corrected for both plates in the same strength of acid from the data they themselves furnish the E.M.F. between two plates of plain lead in different of strengths of acid.

Only the middle portion of this curve can be considered to correspond with the normal reactions represented in the thermo-chemical equation. The rapid fall of E.M.F. which commences with about a 10 per cent. solution, and becomes very marked for strengths below 5 per cent., is due to the formation of basic sulphate and oxide which Messrs. Gladstone and Tribe long ago showed to take place in weak acid. The turning over or flattening of the curve for the highest strengths of acid does not appear to have been specially noticed; but it is, no doubt, due to the local action, which takes place with increasing rapidity in 40 to 50 per cent. solutions (Sp. Gr. 1·300 to 1·400) and upwards, and it might, in fact, have been predicted by *a priori* reasoning from the results of experiments by various investigators on the effects of local action on the E.M.F. of primary cells.

To ascertain how far this curve agrees with the calculated E.M.F. for various strengths of acid, intermediate values must be interpolated between the two extreme values already obtained for pure acid and for very dilute acid by substituting successively the heat formation of $[H^2,SO^4,H^2O]$ $[H^2,SO^4,2H^2O]$, $[H^2,SO^4,5H^2O]$, and so on in the thermo-chemical equation in place of $[H^2,SO^4]$, and the resultant curve is given in curve *a*, Fig. 1. On comparing the two curves A and C it will be observed that, as Messrs. Gladstone and Hibbert have already pointed out, they only coincide at two places—namely, for about 7 per cent. acid and for 100 per cent. or pure acid—and that for all other strengths the observed are considerable higher than the calculated figures. Now both these points of coincidence occur at parts of the curve of observed values where, as has been mentioned above, it corresponds to abnormal reactions whose resultant E.M.F. is lower than that normally to be expected, and it suggests the probability, therefore, that the agreement is only an accidental one and that—except for very weak acid, where the reason for the rapid fall of E.M.F. is known—a discrepancy still remains to be accounted for throughout its length, due perhaps to some portion of the reactions not having been properly or fully stated in working out the thermo-chemical equation.

A further and closer examination, however, of the changes occurring in the electrolyte shows that a reaction does exist which up to the present appears to have been overlooked. Full allowance has been made for the energy required to separate two molecules of acid from the water with which it is diluted, but no account has been taken of the energy due to the further dilution of the remaining acid by this liberated

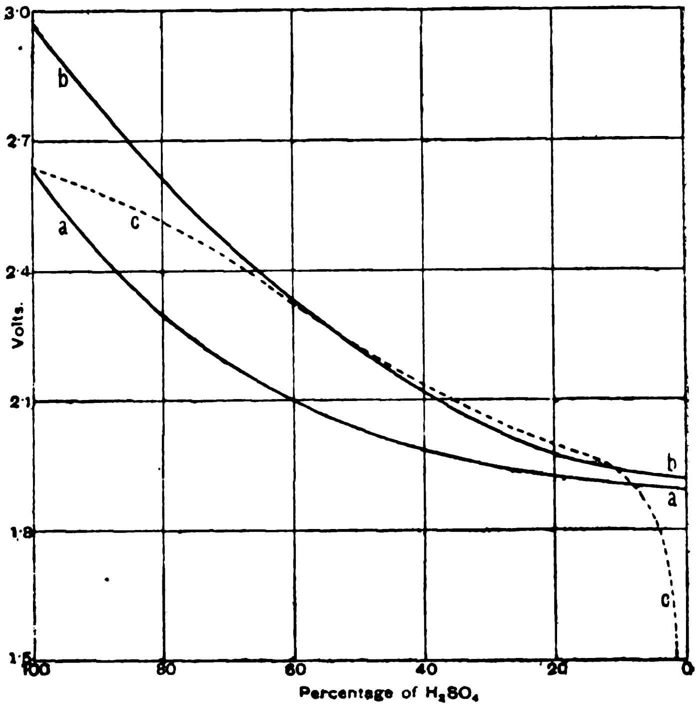

Fig. 1.

water together with the two molecules of water which replace the acid that has been used up. As an example of the difference made by this correction and the way it is applied, the case may be considered of a solution whose strength is represented by the formula $H^2SO^4,19H^2O$, corresponding to 22·3 per cent. of acid by weight or a density of about 1·163. The ordinary thermo-chemical equation, without taking this extra reaction into account, is :—

$$\left.\begin{array}{l} [2Pb,SO^4] + [2H^2,O] - [2H^2,SO^4,19H^2O] - [Pb,O^2] \\ 225940 + 136720 - 211870 - 62300 \end{array}\right\} \begin{array}{l} = 88490 = \\ 1{\cdot}923 \text{ volts.} \end{array}$$

Now the term to be added for the heat generated by the further dilution of the acid remaining is

$$+ [x(H^2SO^4 19H^2O), 2\ (19H^2O + H^2O)] = 3520 = {\cdot}077 \text{ volt},$$

and 1·923 volts + 0·077 volts = 2·0 volts.

x may stand for any quantity or number of molecules of dilute acid so long as it is sufficiently large that the addition of the extra water—in this case 40 molecules—does not sensibly alter its degree of dilution.

If the corresponding correction is made for the extreme case of perfectly pure acid it will at once be apparent that the only water here liberated are the two molecules

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that replace the decomposed acid, and these combined with the remainder to such good effect that about 20,000 calories are liberated, equivalent to an additional ·435 volt. For the other extreme of a very weak solution, the acid is already so fully diluted that hardly any more heat can be generated whatever further quantity of water is added, and consequently the correction becomes comparatively small; but at the point where the E.M.F. drops off sharply—that is, about a six per cent. solution—it is still sufficiently large to be worth considering. Curve *b*, Fig. 1, gives the calculated E.M.F. *with the above correction* for all strengths of solution, and it will be observed that it practically coincides with the one giving the E.M.F. obtained by actual measurement, for solutions containing from 10 to 65 per cent. of acid, or thereabouts, corresponding to specific gravities from 1·070 to 1·570, which is a far wider range than is ever used in practical cells. Above 65 per cent. the curve of observed E.M.F.'s commences to fall away from the other, and continues to do so right up to 100 per cent., which is exactly what might be expected, and the reason for which has been already explained.

It may now fairly be claimed that the double sulphating theory of discharge does account for the E.M.F. of lead storage cells strictly in accordance with Thomson's law, while none of the others do so even approximately; and, from a thermo-chemical point of view, therefore, its case may be considered as proved.

Although it might not at first sight appear probable that such a minor matter as that of the rate of dilution of the acid in a cell during discharge could have any practical bearing on the design of accumulators, yet it does suggest some considerations regarding the amount of acid required and its best distribution, which are of considerable interest. The results to which they lead have long ago been more or less completely recognised as the outcome of actual experience, without a very clear comprehension of the underlying reason, and they will well bear a little further emphasising and explanation. It has already been mentioned that in the early days of lead accumulators, the only function supposed to be served by the sulphuric acid was to render the electrolyte conductive, and that its presence in large quantities was considered to be actually injurious. But as soon as it was admitted that sulphating was one of the normal processes of discharge, it followed, as a necessary corollary, that at least the theoretical amount requisite for this purpose must be supplied and a little over, to prevent the solution from being reduced to pure water by its complete abstraction. Experience, however, quickly demonstrated that a cell worked far better when a large excess of acid was present so as to prevent the specific gravity from falling too low or varying between too wide limits, and a proportion of from three to five times the necessary amount was finally adopted and has remained the general practice ever since.

Next it was found that not only must the quantity of acid in the solution be large, but it must also have a free access to the surface of the electrodes; and experiment showed that, within certain limits, cells worked more efficiently the further the plates were apart, in spite of the fact that the losses due to internal resistance must be proportionately increased. More recently, the researches of Messrs. Gladstone and Hibbert into the variations of E.M.F. with strength of acid, and of Messrs. Duncan and Wiegand into the rates of diffusion from the active material into the surrounding liquid, have incidentally confirmed the necessity of providing for a rapid diffusion and free supply, not only throughout the main body of the electrolyte at the surface of the electrodes, but also with regard to the whole mass of the active material and the acid contained within its pores. Now, although unconsciously, the tendency and ultimate object of every one of these modifications is to enable the utmost energy to be obtained from the recombination of the liberated water, with the conversion of the largest possible percentage of it into electrical work, and the smallest possible percentage into heat. That an insufficient supply of acid causes a reduction in the practical capacity of a cell, and that a poor circulation throughout the bulk of the electrolyte, or an impeded diffusion within the pores of the active material, causes both this and an actual loss of efficiency as well may be proved by considering the following hypothetical case.

Suppose a set of positive and negative plates are run down in a cell holding very little more acid than is theoretically sufficient for their discharge, but standing in another vessel which contains a much larger quantity of acid of the same specific gravity. The two liquids are completely separated by the inner cell; but when required it can be removed, leaving them in free communication. On the completion of the discharge a certain amount of energy will have been given out in watt hours, and the electrolyte reduced to an extremely weak solution of acid. The inner vessel is next removed and the two solutions allowed to mix. The dilution of the stronger by the weaker acid causes the liberation of a definite quantity of heat, which could be measured by suitable apparatus, and its electrical equivalent in watt hours calculated.

Now, if the dividing cell had been removed *before* the discharge began, and the plates run down in the larger quantity of acid, it is evident that, the final conditions being the same, the total amount of energy liberated must be equal to that given out electrically when the discharge took place in the smaller vessel, plus the heat generated in mixing the liquids; but *the whole of it will now appear as electrical energy*, the difference being shown by the higher and more constant E.M.F. maintained owing to the strength of acid for corresponding periods of the two discharges always being greater in the latter than in the former case.

Practically, then, an insufficient supply of acid means a rapid fall of voltage during discharge, and indirectly, therefore, a smaller output in ampere hours, because the maximum permissible drop of E.M.F. will be reached at an earlier stage.

A consideration, however, of what takes place during recharging will show that the *efficiency* is not affected or reduced. If the cell is charged in the larger quantity of acid, the work that must be done upon it will exceed that necessary if charged in the smaller cell by the amount that was liberated on mixing the two solutions; but this is just the amount by which the energy of the one exceeded that of the other during discharge, and, therefore, the ratio in watt hours of charge to discharge—that is to say, the efficiency—will be the same in both instances. As on discharge so on charge, the strength of acid for corresponding periods will always be greater in the former than in the latter case, so that the back E.M.F. and the charging E.M.F. required to overcome it will also be larger.

The conditions that exist in a cell plentifully supplied with acid; but in which, owing to a poor disposition of the parts or insufficient porosity of the active material, the diffusion is more or less impeded, may be represented in an exaggerated form by supposing that the containing vessel for the smaller quantity of acid is of a porous nature and allows a certain amount of diffusion to take place between the two liquids. Assuming that the rate of diffusion is very slow, the discharge will reduce the strength of the solution in the inner vessel to practically the same degree as before, and the same amount of energy will be given out electrically; while, by leaving them until the solutions in both vessels are equalised, the same amount of heat will be liberated, only more slowly. On proceeding to charge, however, the conditions are different. The strength of acid in the inner is now the same as that in the outer cell to begin with, and, moreover, it concentrates rapidly, so that by the time the charging is completed it is considerably the stronger of the two. On leaving at rest equilibrium will again be restored by diffusion, and a further quantity of heat generated, this time at the expense of the solution in the smaller vessel, which proves that more work has been done than would have been necessary if there had been free communication between one and the other. Imperfect diffusion, therefore, means a loss of electrical energy both during charge and discharge by the direct production of heat, and, consequently, a reduced efficiency, which makes itself apparent in an unduly low E.M.F. when discharging and an unduly high back E.M.F. when charging. No account is, of course, taken in the above examples of variations of internal resistance with changes in the strength of acid, as this would only complicate matters; also, the rate of charge and discharge is assumed to always be the same. It would approximate more nearly to the conditions that actually

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exist in practice if diffusion through the porous pot were supposed to be constantly taking place during charge and discharge, although not with sufficient rapidity to maintain equilibrium, but it would not then afford such a good illustration from a theoretical point of view.

Curve *b*, Fig. 1, was calculated on the extreme assumption that the quantity of electrolyte employed is so large, and the rate of equalisation of strength by diffusion so rapid, that no sensible weakening is produced during discharge, either in the bulk of free liquid or locally in the portions directly surrounding the active material; and in practice these conditions are very nearly attained in all well-designed cells. The total fall of E.M.F., due to weakening of the acid as a whole, is only about ·05 volt from beginning to end of discharge, and the further loss through imperfect diffusion is not much for reasonable rates of output. The latter loss, however, only appears as a polarisation effect, and must be measured accordingly—that is to say, it is not present on open circuit, and is dependent on the rate of working. If a series of curves, showing the variation of E.M.F. with strength of acid, were constructed on the assumption of various limited quantities of electrolyte, they would all be found to lie below curve *b*, the smaller the quantity the less being the E.M.F. for every given strength and the lower, therefore, the corresponding curve, but none of them would fall as low as curve *a*.

(To be continued.)

THE PHOTOMETRY OF DIFFUSED REFLECTION.*

BY E. LOMMEL.

In a previous Paper "On Fluorescence" I have shown, under the heading "The Principles of Photometry,"† that in theoretical photometry it is not the surface elements of the luminous surface, but the volume elements of the luminous body which must be regarded as emitting light. Accordingly, the following three propositions were taken as a basis for the theoretical treatment of photometric problems :—

1. The quantity of light radiated from one volume element to another is inversely proportional to the square of their distance.

2. The quantity of light emitted from a volume element, and incident upon a surface element, is proportional to the cosine of the angle of incidence.

3. The light radiated by a volume element is enfeebled on its way through the radiating body according to the law of absorption.

Lambert's law of the cosine of the angle of emission was thus eliminated from the set of photometric principles, and its place was taken by the present proposition 3. The cosine law was now obtained as a consequence of the above principles, but only for opaque glowing bodies ; for self-luminous bodies transmitting light, such as flames, the cosine law does not hold.

In the work referred to, the behaviour of none but self-luminous (incandescent and fluorescent) bodies was taken into account, whereas the much more difficult problem of bodies glowing with borrowed light by diffused reflection was left untouched.

For diffusively reflecting bodies also the cosine law had, since Lambert, been taken as determining the intensity of light reflected by them. This assumption could, however, neither be based upon theory, nor did it appear to correspond with the facts of observation. This state of things has recently been emphasised by Seeliger, with special reference to the photometry of the planets. He showed, by a series of observations, that an experimental corroboration of Lambert's law for diffusing bodies cannot be thought of. *Apropos* of these works of Seeliger, I have resumed the work already begun in 1880, dealing with the task of deducing the behaviour of diffusively reflecting bodies from the above-stated principles of photometry.

1. If through the surface $d\,\infty$ of the volume element $d\,\infty\;d\rho = d\,v$ of an illuminated diffusing body, the amount of light $d\,\infty$ (*i.e.*, unit light per unit of area) penetrates perpendicularly, let $l\,d\,\infty\,d\,\rho$ be the amount of light diffused in all directions by the volume element. The quantity l we may call the *diffusive power* of the body. This is independent of the colour of the incident light, and only depends upon the degree of dulness, pulverisation, disintegration, sponginess, cracked structure, &c., of the diffusing body ; for a perfectly clear, limpid body the diffusive power l is zero.

2. Since the beam of light of intensity $d\,\infty$, in passing through the distance $d\rho$, loses the amount of light $l\,d\,\infty\,d\,\rho$ diffused in all directions, it is enfeebled by diffusion according to the same law as holds good in the case of absorption.

* Abstract from *Wied. Ann.*, Vol. XXXVI., p. 473, 1889.
† *Wied. Ann.*, Vol. X., pp. 449 and 631, 1880.

3. At the same time it is enfeebled by absorption proper, both in passing through the diffusing particles themselves, and through the transparent medium in the space between them. By this absorption it loses the further quantity

$$k\,d\,\infty\,d\,\rho,$$

where the absorptive power k is a function of the wave length, since particles and medium may be "coloured."

4. The supposition hitherto made, that the volume element is a rectangular prism with its edges parallel to the direction of the incident beam, is not at all necessary. For, whatever may be the shape of the volume element, it may be supposed to be subdivided in a direction parallel to the rays into narrow right prisms, each of which affects the incident light in the manner specified. By a volume element of any shape, therefore, the quantities of light $k\,d\,v$ and $l\,d\,v$ are abstracted, by absorption and diffusion respectively, from a beam having unit quantity of light per unit of sectional area.

5. The quantity of light $l\,d\,v$ is radiated in all directions by the volume element. If we assume that the radiation takes place equally in all directions, then the surface 4π of a sphere described with unit radius about the volume element is uniformly illuminated by the quantity of light $l\,d\,v$. The quantity of light, therefore, which the element $d\,v$ radiates in any direction per unit of area of this sphere is

$$\frac{l}{4\pi}\,d\,v.$$

. . . . . . For absolutely white bodies (where R = 0), the amount of light radiated by a surface element $d\,\infty$ in all directions, when illuminated by parallel rays at an angle of incidence i is $a\,d\,\infty\cos i$, where a is the intensity of the incident light. The amount of light radiated by a body equally illuminated from all directions in a direction at an angle ϵ to the normal is $a\,d\,\infty\cos\epsilon$. We therefore obtain the following propositions :—

If an absolutely white body is illuminated by parallel rays from any direction, the amount of light sent out in all directions from its surface (its illuminating power) is proportional to the cosine of the angle of incidence.

If the surface of an absolutely white body is equally illuminated from all directions, the quantity of light radiated by it in any given direction is proportional to the cosine of the angle of emergence.

These propositions, enunciated for absolutely white bodies, also hold in coloured bodies, for those colours whose absorption may be taken as indefinitely feeble.

But these two propositions show in what sense, and with what reservations, the cosine law for the angles of incidence and emergence respectively may be taken as valid according to our theory. . . . The intensity of light L radiated in a direction ϵ, by an opaque diffusing body, when the light is incident vertically, is given by the formula—

$$\frac{4\pi}{a\,d\,\infty}\,L = \frac{l}{2\,(k+l)}\,(P+\mu\,Q),$$

$$\text{where } P = \frac{2\cos\epsilon}{\cos\epsilon+1}, \text{ and } Q = P\,(\log 2 + \cos\epsilon\,\log\frac{1+\cos\epsilon}{\cos\epsilon}).$$

[μ is a constant depending upon the physical constitution of the body.]

. . . Of the substances investigated, marble alone approximately follows the cosine law. According to our theory it would only hold in the case of illumination from all directions for a body approaching absolute white.

The numbers for paper and cardboard do, indeed, approach the new law more closely than the cosine law ; but we cannot speak of even an approximate correspondence. But since these substances are translucent, the formula found for perfectly opaque plates cannot be applied to them ; we should have to use the formula applicable to any given thickness of plate. But this would give for a thin sheet the light radiated as being independent of the angles of incidence and emergence. An increase of this amount of light with increasing angle of emergence up to a maximum, as found by observation, cannot be explained on the basis of the new law of emergence, any more than on that of the cosine law.

That the angles of incidence and emergence should be interchangeable, as demanded by Lambert's law as well as the new law, is also contradicted by the numbers obtained for paper and cardboard.

On the other hand, the values found for porcelain agree pretty closely with those calculated by the new law, while they diverge considerably from the cosine law. The "albedo" upon which the calculation was based was 0·4, which Lambert takes as the approximate value for white bodies in general. While the divergences from the cosine law amount to 31 per cent., they do not exceed 4 per cent. in the case of the new law.

In the preceding I have also indicated the method for the theoretical treatment of the diffused light passing through a translucent dull body. A closer investigation of this question is reserved for a future communication.

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The Electrician.

(The Oldest Electrical Journal, 1861—1878.)

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AMERICAN NOTES.

If funds do not permit or if inclination does not lead the average English electrical engineer to betake himself from time to time across the Atlantic to see for himself all the engineering curiosities that the restless ingenuity of the Americans has prepared for him, the deficiencies of his education in this direction appear likely to be made good in some degree by the disinterested zeal of his more fortunate brethren. Hardly a year now passes without the members of the Institution of Electrical Engineers being enlightened by the American Notes of a brother member; a few years ago it was Mr. ADDENBROOKE, last spring it was Mr. PREECE, this autumn it is Mr. H. D. WILKINSON. The practice is one to be encouraged. A nation which considers that it has nothing to learn is in a parlous state; the bourne to which such self-sufficiency inevitably leads is just now being for the *n*th time made plain by the spectacle presented by the best known exponent of the art of celestial self-satisfaction.

At the same time it is somewhat to be regretted—not, of course, so far as the lucky individuals themselves are concerned—that almost all those who return from a tour in the States come back infected with the optimism, cheery nonchalance, and fondness for "sonorosities," which distinguish the Anglo-Saxons of America from those of Great Britain. Thus, in January last we were solemnly assured that "nothing grander in design or more beautiful in execution has ever been seen in this world," than Rome in the days of ANTONINES, no not exactly, "than the group of buildings situated in Jackson

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Park, Chicago, and called the 'World's Fair,'" although the world for some reason failed to go there. Nothing but the exuberance of expression begotten of ten weeks' residence in the States could have led to such an entertaining exaggeration. The phlegmatic, critical Briton becomes, to all intents and purposes, a sort of inverted CÆSAR as soon as he sets foot in America; he goes, he sees, and is conquered. It is related of EMERSON, the confirmed optimist, that he was taken by CARLYLE, the confirmed pessimist, to see all the choicest horrors of the metropolis; but, notwithstanding, continued of the same cheerful opinion still. In much the same way, the author of "Notes on Electric Tramways in the United States and Canada" appears to have been taken in hand by his American friends, and to have found everything good. Cars "weighted out of shape and scraping the ground," rails "projecting above the road-bed one or two inches," tramcar lamps brilliantly lighted up by earth leakage, fragments of a flywheel being taken out "through an opening in the station wall," do not distress the translated Briton in the slightest, so long as the end is attained. At home no self-respecting Briton would allow himself to be baulked of a good grumble, if he were taken anywhere in third-class style at first-class fare, by the retort that he had "got there all the same," although in St. Louis or Chicago, apparently, this irrelevancy would completely silence him.

Stay-at-home electrical engineers, however, cannot afford more than other folk to look a gift horse in the mouth, and, instead of deploring this tendency to look at American phenomena through American glasses, they would do well to regard it as an outward and visible sign that a visit to America has in very truth been made. Too many who cross the Atlantic come back with their lips sealed by this or that consideration, or biassed by this or that interest, and apart from its value as a means of promoting discussion, Mr. WILKINSON's paper, which we commence to print in this issue in order that its existence may be brought to the timely notice of those desirous of taking part in the forthcoming debate at the Institution, is a useful index of the impression left by a careful inspection of transatlantic methods of electric tramway working. To paraphrase a remark of the author with regard to electrolytic corrosion in Boston, we may say in regard to electric traction men in the States generally: They have purchased experience at heavy cost, which should benefit us when our turn comes. To that end the author's emphasis of the great importance of rail-bonds of adequate cross section, his toleration of the double-trolley method of working, his favourable opinion of the Love slotted-conduit as judged by its performance at Chicago and Washington, his statement as to the revenue derived by tramway companies from current supplied off the 500-volt circuit to small motors, merit the attention and criticism of those engaged in the praiseworthy task of converting "the Britisher," and adapting the electric car to suit his notions of what constitutes safety, beauty, and an adequate dividend. The task is, indeed, no easy one; and even were it far easier it is a long cry, when there is but little money to spare, from conversion to application. If our leading local authorities take the matter of tramways in hand with the same energy as they have the matters of gas, water, and electric light works, conversion may, it is true, be followed by the immediate application of the new ideas to practical cases, and we may very possibly witness an electric tramway boom comparable to anything of the kind that has happened across the Atlantic. Meanwhile, the only thing to be done is to make due preparation, and as an aid to that end to purchase the dearly-bought experience of others at a cheap rate.

THE BOARD OF TRADE ELECTRICAL STANDARDISING LABORATORY.

(Concluded from page 667.)

The second Standard is that for one hundred volts, and is a specially designed multicellular voltmeter. The following is the official description of this instrument.

STANDARD OF ELECTRICAL PRESSURE.

CONSTRUCTION AND USE OF THE BOARD OF TRADE ONE HUNDRED VOLTS ELECTRICAL STANDARD.

The instrument is shown in plan and sectional elevation on the accompanying drawings. The letters refer to the paragraphs, no reference letters being required on the illustration.

It consists of:

Suspended Vanes.—(*a*) An arrangement of 10 parallel vanes, shaped like the moving portion of Sir W. Thomson's Quadrant Electrometer, fitted on an axis passing through the centre of gravity of each vane and separated by distant pieces to a distance of nine millimetres apart.

Concave Mirror.—(*b*) On the same axis is fixed the aluminium frame of a concave mirror 19 millimetres in diameter and about 61 millimetres focal length, which is held in the frame by means of three light phosphor-bronze springs.

Suspending Wire.—(*c*) This arrangement is suspended by means of a wire 0·05 millimetre in diameter and 18 centimetres in length, formed of an alloy of 10 parts of iridium to 90 parts of platinum, attached to the end of the axis above the mirror so that the axis hangs in a vertical line.

Horizontal Adjustment of Position of Vanes.—(*d*) The upper extremity of the suspending wire is fixed to the centre of a circular brass plate having teeth cut in the circumference, into which a tangent screw is geared so as to enable the end of the wire to be rotated in the horizontal plane for the horizontal adjustment of the vanes.

Vertical Adjustment of Vanes.—(*e*) The vertical adjustment of the position of the vanes is accomplished by the raising or lowering of the platform on which the circular brass plate mentioned above is pivoted by means of three screws for raising and three for lowering.

These screws regulate the distance of the platform above a similar platform fixed by means of three supports to the framework of the instrument.

Quadrants.—(*f*) The vanes are suspended so as to slightly enter at the zero position of the instrument into the spaces between two sets of 11 thin polished brass plates shaped as quadrants of a circle, which are fixed horizontally one above another to a vertical support. These two sets of plates are in metallic connection, and are carefully insulated from the framework of the instrument.

Vibration Checking Arrangement.—(*g*) In order to reduce the vibration of the suspended system, and the time which must elapse before an accurate observation can be taken, a thin horizontal brass disc is suspended in refined mineral oil contained within a glass vessel, by means of a wire attached to the lower portion of the axis of suspension of the vanes.

Outer Case.—(*h*) The suspended system and quadrants, with their supports, are inclosed in a brass case having in front of the mirror a rectangular window of parallel-worked glass. A hole is cut in this case for the insertion of a key fitting the squared arbor of the tangent screw (*d*).

Terminals.—(*i*) The terminals, by means of which connection is obtained with the vanes and quadrants, are fixed on a thick piece of polished ebonite projecting beyond the brass cover (*h*).

One terminal is in connection with the metal framework, the other is entirely insulated; and a tongue of brass or switch connected by means of a brass rod with the two sets of quadrants can be turned so as to make contact either with the insulated or with the uninsulated terminal.

Framework and Supports.—(*k*) The arrangement described above, forming the electrical portion of the instrument, is mounted near the apex of a framework of brass in the form of a circular arc which rests by means of three feet on a horizontal

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slab of polished marble supported on a large block of Portland stone on a concrete foundation.

A screw thread is cut on the feet for accurate levelling of the framework, to which two spirit levels are attached.

These lines form the fiducial marks; that on the left of the observer giving the zero position, and that on the right the correct position for 100 volts pressure.

The distances from the mirror (b) of these tablets and of the

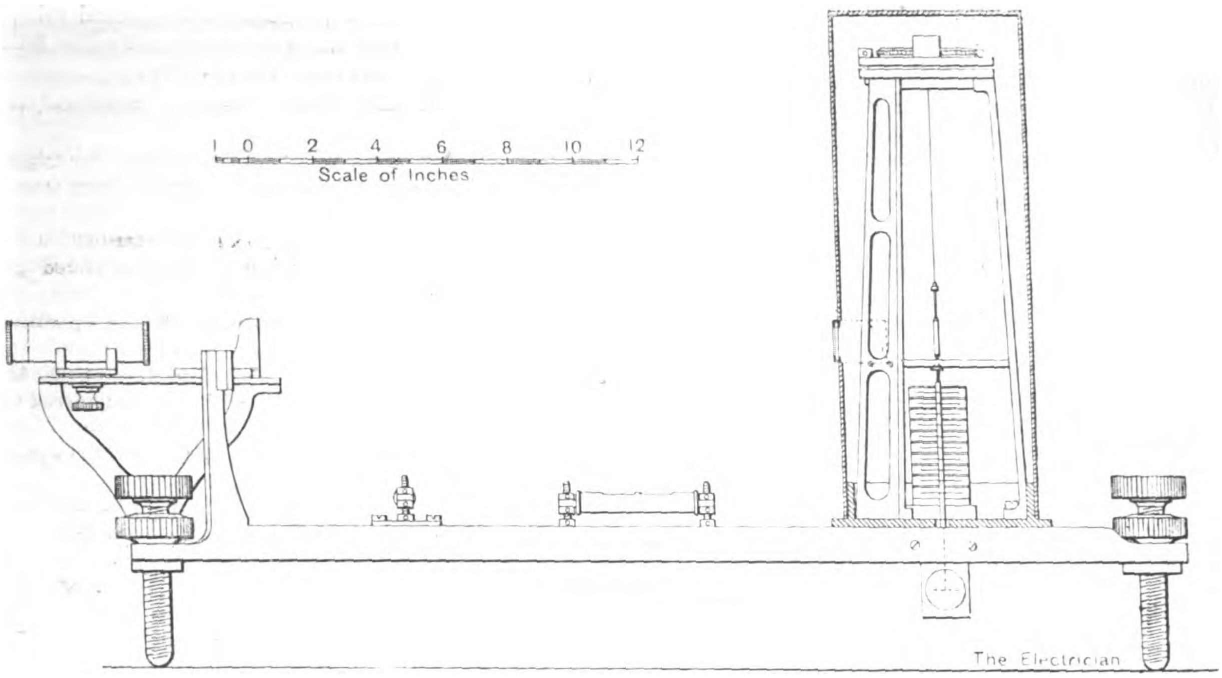

Fig. 1.—Side Elevation of the Volt Standard.

Eyepiece and Cross Wire.—(l) On a support attached to the centre of the curved portion of the framework is fixed the observing portion, consisting of a magnifying eyepiece in front sighting wire (l) is adjusted so that the image of the line on the tablet, when the mirror is at the proper angle, coincides with the sighting wire.

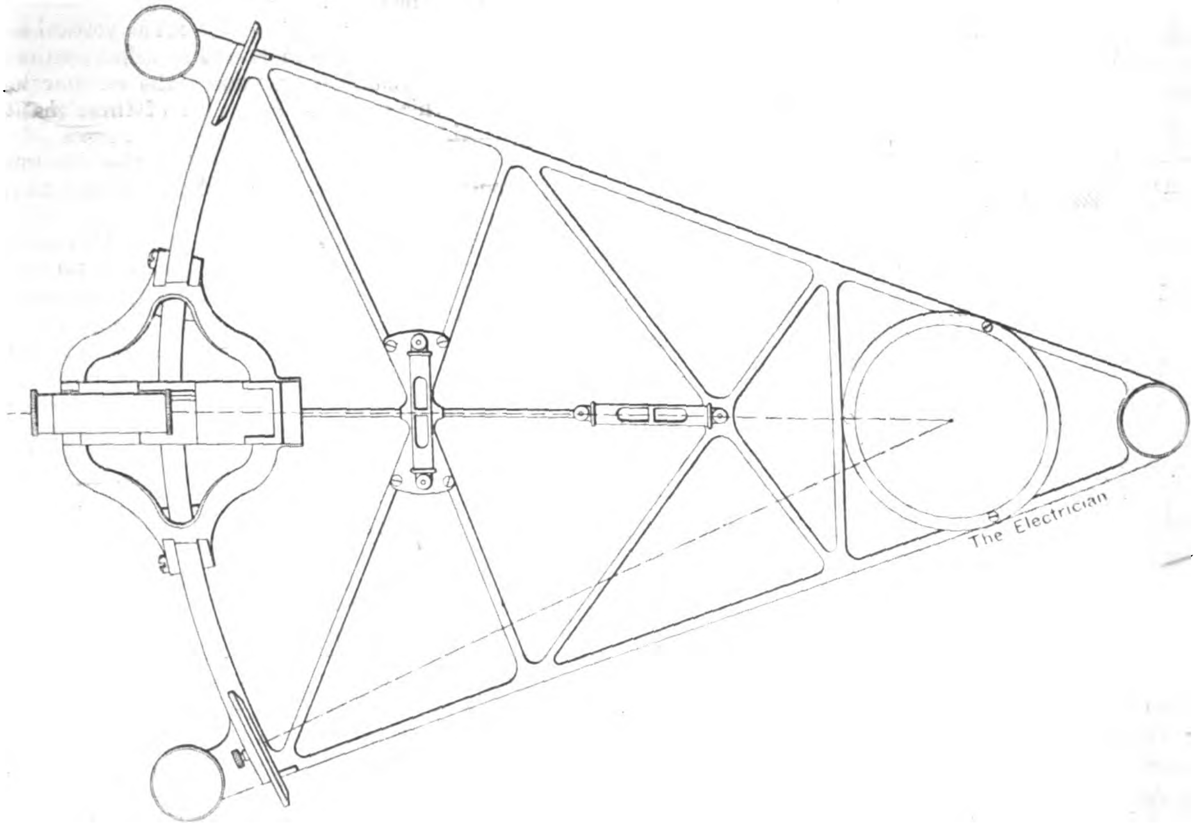

Fig. 2.—Plan of the Volt Standard.

and in the focus of which is stretched a vertical copper wire 0·06mm. in diameter.

Fiducial Marks.—(m) At each end of the arc is erected a vertical support, to which is fixed a tablet of brass with the surface facing towards the mirror platinised. On each of these faces is engraved a vertical line.

Use of the Instrument.

Adjustments.—The instrument must be in accurate adjustment as regards level and position of the suspended system.

The vertical adjustment of the latter is obtained by trial. The vanes should be at equal distances from the quadrants above and below, this position giving minimum sensibility.

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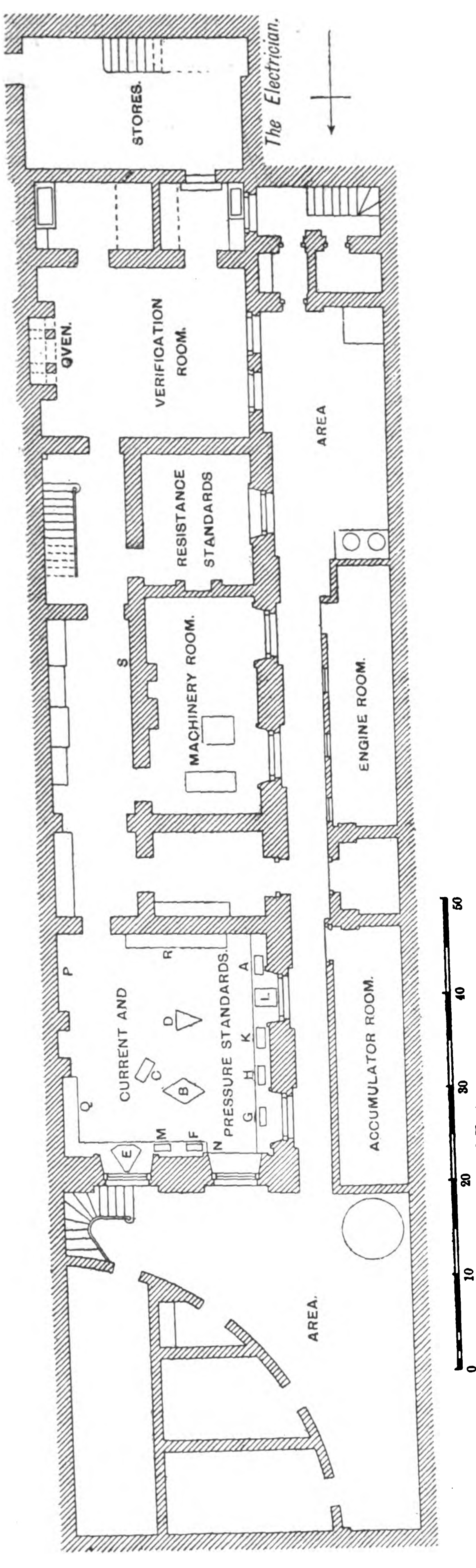

Scale of Feet.

FIG. 3.—General Basement Plan of the Electrical Standards Department of the Board of Trade.

The horizontal adjustment of the suspended system is obtained when the image of the zero fiducial mark produced by the mirror (*b*) exactly coincides with the sighting wire (*l*), the switch (*i*) being turned so as to connect the quadrants with the metal framework of the instrument.

(The levelling of the framework and vertical adjustment of the suspended portion of the instrument were carefully attended to when the instrument was first set up, and these adjustments have since that time remained constant. The horizontal adjustment of the suspended system requires occasional attention from time to time.)

Readings.—Arrangements should be made for obtaining a pressure which can be continuously varied from about 98 to 102 volts.

This pressure is applied to the 100-volt standard, and to the instruments to be compared with it, and is adjusted until the image of the fiducial mark indicating 100 volts pressure exactly coincides with the sighting wire (*l*) by observation through the eyepiece.

This coincidence is maintained, by adjustment of the pressure, if necessary, until the expiration of five minutes from the time of first applying the pressure, when, if there is no visible vibration of the mirror, the pressure is exactly 100 volts.

The general arrangement of the Laboratory is shown in the plan Fig. 3, and consists of the various rooms already enumerated (p. 665 *ante*). The accumulators in use consist of a battery of four large 61-plate Crompton-Howell cells, which are generally used two in parallel or the direct production of large currents, and 108 11-L E.P.S. cells. The large cells can supply currents of any amount up to 2,000 amperes for a short time, and are charged in series at the rate of 200 amperes. The E.P.S. cells are used for running the transforming machinery and for supplying continuous pressure up to 200 volts. The discharge rate is never allowed to exceed 22 amperes even for short periods. Current from the large cells is brought into the room containing the standards of current by mains consisting of flat copper strips, the lead and return being sandwiched together to avoid magnetic disturbance. A break is provided just outside this room for the insertion of regulating resistances, which for the most part consist of carbon rods with suitable terminals. The use of carbon in this connection has this great advantage in addition to that of handiness, that as the resistance diminishes with increase of temperature, the fall of current which would otherwise take place from the slight polarisation of the cells and the warming of the metallic circuit can be completely obviated by choosing suitable lengths and cross-sections of carbon. Great steadiness of even the largest currents for an ample time has thus been obtained. Fine adjustments of current are secured by the use of rheostats formed of carbon plates under variable pressure inserted either in the main circuit or as a shunt to the measuring instruments.

A large electric balance (A, Fig. 3), made under Lord Kelvin's supervision, is fixed immediately at the point of entry of the above-mentioned large mains. This instrument can read up to 10,000 amperes. Round two sides of the current and pressure standards room is fixed a concentric main of the same pattern as those used by the London Electric Supply Corporation for trunk mains from Deptford. The outer conductor is cut across at intervals, and large terminals clamped on at each side of these breaks to which the current-measuring instruments are attached, while copper bars are provided for short-circuiting every instrument. The inner conductor is only exposed at the two ends, where it can be similarly connected to the outer conductor, either through an instrument or by means of a short-circuiting strap. A complete anti-induction circuit is thus provided for current. A shelf of enamelled slate is carried on corbels let into the external wall of the building underneath the concentric main as a support for the current-measuring instruments. The Ampere Standard B is placed upon a stone pedestal near the centre of the room, and the auxiliary ampere balance C upon a similar adjacent support. The Volt Standard D, which really measures 100 volts, or one hekto-volt, occupies a third stone pedestal in the centre of the room. Another instrument of the same pattern is placed at E. On the shelves round the wall of the room are five sub-standard

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Kelvin balances of the following ranges, 1 to 5 amperes (F, Fig 3), 5 to 30 (G), 30 to 120 (H), 100 to 600 (K), and 500 to 2,500 (L). The first two of these have aluminium beams. A composite watt-balance is placed at M. One of the remaining walls, R, is occupied by various pressure-measuring instruments for low pressures, and the fourth wall partly by pressure-measuring instruments for high pressures, Q, and partly by a switchboard, P, for regulating the transforming machinery. A highly insulated platform is provided for standing on when manipulating the high pressure instruments. On this board are a pair of Cardew voltmeters, supplemented by twelve of resistance tubes. Each of these is practically a complete Cardew voltmeter, but without hand movement and dial. Each contains the usual wires and pulleys under exactly the same "live" condition as in a working voltmeter. By means of these resistances, which can, of course, be independently checked and mutually compared, differences of potential up to 2,150 volts can be measured. A number of miscellaneous instruments are left in this room on the table R near the door. A "chain" of voltmeters—that is to say, a set of instruments ,the range of each one overlapping two others, as with the sub-standard ampere balances—will be placed here.

The chief work which has been done in this room is the comparison of the three standards of current, volt, and resistance. The standard ampere, as obtained by many repeated determinations by the silver voltameter, was discharged by the accumulators and passed through the Ampere Standard, the auxiliary balance, and through a hundred ohms in the resistance (N, Fig. 3), and gave a difference of potential of 100 volts, which was observed on the Volt Standard. The 100 ohm resistance is made of manganin, and is maintained at a constant temperature by oil circulated by a small electric motor, and by the circulation of water in an outer jacket. This hundred ohm resistance had to be compared with the Ohm Standard, the value of which was accepted from the British Association determinations. The volt was thus deduced from the corelation of the Ampere and the Ohm. The scale of the Volt Standard is long enough to include the pressures due to 69, 70 and 71 Clark cells, and by direct comparison, the value of the cell was thus determined. The work of carrying out this triple comparison occupied many months.

It may be said that while the Imperial Standard Yard and Pound have to be most carefully treasured, and if destroyed can never be actually recovered, physical units are not equally precious, and may be re-determined. All that is necessary for re-determining the ampere is to remember "three noughts three ones and an eight"—0·001118—the electro-chemical equivalent of silver, a formula not unlike "three feet three inches and three-eighths," the length of a metre. A current of about 0·8 ampere is kept continually passing through the Ampere Standard to keep it warm and dry. The period of a complete swing of the standard of current is about half a minute, and hence the need for an auxiliary balance, to act as the "finder" of a telescope.

Among the instruments at present in construction is a huge Cardew voltmeter of the horizontal pattern, with compound iron and brass tube, 10ft. long. This is fastened to the wall at S. This instrument will have no gear, and will be read optically.

The transforming machinery consists of a continuous current motor and an alternator with shafts in line and both keyed to a common pulley, while a continuous current high pressure dynamo can be run from this pulley by means of belting. By varying the exciting currents of these different machines a very delicate adjustment of the transformed current or pressure is obtained. There are, in addition, various alternating current transformers for giving a range of current up to 500 amperes and of pressure to 10,000 volts.

The room containing the Standard of resistance and Clark cells is a small room arranged to be kept at a uniform temperature of 16°C. In this room is a Carey Foster bridge, and Thomson reflecting galvanometer with a transparent scale. Profs. Kahle and Lindeck worked in this room for several weeks on the comparison of standards of resistance under the direction of Prof. von Helmholtz, and were quite satisfied with the agreement of the Standards with those of the Reichsanstalt. Prof. Carhart also made comparisons for the U.S.A. Standards Bureau.

The Verification Room is fitted with a concentric main running around three sides, slate shelves for the support of instruments; and a large fireclay oven 2ft. 3in. wide, 2ft. 6in. deep, and 3ft. high, with plate glass front perforated with holes for leads, is heated by gas, for testing instruments at various temperatures. It has been run to a very high temperature, but it is not proposed to use it for more than 30° C. This room is fitted up with secondary standards for the measurement of current and pressure up to the limits of instruments in common use. In this room calibration and tests of meters have been carried out. This work has nothing to do with the calibration and sealing of meters which is carried out by the London County Council, but relates to the approval of the patterns. Some twenty-four meters are now under test. In this room deci-ampere deka-ampere, and hekto-ampere Kelvin balances are employed.

Ammeters and other instruments will be calibrated here when the laboratory is ready for this branch of work. No official tests of this kind are at present carried out, but since the issue of the Order in Council, the question of opening the laboratory for the commercial verification of instruments has been under consideration, and a scale of fees is being prepared.

In the verification of instruments in this laboratory definite units and multiples of those units are dealt with. For instance, if an instrument reading to 100 volts is sent for verification at certain points, say 90, 95, and 100, the readings of those instruments when pressures of those amounts are applied are given, and not the values of the indications 90, 95, and 100 on the instrument. It is obvious that where a large number of instruments have to be checked this method is necessary for economy of time and power.

NOTES ON THE ANGLO-AMERICAN TELEGRAPH COMPANY'S 1894 ATLANTIC CABLE.

BY ARTHUR DEARLOVE.

The successful completion of this cable may be considered a fitting opportunity to review the progress made of late years in cable design as represented by the construction of this, the fifteenth, Atlantic cable. The development of telegraph traffic between Great Britain and America has rapidly increased, and the public demand for the quickest possible service has always been fully recognised by the Anglo-American Telegraph Company, who, to ensure such a service, recently determined to lay a new cable of exceptionally high working speed.

The Company's consulting engineers, Messrs. Clark, Forde and Taylor, were requested to design and make estimates for such a cable, and their instructions were that it should be capable of transmitting not less than 40 words per minute.

Since the introduction of automatic transmission on their cables, at the instance of the Company, by Mr. Herbert Taylor, early in 1888, the speed of working which, till then, had been governed by the rate at which the sending clerk could efficiently manipulate the keys, has been increased more nearly to the limits imposed by the electrical "constants" of the lines. In a core of given materials these "constants," as is well known, depend upon the dimensions assigned to the conductor and insulator respectively, and it is a matter of great importance commercially that their relative weights should be judiciously chosen.

Broadly speaking, the cost of the core is governed by the weight of the dielectric, and the working speed by the weight of the conductor, the latter, however, being limited by the necessity of maintaining, for mechanical and manufacturing reasons, a sufficient thickness of the insulator.

Subject to these conditions, the problem, therefore, is to provide the required working speed at a minimum cost, and the solution arrived at by the engineers was that the core should have a conductor weighing 650lb., insulated with gutta-percha weighing 400lb. per nautical mile.

Next, with regard to the mechanical construction of the cable, the sections given below (Fig. 1) are from photographs of the types actually laid.

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The length manufactured was 1,952 knots, the total weight of which was over 5,000 tons. The most important type to which I shall specially refer is, of course, the one designed to be laid in deep water of from 1,000 to 2,500 fathoms (see Fig. 1).

For very good reasons the endeavour of cable engineers has been to combine great tensile strength and low specific gravity with durability, and until some new material other than steel and possessing the requisite properties is introduced, no marked improvement on the type referred to appears probable.

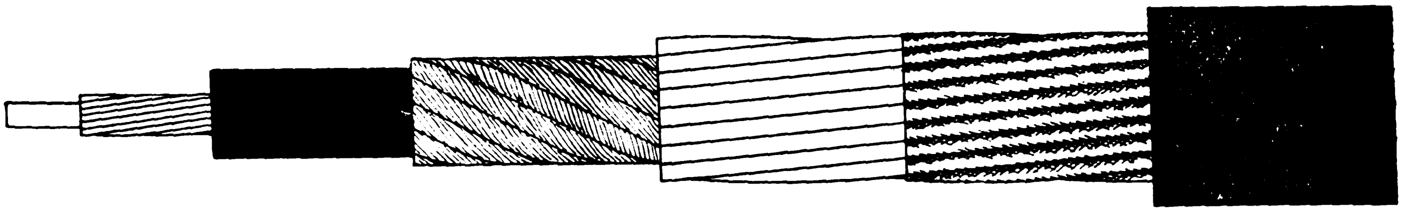
In the Sixties and Seventies the question of supreme importance was how to construct a cable that could be successfully laid in deep water, and on this point Company and contractor were of one mind; but in more modern practice, besides the above requirement, the telegraph companies and their engineers have insisted upon the necessity of a type which, though less easy to lay, is likely to possess greater durability and be more easily raised for repair after many years' submersion.

Formerly, it seems to have been considered that the merits of a deep sea type could be expressed in terms of the number of fathoms of its own length, hanging vertically in water that it could support without fracture. Now, the information so so-called "light cable" the strain due to friction may easily be greater than that due to the dead weight of the cable itself.

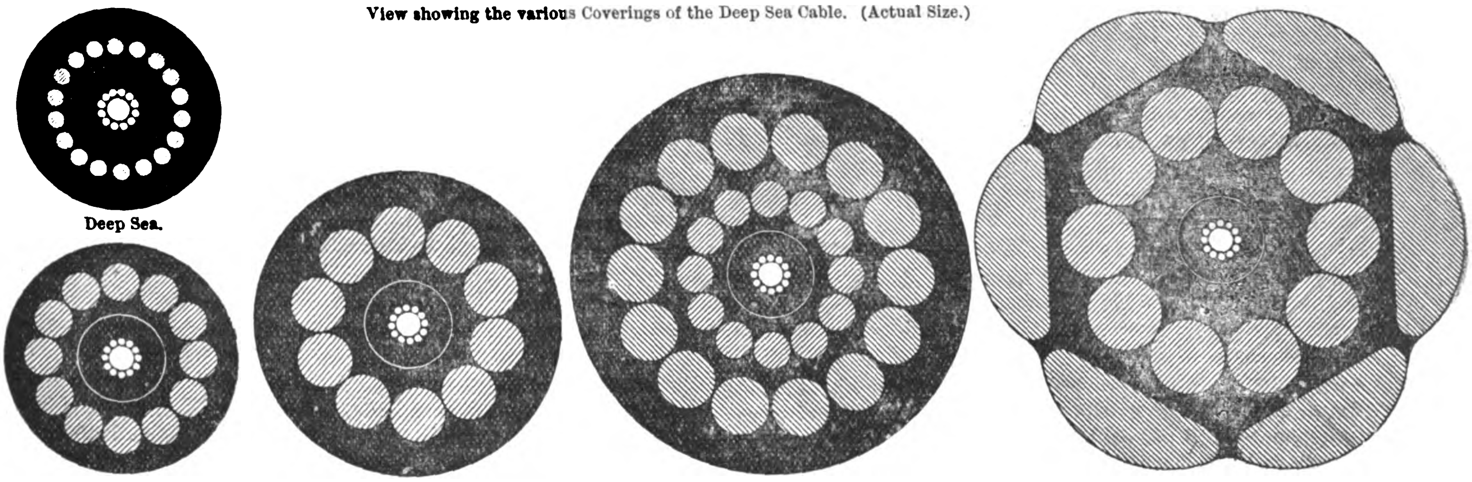
The following table gives the mechanical data of the Atlantic deep-sea types adopted in 1894 and in the seventies by the Anglo Company:—

1894 cable.		Atlantic deep-sea type of 20 years ago.
Sheathing.	18/14 steel, each wire compounded & taped.	10/13 homo., each wire covered with compounded hemp yarns.
Outer serving	Two tapes & compounds	One jute yarn whipping
Breaking strain	8·2 tons.	6·4 tons.
Elongation	4 per cent.	—
Weight in air	40·2 cwt.	45·0 cwt.
„ „ water	22·75 „	18·6 „
Specific gravity	2·30	1·70

The available strength of the 1894 cable is nearly 30 per cent. higher than that of the type composed of a combination of hemp and iron. Moreover, in the former each wire is guarded from corrosion by a gutta-percha compound, and further pro-



View showing the various Coverings of the Deep Sea Cable. (Actual Size.)



Deep Sea. Light Intermediate. Heavy Intermediate. Newfoundland Shore End. Irish Shore End.

Fig. 1.

expressed is no doubt of value, and a large number of fathoms (say, from 5,000 to 10,000) implies excellence from a paying-out point of view; but for picking-up operations the actual breaking strain of the cable as expressed simply in tons and hundredweights is regarded as being of at least equal importance.

Cables are not laid in water from 5,000 to 10,000 fathoms deep, and for obvious reasons never will be, and the condition on which the possibility of the recovery of a cable from existing

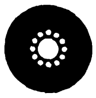


Fig. 2.—Core.

depths really depends, is the margin of strength between the actual breaking strain and the weight of the suspended portion of the cable.

The weight itself is only one of the factors of the picking-up strain; another factor is the friction between the cable and the water, which depends on the rate of picking up, and on the nature and area of the surface of the suspended part, but is quite independent of the specific gravity of the cable. In a tected by a separate tape. It is contended that for these reasons the chances of successful recovery after years of submersion have been materially increased.

As previously mentioned, a core of 650lb. copper and 400lb. gutta-percha was adopted. The section of it is shown in Fig. 2. The data below apply to this core, and, for comparison, corresponding data are given of the earlier core used for Atlantic cables.

——	1894.	1873 Atlantic.
Weight of conductor	650lb.	400lb.
Weight of insulator	400lb.	400lb.
Res. per knot in ohms laid	1·682	2·93
Cap. per knot in microfarads	0·420	0·353
Diameter of core	0·475in.	0·460in.
Breaking strain	1,000lb.	—
Relative earning power per unit of cost	1·55	1·00

Until it is shown how practically to construct a core having the properties of Mr. Oliver Heaviside's "distortionless circuit," a step in the right direction has been taken by liberally increasing the weight of the conductor.

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With gutta-percha at six or seven times the price per lb. of copper, the advantages of restricting the weight of the former material are obvious; but another point which might be lost sight of is that the heavier conductor hardly affects the diameter of the core, so that its adoption does not sensibly increase the cost of the sheathing, or of the shipping.

It should, however, be borne in mind that the principle must not be pushed too far, and that suggestions in this direction should only be acted on under the advice of those having a practical acquaintance with the details of the subject.

A contract for the work was made between the Anglo-American Telegraph Company and the Telegraph Construction and Maintenance Company, on February 23, 1894, and the cable was manufactured and the ships loaded and ready for the laying of the main section on the 30th June.

The heavy types of the Irish shore end were laid in May. The expedition was in charge of Mr. F. R. Lucas, the engineer-in-chief to the contractors, whose steamers, the "Scotia" and the "Britannia," were employed to lay the cable.

Mr. Herbert Taylor and staff accompanied as engineer to the Anglo-American Company. The cable was laid from Newfoundland homeward, the operation being conducted by Mr. Lucas with great skill and judgment, under somewhat adverse conditions as regards weather. A very unusual amount of ice was met with, and the great prevalence of fog made it at times difficult, or impossible, to fix the position of the ships by observation. An average of 9 per cent. of slack was laid, and the retarding strain carried, when paying out at the rate of seven knots an hour, was between 17 and 18 cwt. per 1,000 fathoms of depth.

It will be seen that in dealing with this heavy type of main cable, it is necessary to have machinery provided with ample brake power, as in 2,500 fathoms the strain to be carried is 45 cwt., which, at a speed of seven knots, implies the absorption of energy by the brake equivalent to over 100 H.P. The cable was completed on July 27th, and the subsequent tests with galvanometer and electrometer showed it to be in a perfectly healthy electrical condition. Its length is 1847·54 nautical miles. During the thirty days after completion a large number of tests were taken, the general result of which is given below.

With the galvanometer the mean dielectric resistance during half-an-hour's test with both currents was } 55,580 megohms per knot.

With electrometer. After charging with 100 volts for half-hour. Mean of both currents.

Time, mins.	Loss of charge, per cent.	Calculated Res. per knot, megohms.
5	0·85	83,225
10	1·64	86,270
15	2·49	85,700
20	3·33	84,360
25	4·06	86,140
30	4·83	86,530

The average resistance of the core when tested at 75° F. was 686 megs. per knot after one minute's electrification.

The electrometer tests were taken with Ayrton and Mather's electrostatic voltmeter, designed for electric lighting measurements. This instrument was found to be very suitable for cable testing. Unlike the quadrant electrometer, it is quite portable, and will be found extremely useful on cables like the Atlantic, in which the prevalence of strong earth currents makes tests taken with the galvanometer extremely tedious and difficult.

The conductor resistance of the line was obtained by joining the distant ends of the four cables between Valentia and Newfoundland two and two, and measuring the resistance of the metallic circuit.

The total C R of the new cable thus determined is 3,107 B. A. ohms.

Having taken a special interest in the determination of the capacity of long cables, I give the results obtained. The method is now well known to cable electricians.

The following table of figures is typical of the whole series of 60 observations which were made, approximately 10 for each period of charge, the total mean is given. This mean gives a total capacity for the laid cable of 775·26 microfarads, or 0·4196 microfarad per knot.

Standard Cap. 80·1 Microfarads. E.M.F. 30 Volts.

Time of charge. secs.	Pole of Battery applied.	Slide reading at balance.	Earthing period secs.	Disch'rge in scale divisions D.	Equivalent value in slide reading of D plus or minus.	Corrected slide reading.
5"	Z	939	5"	20 L	4 R	935
5	C	925	5	140 L	22 L	947
10	Z	935	5	50 L	5 R	930
10	C	919	5	170 L	25 L	944
20	Z	950	5	115 L	14 R	936
20	C	930	5	40 L	6 L	936
30	Z	917	5	120 R	17 R	934
30	C	919	5	168 L	24 L	943
40	Z	922	5	180 R	21 R	943
40	C	953	5	150 R	23 L	930
50	Z	915	5	130 R	20 R	935
50	C	935	5	25 R	3 L	932
60	Z	976	6	310 R	44 L	932
60	C	891	6	335 L	51 L	942

Mean of these corrected slide readings .. = 937
Mean slide reading of all observations ... = 936·44

The mean capacity of the whole cable when tested in core lengths at 75° F. was 0·4207 microfarads per knot, with which the observed value is in close agreement.

The above slip (Fig. 3) is a facsimile of the signals received at Heart's Content when sending with an improved automatic transmitter under ordinary working conditions and with duplex connections:—

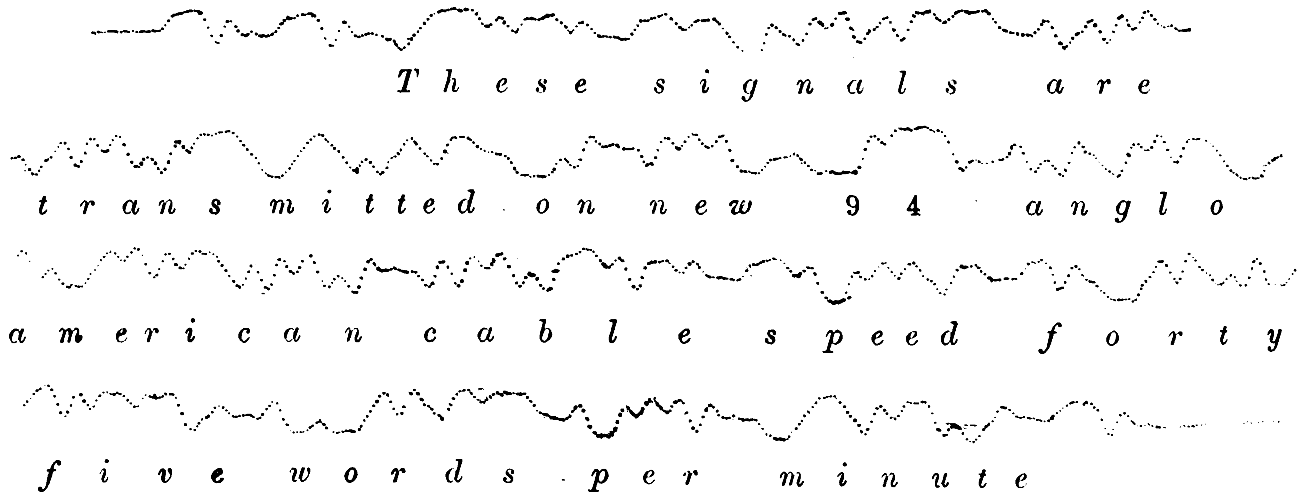

Fig. 3

The speed actually attained for traffic is 47 to 48 words of five letters per minute, and press work is satisfactorily done at

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50 words of five letters per minute. The theoretical speed of this cable, with a K.R. of $2{\cdot}42 \times 10^6$, taken from the writer's "Tables,"* is 48·8 words of five letters per minute.

Speed of Anglo-American Company's Cables in Five-letter Words per Minute.

	Attainable speed.	Actual working speed.
1873	30	28
1874	30	28
1880	25	24
1894	50	47⅗
Totals	135	127⅗

The whole four cables are duplexed, which practically doubles the working power of the lines.

The Anglo Company have, by adding this new cable to their system, placed themselves in a position for transmitting an immense amount of traffic with the least possible delay, and the Company are to be congratulated upon the recent addition to their property.

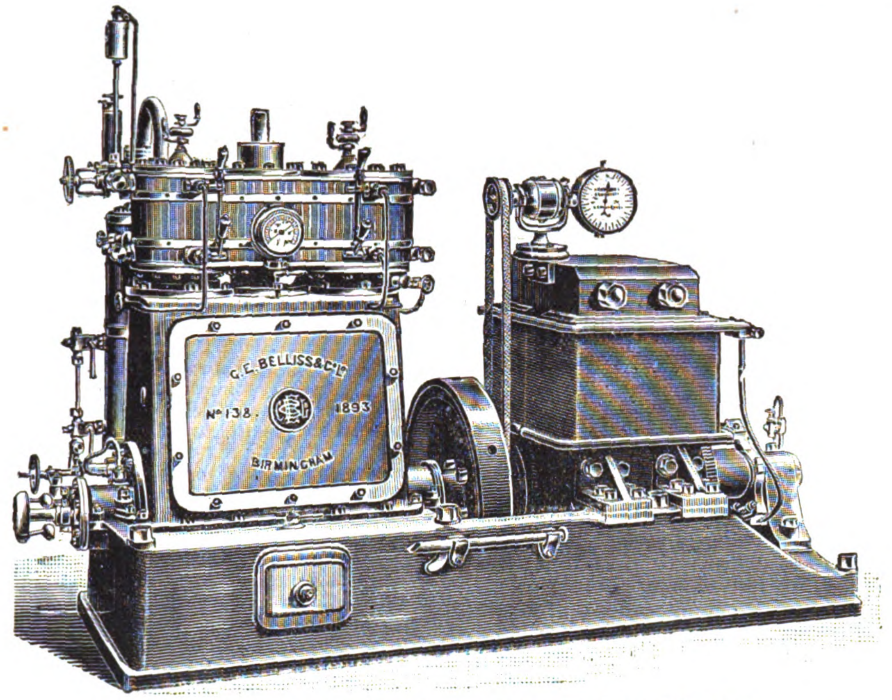
* "Working Speed of Submarine Telegraph Cables, &c." By Arthur Dearlove.

HIGH-SPEED DOUBLE-ACTING ENGINES.

The accompanying engraving illustrates one of the high-speed self-lubricating type of engines manufactured by Messrs. G. E. Belliss and Co. (Limited), Birmingham. These engines are used chiefly for electric lighting purposes, both for central stations and for ship work; and, at the present time, they have in hand a number for central stations, including Kingston-on-Thames, St. James and Pall Mall, Kensington and Knightsbridge, St. Pancras new station, Bedford, Ayr, &c., and, in addition, a number of other similar engines for driving direct fans and centrifugal pumps where high speeds are required.

The makers claim for this engine distinct advantages over the ordinary single-acting engines in both efficiency and simplicity. As will be noticed from the engraving, the working parts of the engine are enclosed by a neat cast-iron casing with large door, this being one of the chief features of the engine, whereby the working parts are readily accessible when required, and at the same time, by enclosing the engine, all the dirt and dust are kept from the bearings, and the oil, which is usually splashed about with an open engine, all passes down to the bedplate below. By means of a special system of lubrication, the oil is used over and over again, and a copious supply under pressure being delivered to every bearing, the engine works noiselessly and with very little wear, this being borne out by the statement of the makers that their engines have been at work for years without any necessity for adjustment of the brasses.

Another feature of the engine is the single valve gear with the two-crank compound engine, which makes a simple and compact arrangement, and allows of prompt governing. The point of cut-off, release, and compression, are all equally affected in both cylinders at the same moment. The makers state that at trials made with engines fitted with this type of valve, and an automatic expansion governor, the speed of the engine, on the whole load being suddenly removed, increases only about 5 per cent., and immediately settles to what it was with full load, being, it is said, absolutely isochronous. For the same reasons the powers are maintained practically equal in both cylinders under varying conditions of load, and, combined with the single-valve arrangement, the governing is necessarily prompt and effective.



Belliss Self-Lubricating Central Station Engine and Dynamo.

GOVERNING ELECTRIC LIGHT ENGINES.*

At various times and from different quarters we receive letters complaining of the difficulty which the writers find in obtaining governors which will satisfy the demands of the electrician. Apparently every centrifugal governor in the market has been tried, and not one gives complete satisfaction. Are we to assume that the governor wanted cannot possibly be made, or that it is beyond the powers of inventors to produce one? We think neither solution of the difficulty is sound. The much-desired governor is not forthcoming because the electric light engineers have not explained fully what they want, and—which is perhaps more to the purpose—why they want it. Let us endeavour to make good this deficiency.

The conditions under which electric light engines run are very trying. It is essential that they should always run at precisely the same speed, no matter what the load; or else the speed must be varied with the load in some definite ratio. Then the load varies from time to time through enormous ranges, and with great rapidity. Thus, for example, we have an engine of, say, 350 H.P. It is developing 150 H.P. Suddenly, by the turn of a switch, perhaps a mile away, the load is doubled. Now, if the engine is not prepared to take this instantly, without a check, the lights already on absorb-

* From the *Engineer*.

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ing the 150 H.P. first named will blink, and possibly drop very considerably in intensity, for some seconds. This blinking the pubiic will not stand. It is a thing of all others to be avoided. Under some conditions of working, this engine, now with a load of 300 H.P. instead of 150, must make precisely the same number of revolutions as before. If it runs a little faster the first lights may have too much current; if a little slower, too little. Under other conditions of working, the engine must run faster with 300 H.P. than it did with 150, but the new speed must bear a precisely definite ratio to the old speed. Thus, then, we have two diverse sets of conditions. Under the first, the number of revolutions made per minute must remain unaltered, no matter what the load; under the second, the speed must bear an invariable ratio to the power. It will be seen that in either case the conditions are extremely trying.

When the ordinary centrifugal governor is used, no matter whether it acts on the throttle valve or on the expansion gear, a definite speed of engine accompanies each position of the governor balls. If the engine is making 100 revolutions and indicating 150 H.P., the circumference of the circle described by the centre of gravity of the balls has a given dimension. If the engine takes more steam and develops 200 or 250 H.P., then the circumference of the circle must be larger, for unless it is larger the throttle valve will not be opened further, but the balls cannot remain further apart unless the number of revolutions is augmented. Clearly, therefore, such a governor cannot comply with the condition of constant velocity of rotation of the crank shaft. Consequently, a centrifugal governor will not comply with one set of conditions. On the other hand, however, it might be made to comply with the second set of conditions, under which the speed is to vary with the power, if only a definite relation between the speed of the governor and the power could be commanded. It will not suffice to have a definite relation between the speed of the engine and the position of the governor balls. Only those who have tried to get a throttle valve or a Corliss governor to bear a definite relation in position to the power and the speed of the engine, can realise the difficulty of the problem to be solved. In practice a great deal has after all to be left to the engine driver, and he has to do the work that a properly-made governor would perform. All this, it will be seen, applies to the action of the governor in keeping the engine to the normal rate and correcting the small changes in speed due to a thousand and one trifling irregularities of load, friction, steam pressure, &c. The great initial difficulty remains untouched; namely, the power of the governor to deal with lightning speed with large alterations in load. What appears to be needed is a governor which the moment the speed drops or rises—say 1 per cent.—will open the throttle valve full or shut it absolutely, and will then by a series of very rapid alterations or oscillations open and close it through smaller and smaller arcs until the new position suited to the load has been attained. Something quite analogous to this is found in the gas engine, and it is by no means certain that the same principle might not be applied with advantage to the steam engine. Messrs. Brown Brothers make an anti-racing gear for marine engines. Mr. Weir has, we fancy, something of the same kind. The moment the engine tends to race, the inertia of a small moving weight opens a trigger, and the throttle valve closes. We have here the fundamental idea of a governor for electric light engines. The isochronal governor complies well enough with the conditions up to a certain point. The balls will remain in any position independent of the speed; it is only a change in speed that will cause them to move in or out, to or from the central spindle; but the isochronal governor is altogether too delicate a plant for the engine-house of an electric light station, and, besides, it is prone to "hunt" to a most distressing degree. On the whole, it appears to us that a modification of Pitcher's governor would best satisfy the conditions. This governor was at one time largely used by Fairbairn for regulating cotton-mill engines. The principle involved is very simple. A piston driven by the engine works up and down in a cylinder, and pumps air under another piston in a second cylinder. The air escapes through a snifting cock. The piston rod of the second piston is jointed to the throttle valve. If the engine runs too fast the air cannot get away in sufficient quantity through the snifting cock; the second piston rises and shuts off steam. In the same way, if the engine runs too slowly, the second piston sinks and opens the throttle valve. By substituting water for air the whole apparatus can be reduced in dimensions, and a very obvious modification will put the governor into such a condition that the opening of the throttle valve may be anything for any speed, its position not depending on the speed, as is the case with the centrifugal governor, but on change of speed.

Whether the governor acts on a throttle valve or on the expansion gear seems to be a matter of no consequence, as far as governing is concerned. We have seen an expansion gear governor taken off and replaced by a throttle-valve governor with excellent results, and no appreciable difference in steam consumption. Throttle-valve governors generally fail because the valve is not properly constructed. There is no sort of relation between the area opened and closed and the position of the governor. The result is, of course, disappointing. The best arrangement, it appears to us, would consist in passing the steam through a circular orifice in a plate in which moves a cone. If this cone is sufficiently tapered a very long range of motion will be required to make any material alteration in the area opened for the steam to pass through. But if, instead of making the sides of the cone straight, we curve them, then it is obvious that we can establish what relations we please between the position of the governor and the area for steam admission.

It is quite beyond our purpose to go into matters of detail, our principal object has been to direct attention to a much-felt want. Some electric light engineers are, no doubt, satisfied; but we often find that the satisfaction is based on ignorance. They do not know what a first-rate governor could do for them. Engine builders, again, often say that if the engine does not govern properly, the conditions under which current is generated are at fault and should be changed. The electrician's answer is simply, in some cases, that he cannot change them, and in others that he will not. We have ourselves no doubt that any competent inventor who would take the trouble to master the whole question could produce what is desirable. But the thing will never be done if a cotton mill engine is taken as a standard. The conditions to be satisfied are in essential particulars totally dissimilar. In what respects, the would-be inventor will do well to find out before he does any scheming.

SIR: Your article upon this subject is valuable and interesting, but it may be doubted whether the subject is so much in need of the "competent inventor" as is assumed. It is right to say that "the thing will never be done if a cotton mill engine is taken as a standard" but there are high-speed engine makers who have given as much attention to the subject of governing as cotton mill engineers, and, as they believe, with as much success: it is only necessary to refer to the late Mr. Willans. You, apparently, intending to take a typical electric light engine, select one running at 100 revolutions per minute. Your argument is, of course, unaffected by the number of revolutions, but does not the selection suggest a turning of the eyes towards the cotton mill engine after all, in forgetfulness of the fact—about which, I believe, there can be no doubt—that of all the public electric lighting work in Great Britain, very much more than half is performed by high-speed engines running at from 350 to 400 revolutions per minute, and standing on a much better footing as regards governing than an engine designed to run at 100 revolutions only? Surely it would not be unreasonable to take an engine of the high-speed class as the typical electric light engine. The first point I would refer to in your article is the very useful demonstration of the inevitableness of some change of speed with a change of load, owing to the different position necessarily assumed by the governor balls. It were well if this fact were generally understood; there would be less asking for impossibilities. It is, however, easy to give an accuracy of governing quite sufficient for the purposes of an electric lighting station; a total variation of 2 per cent. between full load and a very light load—which means a variation of speed of less than 1 per cent. through any variation of load likely to occur in practice—is easy of attainment. The change from 150 H.P. to 300 H.P., which you consider, need not involve a greater change of speed than this, and certainly, if in any station the engines are run with a much greater variation of load than from full load to half load, there must be something so radically wrong, either in the design or in the management of the station, that all governing questions sink into insignificance beside it. The Continental blunder of using a very few large units of power, instead of a greater number of small units, is happily understood, and is generally avoided in this country.

Having in view important stations where direct-coupled alternators of large power are driven at high speeds by Willans engines, and where the working is reported to be absolutely satisfactory, one is tempted to wonder what class of plant it is which gives rise to the complaints of the electrical engineers which you refer to. If closer governing than is above described is required by any electrical engineer—though it is hard to understand why—the means for attaining it are quite well understood. It is only necessary to fit a Knowles supplementary governor to bring the main governor balls away back to the original position. There are places where this is worth doing, but surely electric light stations are not amongst them.

Of equal interest are your remarks upon sudden changes of load, and the avoidance of "blinking" in connection with them. You advise a governor which on a small change of speed shall absolutely close the stop valve or open it wide. Now this is what any really well-designed governor, such as that originally schemed by Mr. Willans, does; except that, for the avoidance of hunting, it never absolutely closes, but always leaves an opening sufficient for the passage of steam enough to run the engine light. The throttle valve is of such proportions that a very small travel covers its whole range from closed to open, and is produced by a correspondingly small movement of the governor balls. Your picture of the desired effect—"a series of very rapid alterations or oscillations"—suggests rather what one tries to avoid, though it is very likely to ensue if the change from full open to closed, or nearly closed, is produced by too small a movement of the governor balls. In other words, if the apparatus is too sensitive it will also be too delicate; it will move too easily, and the governor will hunt upon small provocation. To avoid this we must govern a little more coarsely, and substitute, say, 2 per cent. for 1 per cent. Nevertheless, it is comparatively easy to work to the 1 per cent. standard so long as disturbing causes, like varia-

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tion of boiler pressure, grit in the valve, &c., are absent. But what should be pointed out is that when we have thus been given exactly what in your article is asked for we shall be no nearer to the desideratum—viz., the power to instantly increase the load from 150 H.P. to 300 H.P. without causing the lights to blink, and possibly to drop in intensity. No quickening of the governor action will help, for it already acts so quickly that in a slow-running engine the throttle valve may be shifted long before the next cylinder admission comes round.

The truth is that the interesting point you have raised is not a governor question at all; it relates solely and only to the flywheel. With such an increase of load as you suppose no augmentation of the next supply of steam to the first cylinder, in a compound or triple engine, can produce power enough at once to prevent a check to speed. That can only be avoided by storage of power. For the moment the full power cannot be obtained from the engine; it must be obtained from a heavy flywheel, and there is no other way of preventing the drop in intensity of the lights. Needless to say, the whole matter is merely one of calculation when the data are given. The smaller the permissible drop in speed, for a given change of load, effected with a given quickness, the heavier the fly-wheel must be. As a fact, there never ought to be a serious "blink" in the lights, because there never ought to be a change both great enough and sudden enough to cause one. An instantaneous addition of 150 H.P. power to the load is scarcely conceivable in any lighting station, or if conceivable, it implies a plant of great size, giving an output compared with which 150 H.P. is small. Let it be borne in mind that the supposed difficulty hangs upon the word "instantaneous"; if the change is spread over a few seconds even, the difficulty vanishes. An hotel or other large building may be brought on very rapidly, but scarcely instantaneously.

Engineers should recognise that in a great number of cases where they speak of good or bad governing, they really mean sufficient or insufficient flywheel power for the particular work in view, and nothing else.

Thames Ditton, October 2nd. MARK ROBINSON.

NOTES ON ELECTRIC TRAMWAYS IN THE UNITED STATES AND CANADA.*

BY H. D. WILKINSON.

During the period of the Chicago Exposition last year I had opportunities of looking into systems of street traction in that city, and of discussing points of immediate interest with engineers from different cities whom it was my privilege to meet.

For several weeks previous to the opening of the Exposition the scene for miles round was one of the greatest activity in the construction of street tramways, centring from all districts on the south side, and forming connections from the city main cable car line. The continuation of the elevated steam road to the Exposition along Sixty-fourth-street was also a smart piece of work, including the erection of six stations and a pin-connected truss bridge across the Illinois Central Railroad track without obstructing traffic. Immediately this line was finished, trolley wires were strung underneath the girders, and the previous horse car lines, which had grown totally inadequate to the traffic, were converted into electric lines. The motor cars were rarely without trailers, and in the busiest times of the day two, and sometimes three, fully loaded passenger cars were hauled. The term "fully loaded," when applied to cars in America, must be understood in its most literal sense. Besides all standing and sitting room being taken up inside, the drivers' and conductors' platforms are closely packed, and people cling to the outsides wherever there is the smallest foothold. More than this, I have seen cars on busy days with people sitting on the window ledges and climbing on the roof, and the back end of the car framework weighted out of shape and scraping the ground. After seeing one motor car hauling two or three trailers, with 250 people, at the rate of 10 miles an hour, on roads with no drainage and covered with mud, I was convinced that the practice of putting two 25 or 30-horse motors on one car—which would otherwise seem a waste of material and power—was not unreasonable. The full power is, of course, not always wanted, and can be regulated by the controller to suit the traffic; but it is most important to have motors that will stand extra heavy work when required, and need no attention. During the year the number of passengers on all lines in Chicago was about 288 millions, or an increase of 55 millions over the previous year.

The general type of construction in wide thoroughfares is with poles planted in the centre of the road between the double track, carrying iron brackets for the support of trolley and feeder wires, and the general appearance is far from unsightly. This is specially the case when every other post supports an arc lamp or cluster of incandescents and the brackets are ornamental. Span wires are only necessary at curves and in narrow thoroughfares. The entire track construction, including rails and wires, costs about £1,400 per mile, and the car bodies, with motor trucks complete, cost about £800 per car. For a line, say, of 5 miles of track, with 15 cars, the power station, including building and machinery, would cost about £5,000, and real estate and car barns about £3,000—bringing the total cost of equipment to £27,000. The revenue per car mile was from 20 to 30 cents, and the total running expenses 14 to 16 cents, or, on the average, about 60 per cent. of revenue.

The very energetic body of the American Street Railway Association is thoroughly representative, and its members, who are all engaged in tramway work, think nothing of travelling 1,000 miles to be present at their annual conventions. At these gatherings, which occupy three or four days, original papers and reports of investigations consigned to committees at the previous meeting are read and discussed. An exhibition of manufacturers' supplies is also held at the same time, and new electric cars of all kinds are put on the town lines and run on regular service. Members practically own the town during their stay; the largest hotels are full, rooms being taken by representatives of different concerns as temporary offices. The various companies and firms in the town send in invitations to visit power houses and works, books of tram tickets are distributed gratis, and the telephone companies place their lines at the disposal of members. Time will not allow me to do more than refer to the very pleasant participation I enjoyed in the last convention at Milwaukee, Wisconsin. The Papers read have appeared in our own technical Press, and are consequently well known. The supplies comprised car bodies, trucks, motors, controllers, fuses and heaters, track scrapers and sprinklers, steel rails, points and crossings, compressed mica, and overhead line gear of all descriptions, everything that could be put in motion being supplied with electric current. Each member received a small choice souvenir of his visit, the gift of the newly elected president, Mr. Henry Paine.

I now pass on to some of the questions which are absorbing attention, and to describe what I saw of the working of different systems.

The directions in which improvements are sought comprise chiefly—

1. Better construction of road beds and tracks;
2. Better provision for the return circuit;
3. More uniform distribution of potential along the route.

Further, in the power house, the chief questions are in the driving, governing, and safety devices, the best proportion of power between engine and generator, and the problem of fly-wheel inertia.

Beyond these there are the questions of practical and economic systems of delivering energy to cars in cities and crowded portions of towns, such as by the storage battery or underground conduit; and for long-distance transit the use of synchronous or of two or three-phase motors with transmission of current by underground feeders at high-tension.

Some of these questions have given rise to much discussion in America, and most of them have more or less a bearing upon the development of electric traction in our own country. It appeared to me, therefore, that I could in some measure further the progress of the industry in this country by making such observations and inquiries on the present working of tramways in the States and Canada as affected the immediate future; and I looked forward, on my return to the duty as well as the pleasure of bringing the results of these investigations before the members of this Institution.

During the summer of last year I visited the cities of Detroit and Milwaukee, and in November—on the completion of my official duties at the Exposition—the cities of Toronto, Montreal, Buffalo, Cleveland, Cincinnati, Pittsburg, Washington, and Philadelphia; making also a complete examination of the electric railroad recently erected on the Canadian side of the Falls. From the officials of the various companies whose lines and plant I investigated I met with the greatest courtesy and cordiality, and the expressed wish, not only on the occasion of my visit, but at any future time, to furnish such information as might be desired.

With regard to road bed and track construction there is not much to be said, as the general conditions in America differ considerably from those in our own country. In many cities, and especially in the suburbs of large western cities, the rails are allowed to project above the road bed 1in. or 2in., making very rough travel for other vehicles. In fact, the iron road is counted of the first importance in inducing people to live further out of town and build on the prairie, while the road for the use of ordinary vehicles is of only secondary consideration. After a few years, as property goes up in the district, a better foundation is put in, and the roads are levelled up to the metals by paving blocks or glazed bricks. Whole suburbs spring into existence in the wake of the electric tramway. Enterprise in promoting schemes is chiefly due to estate holders seeking to raise the value of their property, and it is remarkable that municipal corporations have given away important concessions for very trifling sums. These concessions after a few years generally become very valuable, and bring a good return to those who have sunk capital and taken risk; but it is now becoming

* This Paper will be discussed early in the course of the next session of the Institution of Electrical Engineers.

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more usual for corporations to look ahead and put in clauses that shall let some percentage of the profits come in for the improvement of the streets.

Practice in the western cities of America is chiefly with T, flat, or step rails, spiked down to wooden cross-ties or sleepers; but on the best lines and in most eastern cities the channelled girder rail as used in England has been adopted on account of smoother travel, less noise, and a flush road surface. The English construction of concrete foundation has been followed on some lines, using a 9in. or 10in. girder rail. The tendency now in the States is to put in very heavy girder rails (90lb. or 100lb.), spiked to wooden sleepers placed at about 2ft. centres, which allows a good deal of spring in the track, and tends to loosen the bond contacts. Some 72lb. channel girder rails I saw in progress of laying had grooves 1⅛in. wide by 1in. deep. The height and base both measured 6in. There was first an 8in. foundation of concrete, upon which the sleepers (6in. by 8in.) were laid at 2ft. 3in. centres and then grouted in. Sand was then tamped round the base of the rails to the depth of 2in., upon which the paving blocks were laid. The points and special work were of cast steel.

The question of returning the current direct to the power house with as little leakage and loss in voltage as possible, is one of the most important in street railway problems. Excluding for the moment insulated returns, the paths open for the return current from the cars to the power house are—

1. By the rails and return feeders;
2. By supplemetary wires;
3. By the earth;
4. By metallic pipes and cables laid in the earth.

The return feeders include not only those cables connecting the nearest point on the rails to the generators in the power house, but cables brought in from more distant points of the line, as the configuration of the same and the load may require. In this matter everything depends on the position of the power house with regard to the route of the line. The primary object in their use is to lessen the voltage losses at the distant portions of the line; but in some districts their use has been largely extended, in order to prevent electrolytic effects on gas and water pipes. The remedy for the latter is clearly to provide a metallic return of ample conductivity, and while on modern lines improved bonding has done much to effect this, the addition of return feeders has had the desired effect in older and badly bonded lines. In Cleveland, Ohio, for instance, I found a very extended use of return feeders, and I was informed by Mr. Charles W. Wason, Vice-President and electrical engineer of the East Cleveland Railway Company, that he had resorted to their use entirely on account of electrolytic troubles with the water pipes of the city, with the result that the action ceased, and, in addition, about 25 per cent. of the voltage was saved. Some idea of the advantage of a saving in volts, apart from the consideration of speed of cars, can be gained from the fact that the current reached 3,000 amperes, and that for, say, 50 volts lost on the line every 1,000 amperes means a continuous loss of 70 H.P. The return feeders in this city are carried overhead, and are connected by riveted joints to the rails at about every 500ft. In Buffalo, also, I observed an extensive use of return feeders, carried undergound with the outgoing feeders within the city limits, but overhead further out.

Coming now to bonding, I have seen many different specimens of this work, and have some samples here to-night for the members' examination. One form of bond joint (Fig. 1) consists of a steel nipple bored to fit the bond wire, and tapered and slotted at one end. This screws into the rail, and the nut screwed up tightens the wire in the nipple, and the nipple in the rail. This was introduced by Messrs. Stern and Silverman, of Philadelphia, and is used on the lines of the Electric Traction Company of that city, the bond wires being passed two or three times through the rail outside the fish-plates to obtain the necessary conductivity.

There are still many very imperfect bonds in use, such, for instance, as that with copper or iron rivets, and soldered bond wire (Fig. 2), of which I have a specimen here. In heading the rivet the soldered joint is frequently loosened, and the bond rendered useless. The channel pin bond (Fig. 3), of which I have a specimen here, is in very extensive use; but a great defect in this device is that it cannot be riveted or made to completely fill the hole, and corrosion takes place in the interstice. The channel pin is used for the double bonds on the Lynn and Boston line, as shown in the illustration (Fig. 4). Another bond is the taper spring steel cap (Fig. 5), which is fitted on the end of the wire and driven into a hole in the web of the rail slightly less than its own external diameter. A similar bush joint, but formed as a sleeve or socket, has been in use some time on double bonds, as in illustration, and promises well (Fig. 6). A considerable improvement consists in making the bond wire in one piece, with shoulders for riveting formed at each end on the wire itself. This device (shown in Fig. 7) is due to Mr. McTighe, of New York, and has been very largely used. The advantages of this plan are that clean, water-tight, and air-tight solid metallic joints are obtained, and that the bonds can be made of any size wire. Mr. McTighe prefers to use these in short lengths of 12in. inside the fish-plates instead of the usual length of 30in., thus saving 40 to 50 per cent. in bond resistance. The short bond cannot be fixed to the web of the rail on account of the fish-plates, but is either attached to the tread or the base, the latter being the better point of attachment, as the bonds are soon worn away when on the tread. This bond, however, sooner or later becomes loose, owing to the difference in the coefficient of expansion of copper and steel, and, this being followed by galvanic action, the resistance, which at first is slight, rapidly increases at the joint. Some provision by which solder could be run in might add to the certainty of this joint, the ductility of the solder taking up the unequal expansion and contraction.

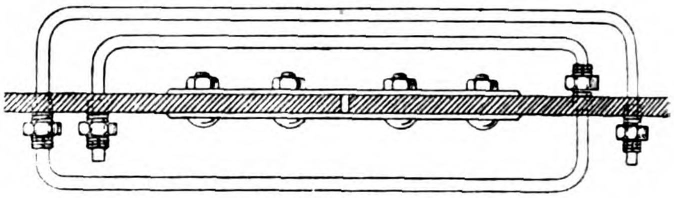

Fig. 1.—Bonding Nipple.

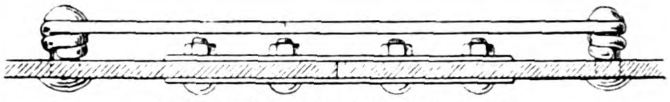

Fig. 2.—Rivet and Soldered Bond Wire.

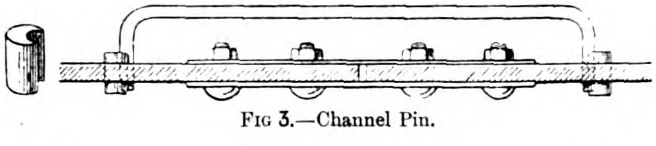

Fig 3.—Channel Pin.

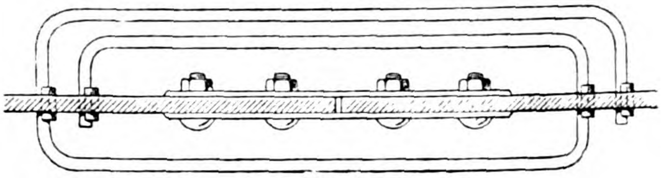

Fig. 4.

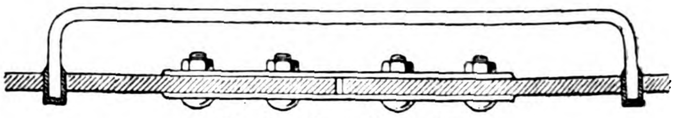

Fig. 5.—Taper Spring Cap.

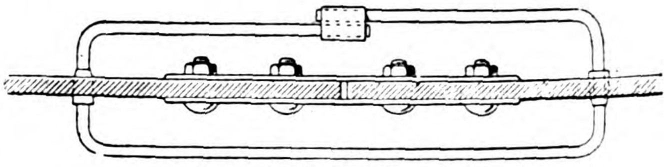

Fig. 6.—Split Steel Sleeve Bond.

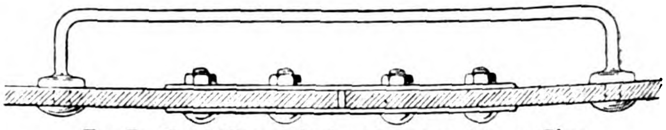

Fig. 7.—Bond Wire with Shoulder Riveted in one Piece.

Some of the older lines in the States, laid before the value of good bonding was appreciated, show an enormous loss of voltage from this cause. I was informed that on an old line in Richmond, Virginia, the bonding was done by No. 6 iron wires, and the same bonds used for a recent extension of 2½ miles, with the result that of 500 volts put into the line not more than 210 appeared at the distant end. The matter was investigated in consequence of bad working, and good copper bonds substituted for the iron wire, with the result that the loss was reduced to 5 per cent.

Bond wires are subject to corrosion by electrolytic action, especially in alkali soils. The wires, consequently, become thinner and conduct badly, and some of the current is shunted round the joint to earth, thus increasing the corrosion. Again, when the wires get very thin they become heated and fuse, thus throwing extra load on other feeders. I was informed that the action was

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prevented by painting the wires, or coating them with shellac and asphaltum. The section or number of bond wires has, of course, to be increased nearer the power station.

The conductivity of the return circuit has been increased on some lines by the use of a supplementary wire, which is usually of bare copper ⅜in. or ½in. diameter, laid along the centre of the track. Cross connections from all bond joints are made by copper wire twisted and soldered to the supplementary wire, and on double tracks the supplementary wires of each track are connected every 30 yards. I saw new lines being laid with these wires in Chicago and Detroit, but I have also seen lines freshly opened up where the supplementary wires were considerably corroded, and was informed that their life was about two years. There were so many joints in the system, the wires used were so small, and were of such poor conductivity in comparison with a well-bonded rail, that the expedient appeared to me to be temporary and unreliable. In fact, I gathered that one of the chief uses of the wire was that its presence allayed to some extent the anxiety of the city authorities, otherwise harassed by water and gas pipe corrosion.

I next come to the earth as a return. I found that earth connections were made on most lines at their lowest points and at the power house. Such connections were made by sinking old car wheels or driving rails or pipes in moist earth, and making as good a connection therefrom to the rails as possible; but, from all I could learn, not much reliance was placed on such returns. The extremes of weather no doubt have something to do with it, as hard dry earth is a bad conductor. Even wet mud, in comparison to the rails, is a poor conductor, as is evidenced by the brilliant arcing at the wheels of cars running on a muddy rail. In the *Street Railway Journal* for last December, some tests by Mr. James D. Rostron, chief engineer of the Union Railway Company of Chester, Pa., bearing upon the conductivity of the earth as a return, were published. Mr. Rostron obtained an average of 285·5 amperes through the track and supplementary wires, 12·8 amperes through the city water mains, and only 0·51 through the earth plates sunk in creeks. If this is confirmed by further tests, it shows that the conductivity of the earth as a return is not high, but depends upon

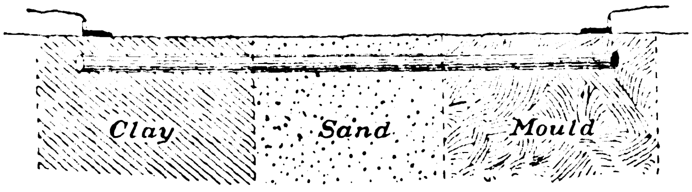

FIG. 8.

the presence of metallic conducting matter within it. While in Chicago, I made some tests to ascertain the approximate conductivity of the earth, and the difference of potential required to force current through pipes not metallically connected to a circuit. I laid some lead and iron pipes in earth, and at 1½in. distance above them I placed two iron plates as electrodes, 6ft. apart. Each plate offered 20 square inches of surface, and the current passed partly through the 6ft. of earth from plate to plate through clay, sand, and mould, and partly through 1½in. of earth at either end (clay and mould), and along the pipes (Fig. 8). I expected the resistance of the latter part would be almost nil, and, as I had 120 volts at disposal, I first put a resistance in series of four 105-volt lamps in parallel. I found, however, that the earth resistance was far more than I anticipated, and I removed three lamps with very slight increase of volts on the remaining one. The current was then half an ampere, and the earth absorbed 20 volts. A few days after, I obtained current from a 200-volt circuit, and put the four lamps on again. I then had 2½ amperes, with 100 volts absorbed by the earth. After keeping the current on for two weeks, the pipes were taken out, and were found to have a pitting of white scale in places at the negative ends. The scale was in white lumps, which, upon being scraped off, revealed the starting of little holes about 3-32nds of an inch diameter. This proved that some of the current, if not almost all, had passed by the pipes through the 3in. of clay and mould. While I attribute this high earth resistance to the clay, which had set hard, I am still of opinion that the earth has more resistance than is generally imagined, and that to attract current in anything but very minute amounts from a well-bonded rail to earth requires special conditions, such as deeply sunk plates, metallic connection to pipes, the ground saturated with moisture, or an excessive density of current in the bonds. I was informed by Mr. C. H. Morse, the city electrical engineer of Cambridge, Mass., that in some tests he made at Saginaw, Mich., for the gas company there, he was surprised to find that pipes were eaten away in two or three months under a return current which did not exceed 500 amperes. The soil was, however, very moist clay, and the rails were connected to earth plates.

(*To be continued.*)

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *September* 28, 1894.

Fundamental Street Railway Patents.—The Courts have just disposed of the claims of Stephen Field and Dr. Wellington Adams as inventors of street railway traction. In the former case the claim was made for a combination of a dynamo, a circuit of conductors, a wheeled vehicle, an electric motor to propel the vehicle, and a circuit-controlling device on the vehicle. The Court decided that the improvements covered by the patent were only such as the public might have obtained by presenting its wants to a skilled mechanic. In the Adams case the application of an electric motor to an axle was broadly claimed, but the Court decided that none of the elements were new; the motor and its several parts, the car axle, the axle boxes, the field-supporting frame, and all other things mentioned in the claims were in use before the time of the patent. In the decision in the Field case the Court, by implication defines invention as follows: "But if the result of the skill of the artisan still shows the barrier of impracticability between the end sought and the result attained, an interval between theory and practice, a limitation upon further development; while the alleged inventor, by the exercise of a discriminating faculty, distinguishes difficulties and estimates their proportions, and breaks down the barrier, or bridges the interval, or stretches beyond the limitation, by an instrumentality which, in the very facts of its construction and operation, by the adaptation of its mechanism to the end sought, suggests design; then he has contributed something of creative thought, he has invented this new instrumentality, his contract is valid, and his monopoly should be sustained." The above patents, particularly that of Field, were but a few years ago considered of value. Since then, however, the courts have taken a more just view of what constitutes invention, with the consequence that the professional inventor finds himself becoming more and more restricted in the exercise of his vocation. By professional inventor is meant one of the class which came so strongly to the front during the palmy days of electrical development, and whose skill lay in drawing up and passing through the Patent Office claims on obvious applications.

CORRESPONDENCE.

WATER-POWER IN GREAT BRITAIN.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As a constant reader of your valued journal, and one who has been for many years interested in hydraulics, I read with great interest your article on "Water-Power in Great Britain" in your last issue, and I send you a reprint of a few notes I made on the same subject to the Royal Scottish Society of Arts. From your description of the water-power at Powick, it certainly does not seem to be so favourably situated for the continuous production of power as one might expect; but this is, as you say, not from want of water, but from excess during floods. Now the whole question is, why the floods? As a resident on the banks of the Severn for a number of years, I am well acquainted with these periodic ebbs and flows.

It is simply a question of storage. The damage done every winter by one of these floods would go a long way towards the cost of reservoirs, that would make excessive flooding a thing of the past. I would that everyone that is interested in water power could know what has been done at the Shaw's Water Works, Greenock, and the great source of revenue that has resulted from a judicious water storage. The rain fall is greatest in the hill districts, where the facilities for constructing reservoirs are greatest, and the whole question of conserving our water is fast becoming a national one. We have done less as a nation than any other, I believe, to make use of the forces of nature, and I hope that the engineers of the Worcester lighting scheme, who have been bold enough to make such an advance in the utilisation of water power may be rewarded with success.

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As a case of what may be done in an entirely different direction, I have recently erected a turbine not 30 miles from Edinburgh, with a fall of 800ft. A reservoir was formed on the hill side, the average flow of water being about 50 cubic feet per minute. This water is brought 1¼ miles in a 6in. pipe for distillery purposes, and, by simply connecting a special high pressure turbine to the end of the pipe, 30 to 40 H.P. is obtained nearly all the year round, and the water after delivering up its power is allowed to flow into tanks for use in the works. The power alone at the low value of £8 per horse power per annum, is worth over £300 per year, and nearly double this if the power could be used night and day.

This is a solitary instance of what could be done in hundreds of cases did proprietors realise the value of water for power.—Yours, &c., JOHN RITCHIE.

Waverley Engineering Works, Edinburgh, near Abbeyhill Station, Oct. 9, 1894.

LEGAL INTELLIGENCE.

Braulik v. Sharp and Kent.

The proceedings in this matter were fully reported in *The Electrician* of September 7th. The plaintiff, Mr. G. Braulik, of Upper Thames-street, London, claimed in the City of London Court the sum of £2. 2s. 6d. for goods supplied to the defendants, Messrs. Sharp and Kent, of Connaught-mansions, Victoria-street, Westminster. The defendants' answer to the claim was that the goods were bought "on appro.," and this was admitted by plaintiff's traveller, but his evidence was to the effect that it was explained at the time the goods were left that if the defendants wanted to return the goods this must be done in a fortnight or three weeks. The defendants had, however, kept the goods for twelve months, and plaintiff held that this was quite contrary to the undertaking given to his representative at the time the goods were left with the defendants. A witness for the defence said that when goods were bought "on appro." in the electrical trade, they frequently remained with the intending customer for a period of six months. After hearing further evidence, the jury characterised the contention of the defendants as absurd, and not in accordance with the practice of the electrical trade. A verdict was, therefore, given in favour of the plaintiff for the full amount claimed, with costs.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

NEW BOOKS AND EDITIONS.

The 1894 Edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK contains 1,000 closely-printed pages, and several new and useful features have been added. The price of the Directory and Handbook, from October 1st, is 5s. post free; abroad 5s. 6d. *The 1895 edition is in active preparation.*

"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell, with this title, will be ready in October. It will contain the latest information respecting the application of electric energy to mining purposes, in which the author has had much experience. The book is well printed, on good paper, and will contain nearly 250 illustrations, a large proportion of which have been specially made for the book. The price is 10s. 6d., post free 11s. (abroad 11s. 6d.). Orders can now be sent in.

"THE WORK OF HERTZ."—The lecture delivered by Dr. O. J. Lodge at the Royal Institution on June 1st is reprinted with corrections and additions, and many original illustrations, price 2s. 6d. net.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., will be ready next week, handsomely bound, full of original illustrations, designs, initials, &c. Price 7s. 6d.

TENDERS INVITED.—The Postmaster-General invites tenders for the supply of red fir telegraph poles, and for creosoting the same. Further particulars are to be found in our advertisement columns; and forms of tender, containing all particulars, can be had on application to Mr. Charles E. Stuart, Controller of Stores, Telegraph-street, London, E.C. Tenders have to be in by noon on Wednesday, the 31st inst.

——— Mr. John Annan, manager for the liquidator in J. W. Hobbs and Co. (Limited), invites tenders for the supply and erection of boiler house plant, engine house plant, switchboard, instruments, &c., for the electric light and power installation at the large block of hotel buildings now erecting on the Salisbury Estate, Victoria Embankment, and Strand, London, W.C. Plans and specification, &c., can be obtained of Mr. R. Hammond, consulting engineer, Ormonde House, Great Trinity-lane, E.C., on and after October 5th; and tenders must be sent in before Friday, October 26th.

TENDERS ACCEPTED.—Messrs. Crompton and Co. (Limited) have secured the order for the whole of the arc lamps for the Edinburgh street lighting.

——— The Halls Committee of the Southport Town Council have accepted tenders for the electric lighting of the Cambridge Hall and the Town Hall at a cost of £862.

——— The Southport Town Council have accepted the tender of the Fowler-Waring Cables Company (Limited) for the supply of 1,200 yards of high-tension cable for laying down in the Scarisbrick New-road, at £57 per mile.

——— The Bedford Town Council have given the contract for fitting up the Town Hall for the electric light to Mr. H. Bacchus, for the sum of £126. 18s., and that for similarly fitting up the Corn Exchange to Messrs. Kilpin and Billson, for the sum of £166. The Electric Light Committee made no recommendation to the Council on the tenders received, as they thought it better first to have plans prepared by Mr. F. H. Medhurst, and a resolution was proposed to that effect by the Chairman of the Committee, but was afterwards withdrawn in favour of an amendment that the work be divided as above mentioned.

——— The Free Libraries and Museum Committee of the Sheffield Town Council have accepted the tender of the Sheffield Electric Light and Power Company (Limited) to supply the cable, and to fix all necessary cable, wire, switches, distributing boards, &c. (not including fittings), for the electric lighting of the Weston Park Museum, for the sum of £174.

——— The Worcester Town Council have accepted the tender of Messrs. Paterson and Cooper for wiring and fitting up the waterworks for the electric light for £100.

TENDERS RECEIVED.—At a recent meeting of the Electric Lighting Committee of the Bury County Council, the Borough Engineer reported upon the tenders for the electric lighting plant and machinery, and it was resolved to give an opportunity to the whole of the persons originally tendering to submit fresh tenders for the continuous-current plant already adopted, and to extend the time for tendering to the October 15th.

SALE BY AUCTION.—Readers are reminded that the sale of modern fixed plant and machinery at York-street Works, Lambeth, S.E. (owing to the removal of Messrs. W. H. Allen and Co. to their new works at Bedford), takes place on Wednesday next at 11 o'clock prompt. The sale will be conducted by Messrs. Wheatley Kirk, Price and Goulty. Further particulars will be found in our advertisement columns.

——— Mr. Geo. N. Dixon has received instructions to sell by auction, on Friday next, the 19th inst., at the Angel Hotel, Dolgelly, Merionethshire, the whole of the electric lighting plant used for the lighting of the town of Dolgelly, particulars of which are given in our advertisement columns. Further particulars can be had of Messrs. Harmood, Banner and Son, 24, North John-street, Liverpool, or of the auctioneer, 66, Hanover-street, Liverpool.

PLANT FOR SALE.—Messrs. Morgan Williams and King, of 39, Victoria-street, S.W., have for disposal electric lighting plant, of which further particulars are given in our advertisement columns.

APPARATUS FOR SALE.—An advertiser desires to dispose of some nearly new electrical instruments, particulars of which are set out in our advertisement columns. The instruments are all in the best condition.

APPOINTMENT.—We are pleased to learn that the Electric Light Committee recommend the City Council of Coventry to appoint Mr. G. S. Ram clerk of works to superintend the engineering portion of the contract for the equipment of the electric lighting station. Mr. Ram is well known as the author of "The Incandescent Lamp and its Manufacture."

APPOINTMENT VACANT.—The Electric Committee of the Belfast Corporation are prepared to receive applications for the post of assistant electrical engineer, at a salary of £120 per annum. Some further particulars are given in our advertisement columns, and applications must be sent in to Sir Samuel Black, town clerk, Belfast, not later than Tuesday, the 23rd inst.

REMOVAL OF WORKS.—Messrs. W. H. Allen and Co., of York-street Works, Lambeth, S.E., announce that they have removed their works to Queen's Engineering Works, Bedford.

REMOVAL.—Mr. Edward Robins, Assoc.M.Inst.C.E., F.S.I., late of Robins, Snell and Gore, has removed to 8, Craig's-court, Charing Cross, London, S.W.

AGENCY.—Mr. Geo. Schultz writes to us that he has terminated his connection with Messrs. Fossick and Co. (Limited), and has started in business as an iron and steel merchant and manufacturers' agent, under the style of George Schultz and Co., at 90, Cannon-street, E.C., where he will conduct the agencies of Messrs. Edgar Allen and Co. (Limited), John Bilsland and Co., W. Smith and Sons, &c., and will continue the business in electrical engineering material.

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BANKRUPTCY.—A receiving order has been issued in the affairs of John Henry Brown, electric cabinet case maker, 16, South-street, and 16, Archer-street, Halifax. The first meeting of creditors is to be held at the Official Receiver's Offices, Townhall-chambers, Halifax, on Oct. 19th, at 11:30 a.m., and the public examination on Nov. 12th, at 11 a.m., at the County Court, Prescott-street, Halifax.

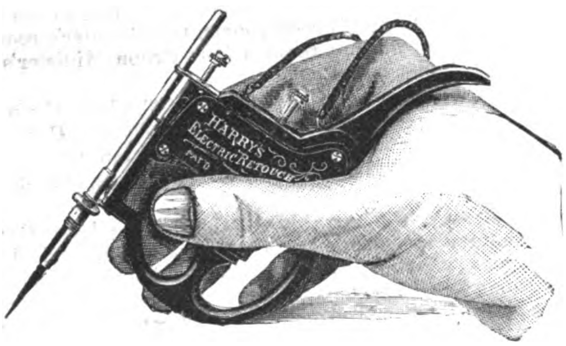
——— Mr. Arthur Shippey was publicly examined before Mr. Registrar Hope, at the Bankruptcy-buildings, London, last week. An account of the debtor's liabilities appeared in a previous issue of *The Electrician*. The examination was ordered to be concluded.

LIQUIDATIONS.—At a meeting of the shareholders of the Practical Electro-Plating and Enamelling Company (Limited), on September 22nd, at Coventry, it was resolved to wind up the Company voluntarily, and Mr. J. O. Asquith, 26, Trinity-churchyard, Coventry, was appointed liquidator.

EXHIBITION AWARDS.—The Elektrizitäts - Aktiengesellschaft vormals Schuckert & Co., of Nuremburg, have been awarded gold medals for their electrical exhibits at the Antwerp and Lyons Exhibitions.

TURBINES AND OTHER WATER MOTORS.—Messrs. Carrick and Ritchie are issuing an illustrated pamphlet describing their new turbines and other water motors for the utilisation of water for power purposes. The quarto pamphlet of 16 pages contains illustrations of vertical and horizontal arrangements of the Waverley turbine, and a table of powers and prices for single and double-discharge machines. Descriptions and similar tables are given of Ritchie's new patent double-gate turbine, the Gerard turbines, jet water-wheels and motors, sluice valves, &c., and an illustration is shown of a Waverley horizontal turbine with dynamo combination.

A PHOTOGRAPHER'S RETOUCHING TOOL.—In retouching photographic negatives the pencil will only mark well when stippled, and many mechanical devices have been tried for giving a reciprocating motion to the pencil. Nearly all of these are too heavy to hold



freely in the hand, but the little tool shown in the accompanying illustration is a marvel of lightness. A little electromagnet vibrates a keeper in the electric bell fashion, and sets the pencil in rapid motion. The instrument may be seen at the office of the *Photogram*, Farringdon-avenue, London, E.C.

INVALID PRINTERS.—The electrical and associated industries are probably as much interested in the printing as in any trade outside their own sphere, and it may be that a paragraph in *The Electrician*, calling attention to the needs of a very deserving charity, may meet the eye of some reader disposed to help. On Saturday last the foundation stone of a convalescent home was laid at Oxted, Surrey, by the Lord Mayor of London, in the presence of a large gathering, amongst whom was a gentleman known throughout the country for his thoughtful charity—Mr. Passmore Edwards. This home, when completed, will provide accommodation for 60 sick members of the printing profession, and funds are urgently needed to complete the structure. Mr. Passmore Edwards has generously given largely towards the building, and it now only remains for those in the printing trades and sympathisers from outside to complete the good work. The offices of the Caxton Convalescent Homes are situate at 33, Chancery-lane, London, W.C., and the secretary is Mr. Irvine.

"THE ENGINEERING MAGAZINE."—The October number of this magazine, now ready, contains articles on "The Evidences of a Revival in Business;" "The Cost of Living in Great Britain and the United States;" "Industrial Development of Chile" (illustrated); "The Ideal Steam Engine Governor" (illustrated); "The Management of Men in Mills and Factories;" "Modern American Machine Tools;" "Review of American Mining Law;" "Lightning and Lightning Conductors;" "Recent Architecture in Philadelphia" (illustrated); and "Probable Evolution of the Electric Railway." The editorial departments have been added to in number, and now include "Electricity," "Architecture and Building," "Civil Engineering," "Marine Engineering," "Municipal Engineering," "Mechanical Engineering," "Industrial Sociology," "Mining and Metallurgy," and "Railroadings," each under the charge of an expert, and containing notes (many illustrated) on subjects of interest. The Index to Current Technical Literature continues to form a feature in the magazine. The book is splendidly produced, and the illustrations are better printed, if that be possible, than hitherto. The October number commences a new volume (the eighth), and this is therefore a good time to make aquaintance with America's leading illustrated industrial magazine. The annual subscription is 12s. 6d. (U.K.), and 14s. abroad; single copies being 1s., or 1s. 3d. post free.

"TECHNICAL WORLD."—Under this title Messrs. Whittaker and Co. are publishing a weekly journal devoted to the advancement of technical education and to the recording, from week to week, of matters of interest to technical instructors and governing bodies of educational establishments throughout the country. The journal at present consists of 16 large pages, and is published at the popular price of 1d. In the current issue Sir Philip Magnus contributes an article entitled "Examinations: Are they a Mere Necessary Evil?" and Prof. Mullineux Walmsley an article entitled "Technical Education for Bakers." The *Technical World* meets an undoubted want, and should have a large sale.

NON-MAGNETISABLE WATCHES.—We have received from Messrs. Samuel Smith and Son, of 9, Strand, London, W.C., their newly-issued illustrated catalogue of watches, clocks, &c. This is one of the very few firms in this country who devote a special branch of their business to the manufacture of non-magnetisable watches, especially designed for use by electricians, electrical engineers, and others engaged in the construction and erection of electrical plant and apparatus. The catalogue is beautifully printed and well bound. Instructions are given to guide the purchaser in providing himself with the best watch for his special requirements, and the book, which consists of nearly 150 large quarto pages, contains, in addition, "wrinkles," with which watch buyers would do well to acquaint themselves. Particulars are given of tests made at Kew Observatory with Messrs. Smith and Sons' non-magnetisable watches, for which the firm have received the highest possible certificates. The firm have succeeded in obtaining the formation at Kew Observatory of a special class for the testing of non-magnetisable watches, and the Kew Committee have erected very powerful dynamos for the purpose. It would appear that watches under the new test undergo a 45-days' trial. Prices are given for converting ordinary watches into non-magnetic and magnetic-current-resisting.

ELMORE'S PATENT COPPER DEPOSITING COMPANY.—This Company inform us that they are now very busy in the manufacture of Elmore copper tubes for Her Majesty's Government and the leading railway companies. The Company claim that they are now able to supply Elmore tubes of 4in. diameter and upwards at a much lower price than brazed copper tubes. Copper sheet is also now manufactured by the Elmore Company.

"SAFETY" STAMP AND POSTAGE BOOK.—Mr. A. A. Coxe, of Ordsal Electrical Works, Salford, Manchester, has just introduced a safety stamp and postage book for general office use. The book is divided into compartments for the various stamp denominations, and claims to have the advantage of reducing labour and time in checking and balancing the use of postage stamps. It is further claimed to be a simple and effective check on stamp peculation.

OIL LAMPS.—Messrs. A. C. Wells and Co., of Midland-road, St. Pancras, London, send us descriptive circulars of their patent "Industrial" oil lamp, which is recommended as a cheap portable light for workshops, offices, factories, warehouses, &c. For positions and under circumstances where oil lamps are required, there are certainly many features of this lamp which take it out of the category of dangerous oil lamps. There are no glass chimneys used, and the lamp is entirely self-contained. By a simple contrivance the oil-well and wick can be lowered for refilling and lighting, so that the lamp has not to be taken to pieces. Mica is used in place of glass, and the container holds sufficient oil to last from eight to nine hours. Ordinary petroleum or kerosine is used for these lamps. By pressing the spring at the bottom of the lamp, the reservoir drops down and rests on the cross-bar, the spring at the same time entering the central-draught tube. After cleaning and lighting, this is lifted again, and the spring returns to its original position. The price of the lamp is 25s., and it is claimed to be of about 100 c.p. Many thousands are in use.

ACTON.—At the last meeting of the Local Board the Chairman said they had many inquiries from private individuals as to whether there was any probability of the electric light being installed in Acton, and that several firms had made tentative offers for the purchase of the Board's Electric Lighting Order. It was decided to allow the competing firms a month in which to send in their final tenders.

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ALDERLEY EDGE.—The Local Board have decided to apply to the Board of Trade for a Provisional Order.

AUCKLAND (NEW ZEALAND).—The Brush Company are supplying a complete electric lighting plant for lighting the *Herald* office at Auckland, and the General Electric Company are supplying the whole of the fittings for the installation, which consists of 300 incandescents and 2 arcs. The specifications were prepared by Mr. J. Darling, of the Union Steamship Company's fleet, and the work is being carried out by Mr. A. G. Horton.

BARROW.—At the last meeting of the Town Council it was moved that the Selection Committee be instructed to take into consideration the question of electric lighting. It was urged that the Gas Committee was not the proper body to have the control of the electric light question, but that a new and representative committee should be appointed to go into the question impartially. After some discussion the motion was lost.

BASINGSTOKE.—At the monthly meeting of the Town Council on Thursday last week, Mr. Hammond's report on electric lighting was referred to the Electric Lighting Committee.

BOLTON.—Wednesday, the 24th inst., has been fixed for the formal opening of the new electricity works in Spa-road, and the turning on of the electric current from that station. Mr. Alderman J. Miles, J.P., Chairman of the Gas, Electricity, and Street Lighting Committee of the Town Council, will perform the opening ceremony.

BOMBAY.—The Crawford Markets have been fitted with an electric light installation by Messrs. John Fleming and Co. Twenty arcs and about 60 incandescents light the buildings, the current being obtained from two dynamos in the municipal workshops.

BRECHIN.—At a meeting of the Police Commission on Monday a report was submitted from the Lighting Committee in reference to the offer of Messrs. D. and R. Duke, to supply electricity to the extent of 1,000 c.p. from their dynamo for the lighting of St. Ninian's-square. The Committee had ascertained that the cost of cable, lamps, &c., would be between £40 and £45. The Committee recommended that the Scottish House-to-House Electric Supply Company having written offering, in the event of the town accepting the terms of that Company for the introduction of the electric light into the burgh, to take over the cable, lamps, &c., and to pay down full value for them, the Board should accept Messrs. Duke's offer, and vote £10 from the improvement fund towards meeting the cost. These recommendations were unanimously agreed to. The Chairman suggested that, in view of the electric light being brought in, the municipal buildings should now be wired, which could be done now for a cost of about £5, but which, if delayed, would cost a good deal more; and this suggestion was agreed to. Dean of Guild Ferguson also reported that correspondence had taken place with the Scottish House-to-House Electric Light Supply Company in regard to the proposal of that Company to apply to Parliament for a Provisional Order to supply electricity to the city. He had received a letter giving the terms at which the Company would be prepared to supply the light, and he moved that a special meeting of the Board be held on Monday to consider and dispose of the whole matter, and that meantime the Company's letter and terms be circulated amongst the members. The motion was unanimously adopted.

BUENOS AYRES.—The rumour is again afloat that a syndicate of British capitalists has been formed to start in Buenos Ayres works for the electric lighting of the city on an extensive scale.

CARDIFF.—The Town Council met on Monday, when it was stated that, although the electric light installation was on the point of completion, but very few applications had been received by the Corporation from private consumers. The Mayor complained of the delay that had been experienced in finishing the installation; the scheme had involved a great outlay, and entailed a serious loss on their capital expenditure. There was an unaccountable apathy on the part of the public in the matter. The Chairman of the Electric Lighting Committee confessed himself disappointed with the delay that had occurred, and with the small number of applications that had been received, but hoped that when the public buildings were illuminated with the new light a larger number of applications would come in.

CHURCH LIGHTING.—The electric light has been installed in the Bayswater synagogue by Messrs. Bergtheil and Young. The previously existing candelabra on the reading desk and in front of the ark are utilised as electroliers, and there is a total of 100 lamps of 16 c.p.——At Worcester, among the most recent customers for the electric light is St. George's Church, the wiring of which is being done to the specification of Mr. F. R. Davenport.——Messrs. Laurence, Scott and Co. have arranged and carried out the lighting by electricity of the "Chapel-in-the-Field" and several other churches and chapels in Norwich and district.——The parish church of Bexhill, Sussex, has now been fitted for the electric light, largely at the expense of the rector, the Rev. W. L. Grane.——A permanent installation of the electric light has been effected at St. Paul's Church, Church-street, Nottingham. Ninety 16-c.p. lamps are used, and several modifications of the usual switching arrangements have been adopted. The work has been carried out by Mr. J. Blackburn, of Nottingham, and has proved very satisfactory.——The Castle-gate Congregational Chapel, Nottingham, was reopened on Sunday after having been closed for decoration and the installation of the electric light. The work has been carried out by Messrs. Thomas Danks and Co. (Ltd.), of Nottingham, a total of 132 16-c.p. incandescents being distributed throughout the building.

COLCHESTER.—The Lighting Committee of the Town Council recently issued a circular to the inhabitants of the district proposed to be lighted in the first instance if the electric light were adopted, for the purpose of ascertaining whether the probable demand would justify the Council in laying down an electric light plant. The Committee reported at the last meeting of the Council that replies received were such as to cause them to recommend that no further steps be taken at present to carry out the provisions of their Order, and the recommendation was adopted.

DARLINGTON.—At the meeting of the Town Council last week the minutes of the Gas Committee included one referring to the Provisional Order the Council had obtained for the electric lighting of the town. Councillor Barron said they had been in communication with the Local Government Board, whom they had assured that when there was any demand for the electric light which seemed to warrant the outlay they would either supply it themselves or arrange for some company to do so under their control. He believed there was no danger of the Provisional Order being revoked.

DOUGLAS (ISLE OF MAN).—The *Isle of Man Times* calls upon the local authorities to set about introducing the electric light at once, in the best interests of the city. It appears that the electric tramway company have added an electric lighting installation to their service, and the advantages of the electric light over gas are at once apparent. The tramway company have lighted by a number of arc lamps a portion of their track at the north end of Douglas Bay, and the insufficiency of the gas lighting along the promenade is painfully apparent by comparison.

THE ELECTRIC LIGHT AT DOWNING-STREET.—The electric light was used for the first time on Wednesday evening in the Cabinet Chamber, the private secretaries' rooms, the Premier's rooms, and in the large hall and waiting rooms in the Prime Minister's official residence in Downing-street.

FAREHAM.—The sanction of the Board of Trade to the purchase of the undertaking of the Fareham Electric Lighting Company by the Local Board, has been received, on condition that the wires referred to in the 22nd section of the Order be placed underground.

FARNWORTH.—At the monthly meeting of the Local Board last week, an inquiry was made as to whether the Electric Lighting Committee was ever going to be convened. Another winter was at hand, without anything having been accomplished, and twelve months would have to elapse before application could be made for a Provisional Order. The Chairman said there would be a meeting of the General Purposes Committee shortly, when the matter would be considered.

HULL.—The Property Committee of the Corporation have decided to fit up the police-court for the electric light, at an estimated cost of £10.

INTERNATIONAL EXHIBITION AT AMSTERDAM.—It has been decided to hold at Amsterdam next year an international exhibition, illustrating hotel arrangements and accommodation for travellers generally, as well as means of transport by sea and land. One of the features of the exhibition will be a reproduction of the old "Nieuwmarkt," or New Market, and another an "electric restaurant" without waiters, in which visitors, by pressing an electric button, will be automatically served with a complete dinner.

KEIGHLEY.—The Town Council at their last meeting had under consideration a proposition that application should be made to the Board of Trade for a Provisional Order; but after some discussion the matter was referred back to the Committee, which, it was understood, is tantamount to shelving the question for another year.

LIVERPOOL.—The *Echo* derives cold comfort from the scheme submitted to the Watch Committee by the Liverpool city engineer, Mr. H. P. Boulnois, by which the ratepayers are to be saved the sum of £7,000 per annum. This is to be effected by curtailing the number of public gas lamps during the "burglar hours." In a city which in many things is progressive, this certainly appears a strange resolve, and it may be it is only the forerunner of an opposite policy, under which the electric light will be introduced to serve as an object lesson to the ratepayers. Mr. Charles Rettie is of opinion that the Liverpool municipal authorities must sooner or later—and the sooner the better—adopt the electric light, and ridicules the reasons given for postponing the matter.

LEEDS.—The new Medical School and the College Hall of the Yorkshire College at Leeds, opened on Friday last by the Duke

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and Duchess of York, are lighted throughout by electricity, the entire installation having been carried out by Mr. T. Harding Churton, of Leeds.

METER TESTING.—The London County Council announce that they are now in a position to test electric light meters. Communications in respect to this matter must be addressed to the Engineer-in-Charge, London County Council Testing Station, 42, Cranbourn-street, W.C.

MILL LIGHTING.—The electric light has been fitted throughout Commercial Mill, Slaithwaite, near Huddersfield, the property of Messrs. Pearson Brothers, the work having been done by Mr. Holmes, of Huddersfield.

MONTROSE.—At a meeting of the Town Council on Monday, Mr. Whiteman moved that the Council support the Scottish House-to-House Electric Lighting Company (Limited) in applying for a Provisional Order to supply electric light to the burgh. A long discussion ensued, and an amendment moved that the matter be delayed until after November, but Mr. Whiteman's motion was carried by a large majority.

POPLAR (LONDON, E.).—The Poplar Board of Guardians have referred to a Committee a letter from the Poplar Board of Works, asking whether, in the event of the Board installing the electric light in the district, the Guardians would be prepared to take current for their offices and buildings for a stated period.

SOUTHPORT.—The Electricity Committee of the Town Council have resolved to illuminate the public buildings and fountains on the inauguration of the electric light on November 9th and 10th, and Councillor Boocock has given notice to move that the electric lighting of Lord-street and the Promenade be at once agreed to.

ST. BRIDE'S INSTITUTE.—This is the name given to a palatial building just erected as a home of technical instruction and physical relaxation for lads and young men engaged in the printing trades in the neighbourhood of Fleet-street, London. On Monday last the first of the technical printing classes was opened. The building is admirably adapted for the purpose, and is to be lighted throughout by electricity. A portion of the installation is already complete, the work being carried out by Messrs. Edmondsons, of George-street, Westminster.

WELLS.—At the last meeting of the Town Council a letter was read from the Gas Company with reference to the proposal of the Council to adopt the electric light in the city, in which the company asked the Council to let them know before taking any action to promote the introduction of the electric light. Some discussion ensued, and eventually the letter was referred to the Lighting Committee to act upon it as they thought best.

WHITECHAPEL (LONDON, E.).—At the meeting of the Whitechapel District Board of Works, last week, the report of the Streets Committee with regard to the scheme for lighting the district by electricity came up for discussion. Mr. Catmur, L.C.C., referred at some length to the three alternative schemes submitted in the report, and pointed out that the only resolution the Committee had passed was one in favour of a comprehensive scheme to light the whole parish, rather than a scheme to light only a portion. He moved that the report be received and adopted, and that the whole question be referred back to the Streets Committee for further consideration and report. The Committee would then recommend the adoption of one or other of the schemes, and that would bring the whole matter before the Board for consideration and discussion. The motion was carried unanimously.

WHITEHAVEN.—At the last meeting of the Trustees of the Town and Harbour of Whitehaven the Chairman laid before the Board some particulars with regard to the progress of the electric light financially for 12 months from September 2, 1893. The expenditure during that period for maintenance and sundry payments had been £1,213. 13s. 8d., and interest on capital had been £1,500. 13s. 4d. The revenue from the electric light was £744. 3s. 4d. The average cost for gas per annum for five years had been £909. 17s. 11d., but for exact comparison the cost must be added of 30 extra lamps which had been provided since electricity had been adopted. This would raise the average cost of gas to £984. Taking the actual sum, however, at £909, the profit on electric light for the year had been £103. 7s. 11d. The estimated working expenses of the station were £990, and the total annual expenditure £2,015. The receipts from the harbour for lighting were £220, and for private lighting, based upon actual present supply, the receipts equalled £1,028. 8s. 6d., making a total income from the harbour and private lighting of £1,248. 8s. 6d., and if they got £909. 17s. 8d. (which would be the cost for gas for the town) showed a profit of £143. 6s. 5d. per annum. It was absolutely necessary to provide two more dynamos, costing £1,479. Taking credit for the output of one more dynamo, and leaving the other dynamo for emergencies, this would give receipts amounting to £1,443. 16s. 6d., or a profit, charging public lighting as before for the last five years, of £232 per annum.

WOLVERHAMPTON.—A question was put at the meeting of the Town Council on Monday as to when the electric light installation would be finished. In reply, the Mayor said that the contractors were to have completed their work before September 18th last; but, owing to the carpenters' strike and other causes, they got behind. The work would, however, be finished in a few weeks.

WORTHING.—The Town Council on Tuesday adopted a recommendation of the Electric Lighting Committee that a consulting electrical engineer be instructed to furnish plans and information respecting the electric light installation.

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

September 11, 1894.

17,284. J. F. McELROY. London. Improvements relating to the transformation and distribution of electric currents.*

17,296. W. R. LAKE. London. Improvements in armatures for dynamo-electric machines. (R. Eickmeyer, United States.)*

17,297. W. R. LAKE. London. Improvements in armatures for dynamo-electric machines. (R. Eickmeyer, United States.)*

17,313. J. S. LOSCH, J. H. PHILLIPS, J. W. MAYER, and J. H. WILLIAMS. London. Improvements in and relating to electric motors.*

September 12, 1894.

17,335. J. GRAHAM and H. CHAPMAN. Bradford. Improvements in the method of electrically governing the voltage of dynamos and speed of engines.

17,353. S. MILLER and C. J. GRIST. London. Improvements in charging primary batteries.

17,357. S. S. ALLIN and W. H. WOOD. London. Improvements in arc electric lamps.

17,365. R. W. BRAHAM. London. Improvements in clamps for raising and lowering electric or oil floor standards, also applicable for table lamps, music stands, and the like.*

17,369. L. EPSTEIN. London. An improvement in secondary voltaic batteries.

17,378. A. B. BLACKBURN and T. L. BOYDEN. London. Improvements in direct-current transformers.

17,379. B. WILLCOX. London. A safety device for electrical elevators or cranes. (The Eisenwerk vormals Nagel and Kaemp Actien Gesellschaft, Germany.)

September 13, 1894.

17,445. W. C. BERSEY. London. An improved electromagnetic friction clutch.

September 14, 1894.

17,498. E. BENEST. London. Improvements in or relating to electric alarm clocks.

17,502. P. R. J. WILLIS. London. An improved electric time-signalling system and apparatus. (W. A. Purcell, United States.)

17,510. H. LE R. BRIDGMAN. London. Improvements in or relating to electro-depositing apparatus.

17,525. J. A. JECKELL. London. Improvements in laying electric conductors and in forming branch connections therefrom.

17,529. F. H. W. HIGGINS. London. Improvements in telephone receivers, transmitters, and silent closets.

17,542. J. E. LIARDET. London. Improvement in the construction of the lead lining or casing of cells or boxes of electric storage batteries.

September 15, 1894.

17,566. W. SCHÄFER and A. HEINEMANN. London. Improvements in electrodes chiefly designed for use in electric accumulators and other electric apparatus.

17,572. H. G. KEEBLE. London. Improvements in electrical switches.

17,588. J. LEITH. Liverpool. Improvements in cables or conductors for electrolytic and other purposes.

September 17, 1894.

16,668. H. NEHMER, F. NEHMER, and T. A. REYNOLDS. London. Improvements in connecting dry batteries without the aid of either terminals or wires.

September 18, 1894.

17,728. E. A. SPERRY. London. Devices for retarding the motion of electrically-propelled vehicles.

17,737. G. H. NISBETT. Liverpool. Improvements in or relating to the manufacture and insulation of electric cables.

17,741. W. P. THOMPSON. Liverpool. Improvements in or relating to galvanic batteries. (A. Lessing, Germany.)

17,761. J. BROCKIE. London. Improvements in electric arc lamps.

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17,774. THE PHONOPORE COMPANY (LIMITED) and E. W. SMITH. London. Improvements in electrical signalling apparatus.

September 19, 1894.

17,789. G. TWIGDEN. Bristol. Improved driving-gear for actuating dynamo-electric machines.

17,808. H. LYON. Glasgow. Improvements in electric arc lamps.

17,845. J. DEVONSHIRE. London. Improvements in electric arc lamps. (E. Thomson. United States.)*

17,846. J. DEVONSHIRE. London. Improvements in electric arc lamps. (E. Thomson. United States.)*

September 20, 1894.

17,922. M. IMMLER. London. Improvements in electric arc lamps.

September 21, 1894.

17,968. L. S. BEARDSLEY. London. Improvements in supporting insulators for electric wires.

September 22, 1894.

18,032. E. TWEEDALE, S. TWEEDALE, and J. SMALLEY. Manchester. Improvements in electric stop motions for preparing and spinning fibrous materials.

18,057. L. ZAUSMER. London. An improved carbon regulator for arc lamps.*

September 24, 1894.

18,128. F. G. M. WETHERFIELD. London. Improvements in electrically-controlled apparatus for checking and registering the attendance of workmen and the like. (C. K. Jardine, British Guiana.)

September 25, 1894.

18,153. J. PERRY. London. Improvements in electricity meters.

18,172. J. J. MACLEAN. London. Improvements in and apparatus for the extraction of gold by electrolysis.

18,188. E. HUNGERBÜHLER and THE ELECTRICAL COMPANY (LIMITED) London. Improvements in and relating to electrical fittings.

[Date applied for under Patents, &c., Act, 1883, Sec. 103, March 6, 1894, being date of application in the United States.]*

SPECIFICATIONS PUBLISHED.

NOTE.—All Specifications can now be obtained at the uniform price of 8d. each.

1893.

15,050. OPPENHEIMER. Electric bells.

17,521. JACKSON and DIXON. Illuminating by the electric arc.

18,115. BORLAND. Electric arc lamp.

20,723. GOOLDEN and EVERSHED. Electric measuring instruments.

20,883. BULLERS (LIMITED) and CHAMBERS. Brackets for telegraphic, &c., insulators.

20,915. AYRTON and MATHER. Alternate current synchronisers.

21,327. BERGMANN and ERBEN. Electric meters.

1894.

1,164. PENN and LOWNDES. Armatures of dynamos and electric motors.

9,862. MORISON. Primary batteries.

12,345. WRIGHT. Electrical transformers.

12,861. POPPOWITSCH and WUSTENFELD. Electrical fishing apparatus.

13,405. CHEETHAM and BROWN. Induction coils.

13,756. WAITE. Electrolytic cells.

13,995. THOMPSON (McLaughlin). Electric railways.

14,240. WILKE. Electric call apparatus.

14,290. BINSWANGER. Electrical lamp holders.

14,445. JOHNSON (Wheless). Electric railways and vehicles.

4,502. CANET and HILLAIRET. Electro-motors.

15,174. AST. Electrical rolling contact making and breaking device.

LATIMER CLARK, MUIRHEAD AND CO. (LIMITED).

Convened by the receiver and liquidator, Mr. James Worley, F.C.A., a meeting of the creditors of this Company took place yesterday (Thursday), at Winchester House, Old Broad-street.

Mr. WORLEY stated that there were about 250 persons who were returned as creditors of the Company, and that being the case, they would observe that there was only a very small attendance. He felt that he was placed in a very peculiar position. There was no obligation on his part to convene a meeting, but he had felt that it was the right course to take. Nor was there any obligation on his part to publish any statement of affairs; but naturally every creditor desired to have reliable information as to the position of the Company, and he had thought that the "shortest cut" would be to make up the books and to issue a statement, which he had accordingly done. Alhough he had called them together he had no proposal to make; but he was ready to give any further explanations that might be required respecting the transactions and the present position of the Company. He regretted extremely that he had felt obliged to say in his report that he saw no prospect of the unsecured creditors receiving any dividend. Against net liabilities put down at £81,697, the assets were returned only at £34,675, leaving a deficiency of about £47,000. There was no doubt, too, that when they came to wind up the estate they would find that the actual deficiency was even more than that, because the values put upon several of the principal assets were merely nominal—book values—and it would be impossible for anyone to say what they would produce until the actual realisation took place. Soon after his appointment as liquidator it became his duty to make a special report to the judge with respect to the issue of debentures, and they would agree with him that, so far as the unsecured creditors were concerned, this was a most important matter, because the claims under the debentures amounted to no less than £60,592; in other words, the debenture claims were so heavy that if the assets were even double what they were, the whole amount would be required to satisfy these claims. The debentures had been issued in regular order, and money was received for them, excepting an amount of about £5,700, representing debentures issued in part payment to the vendor for the original concession. The interest on the debentures had been allowed to accumulate for a considerable time. Many of these, no doubt, had naturally thought: Why did the Company keep on trading so long? Did they not know some time ago that they were insolvent? He might say that, so far as his investigations went, it would seem that the Company was never very flush of money, but there were gentlemen on the Board who possessed considerable means, and who appeared to have taken from time to time a very hopeful view of the prospects of the Company. Hence they were induced to make advances as required from time to time, and it seemed that so recently as last year they quite thought that the Company would be able to retrieve its position. Negotiations had been going on for some time for the reconstruction of the Company—the intention, he understood, being to take over that portion of the business which had been found to be profitable, and to abandon other work which had not been found profitable. It was thought that arrangements would be made on such a basis as would enable the old Company to pay all its creditors in full, and it seemed that the Directors were particularly anxious that something should be arranged on that basis, for the reason that they wanted to finish the contracts they had in hand. If these contracts had been stopped the result would have been even more disastrous than it was now. He was also told that they believed that when these contracts were finished there would be a fair profit to come to the Company; but, as frequently happened with contracts—particularly those with public bodies—when one got to the fag-end of them, claims were made, and requisitions were sent in, which altogether destroyed the reasonable expectations of profit accruing from the work. That, to a great extent, had been the case with this Company. When he was appointed to the dual capacity of receiver and liquidator of the Company, he found that there were several contracts which had to be finished, and he had no alternative but to complete them, because there were considerable sums due to the Company in connection with them. Having given particulars of the contracts in question, he stated that the terms were most oppressive. They were all in favour of the different authorities, and the risk run was considerable, and out of all proportion to the narrow margin of profit on which the estimates were made up. That, in fact, seemed to be "the order of the day." Firms took contracts with little or no margin of profit, and if anything went wrong there was a heavy loss at the end instead of a profit for the heavy responsibility which had been incurred. The heaviest contract of all was that connected with the electric lighting at Richmond. The Company undertook this work direct from the Corporation of Richmond, and then, about two years ago, arrangements were made for the formation of an independent company for taking it over. This was done, but this Company had to subscribe largely to the shares of the Company which took over the business. It was only recently that the contract had been completed. The prospects of the Richmond Company, so far as he had been able to gather, were fairly good, but at the moment they were not doing very well, and, like many other companies in the same position, they required additional capital. It was owing to the money that was locked up in these different contracts that the suspension of this Company last January was due. They could not get in the money owing to them, they were face to face with these contracts, and no course was open to them but to wind up the Company. So far as he could gather there was nothing at all to conceal. No doubt many grave mistakes had been made in the Company, but he had seen no reason to doubt the *bona fides* of those connected with it. The Directors themselves had embarked considerable sums in the Company, and he could not see that they had ever gained anything by it. They had not even had their interest, and, as regarded Directors' fees, for the last seven or eight years no such fees had been paid. It seemed that they had carried on the Company in the expectation that things would "take a turn," and in that case they would have surmounted their difficulties; but, unfortunately, things had gone the other way. No doubt their attention had been drawn to the form of the debenture. It was very comprehensive, and seemed to give the holders a first charge on the undertaking, and all its assets. At the date of the suspension the Company held shares in two or three other companies, to the amount of £16,000, and for this purpose he had taken these at their nominal value, but there did not seem to be any satisfactory market for them at the moment. The value of shares depended on the dividends that were paid on them, but in these cases no dividend had been paid.

In the course of the discussion which followed the action of the Directors was severely criticised. One creditor stated that he was "trapped" into £650 only two days before the failure.

Mr. WORLEY, in answer to questions, stated that the interest on the debentures was originally 5 per cent., and, latterly, 6 per cent., and on loans the interest was also 6 per cent. Quite four or five years' interest on the debentures was unpaid: in some cases seven years' interest was due. About £12,000 or £13,000 in cash was received under the Richmond Contract, but out of this they had to invest £6,000 in the shares of the Richmond Company. As regarded the issue of debentures for £25,000, Mr. E. Clapham, a Director, held £11,200; Dr. Muirhead £14,000, Mr. H. J. Muirhead £1,200, Mr. F. L. Muirhead £1,100, Mr. John Muirhead £3,200, Mr. Arnold Trinder £100, Mr. Latimer Clark £1,800, and Mr.

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Douglas B. Hall £5,000. As regarded the second issue, Mr. Clapham held £2,800, Dr. Muirhead £400, Messrs. H. J. and F. L. Muirhead £4,000 jointly, Mr. H. J. Muirhead £200, Mr. F. L. Muirhead £300, Mr. John Muirhead £2,600, Mr. Clark £400, and Messrs. Trinder and Romer £400. A further sum of £12,000 had been issued to Mr. Clapham and others as security for advances and guarantees given to bankers. The Legislature had not imposed the duty on companies of publishing a balance-sheet. This Company was more in the nature of a private than a public company, and the former were generally the more successful. The debenture register was open to the creditors. He thought he ought to say that the bulk of the unsecured creditors seemed to be firms who had transactions with the Company for years; but there were a few creditors whose cases were hard.

Mr. F. DAWES said that if he was rightly informed Mr. Clapham believed in the concern up to the very last, and he was one of the largest unsecured creditors, if not the largest.

Mr. WORLEY replied that that was so.

Mr. HALL observed that he appeared to be the only Director present, and he could only say that he had been induced to put £5,000 into the concern.

Mr. SPENCER asked whether Mr. Hall, in his capacity of a Director, received a financial statement.

Mr. HALL replied that periodically there was a balance-sheet.

Mr. SPENCER: Was it certified by any you could rely on?

Mr. HALL: I do not know.

Mr. WORLEY, in further reply, said that Mr. Clapham's advances amounted altogether to £24,000, and the trade creditors had had the benefit of all the money which this gentleman had put into the undertaking.

On the motion of Mr. SPENCER, a vote of thanks was passed to Mr. Worley, and the meeting then separated.

NEW COMPANIES, STATUTORY RETURNS, &c.

"LA BOITE MAGIQUE" (LIMITED).—This Company was registered on September 27th, with a nominal capital of £3,000, in 2,500 Preferred and 500 Deferred shares of £1 each, to carry on (*inter alia*) the business of electricians, electrical and mechanical engineers, and manufacturers of and dealers in all electrical apparatus.

T. AND R. BOOTE (LIMITED).—This Company was registered on September 29th, with a capital of £50,000, in £10 shares, to carry on the business of manufacturers of and dealers in electrical appliances and apparatus, carried on at Burslem, Staffs.

BOWES-SCOTT AND WESTERN (LIMITED).—This Company was registered on October 5th with a capital of £10,000 in £1 shares, to acquire the business of Bowes-Scott and Western, mechanical engineers, of Westminster, and to carry on the business of iron founders, mechanical engineers, manufacturers of mining implements and other machinery, tool makers, brass founders, metal workers, boiler makers, millwrights, electrical engineers, &c.

ROBERT HALL AND SONS, BURY (LIMITED).—This Company was registered on October 4th, with a capital of £75,000 in £10 shares, to acquire the business of Robert Hall and Sons, Bury and Manchester, and to carry on the business of manufacturers of and dealers in textile machinery and apparatus, mechanical engineers, metal workers, tool makers, millwrights, electrical engineers, &c.

LLANBERIS WATER AND GAS COMPANY (LIMITED).—This Company was registered on October 4th with a capital of £5,000 in £1 shares, and, as is now usual with provincial gas companies, includes among its objects the establishment, working and maintenance of electric light works for the supply of light to the parish of Llanberis, in the county of Carnarvon.

DIXON AND CORBETT AND R. S. NEWALL AND COMPANY (LIMITED).—The annual return of this Company, made up to August 22nd, has been filed. 6,000 Ordinary and 1,957 Preference shares have been taken up. out of a nominal capital of £120,000, in 6,000 Ordinary and 6,000 £5 per Cent. Preference shares of £10 each. All the Ordinary and 250 Preference shares have been issued as fully paid, while £13,648 has been received in respect of a call of £8 per share on 1,707 Preference shares, leaving £8 in arrears.

EXETER ELECTRIC LIGHT COMPANY.—The annual return of this Company made up to June 26th, has just been filed. The nominal capital of £20,000 is divided into 1,500 Ordinary and 500 "A or £6 per Cent. Preference shares of £10 each; 1,125 of the former and 73 of the latter have been taken up, and 305 Ordinary have been issued as fully paid. The full amount has been called on 820 Ordinary and 58 Preference shares, and £1 per share on the remaining 15 "A" shares, resulting in the total payment of £8,795.

FORD-LLOYD MANUFACTURING COMPANY (LIMITED)—The first annual return of this Company, made up to August 30th, has been filed. 4,707 shares of £1 each have been allotted, out of a capital of £10,000, in £1 shares, and 4,000 of these have been issued as fully paid, while the full amount has been called and paid on the remaining 707 shares.

IMMISCH ELECTRIC LAUNCH COMPANY (LIMITED).—The statutory return of this concern, made up to August 11th, has just been filed. The nominal capital is £12,000, in 10,000 Ordinary and 2,000 £8 per cent. Cumulative Preference shares of £1 each. 8,965 Ordinary and 1,507 Preference shares have been taken up, of which all the former have been issued as fully paid to the General Electric Power and Traction Company (Limited), of Queen street-chambers, London, E.C. Upon the Preference shares a call of 5s. per share has been made, resulting in the payment of £301, and leaving £75. 15s. in arrears.

SAYCEE ELECTRICAL SYNDICATE (LIMITED).—An agreement, dated September 18th, between William H. Longsdorf (the vendor), George M. Gordon (the trustee), and the Company, states that, whereas, by an agreement dated August 16, 1894, the vendor agreed to transfer to the Company certain inventions and patent rights relating to "improvements in primary batteries," in consideration for fully-paid shares, it is, therefore, agreed that the Company shall take over the provisions of that agreement, and allot 6,000 fully-paid Ordinary shares and 500 Deferred shares to the vendor, in full satisfaction for the said transfer of patents.

WALSALL ELECTRICAL COMPANY (LIMITED).—The first annual return of this Company, made up to September 13th, has been filed. Out of a nominal capital of £10,000 in £10 shares, 683 have been taken up, of which 200 were issued as fully paid to Frederick Brown, electrical engineer, of Highgate-road, Walsall (the vendor); upon each of the other shares the full amount has been called and paid.

CITY NOTES.

ALUMINIUM COMPANY (LIMITED).—Mr. G. W. Balfour presided over a meeting of shareholders in this Company, at Cannon-street Hotel, on Wednesday, and said that at the last meeting he placed before the shareholders certain anticipations as to the profits likely to be made, and he was pleased to say these anticipations had practically been verified. He had estimated a profit of about £25,000, whereas the actual profit made was between £19,000 and £20,000. This profit, after the payment of all proper charges, depreciation, &c., enabled the Directors to declare a dividend of 5 per cent. on the A shares, absorbing £3,000, and to carry forward £1,475 to next account. During the past year their sodium business had been maintained, and steps had been taken to cheapen the manufacture, and their efforts with the caustic process had been entirely successful. With regard to the name of the Company he pointed out that this was a misnomer, as they no longer continued the manufacture of aluminium.

BIRMINGHAM CENTRAL TRAMWAYS COMPANY (LIMITED)—At the meeting of this Company, held at Birmingham on Wednesday, the proposal to reduce the capital from £500,000 to £300,000, was carried unanimously.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).—The accounts of this Company, subject to audit, show a profit, which justifies the Directors in recommending a final dividend of 3s. per share, making with previous distributions a total dividend of 6 per cent. for the year ended June 30th last, and also the payment of a bonus of 1s. per share (both free of income tax), which together will amount to £26,000, leaving a balance of £16,501, of which amount £15,000 has been placed to the reserve fund and £1,501 carried forward. These payments will be made on and after the 25th inst. The register of transfers will be closed from the 16th to the 24th inst. inclusive.

CENTRAL CHILI COPPER COMPANY (LIMITED).—Sir John Pender G.C.M.G., M.P., presided on Wednesday over the statutory meeting of the above Company, which was formed some time back to take over the Panulcillo Copper Company, with which the Chairman had been for so many years associated. He said that he had seen the old Company in considerable prosperity and in very great adversity. More than once he had been called upon to lift the concern out of adversity into prosperity. He had himself subscribed, and was the largest shareholder in the new Company in the honest belief that better times were in store for them. The time had expired when shareholders of the old Company might become shareholders in the new, but the Directors were willing to extend this period to the 20th inst. They did not anticipate any difficulty in placing the shares, and over 300 out of the 500 shareholders in the old Company had taken up a financial interest in the new enterprise. He hoped to be able at a future date to announce a dividend. Mr. Collins, one of the Directors of the new Company, expressed his belief in its prospects.

CITY AND SOUTH LONDON RAILWAY.—The traffic returns of this Company for the week ended October 7th, were £892, as against £816 in the corresponding period of 1893, being an increase of £76. The total receipts for the half-year amount to £12,011, as against £11,295 for the corresponding period of 1893, an increase of £716.

CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).—The revenue return of this Company for the quarter ended September 30, 1894, is as follows:—Sale of current for public lighting, £3,141. 19s. 2d., against £3,027. 10s. 9d., in the corresponding period of 1893; private lighting, &c., £7,676. 14s. 9d., against £3,551. 15s.; other sources, £416. 12s. 5d., against £441. 12s. 11d.—total, £11,235. 6s. 4d., against £7,020. 18s. 8d., increase of £4,214. 7s. 8d. The equivalent of 8-c.p. lamps connected on September 30, 1894, was 114,031, against 53,445 in September 30, 1893.

ENGINEERING AND GENERAL CONTRACT CORPORATION.—The poll demanded by the Directors of this Company has resulted in the acceptance of the Directors' report and accounts, and the rejection of the report presented by the Committee of Investigation.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic returns of this Company for the month of September, 1894, amount to £25,200, and from January 1st to September 30, 1894, £207,400. In the corresponding months of 1892 and 1893 the amounts were £199,600 and £203,600 respectively.

SUBMARINE CABLES TRUST.—Notice is given that on and after the 15th inst. the sum of £1. 15s., on account of the coupon due October 15th, will be paid by Messrs. Glyn, Mills and Co., of 67, Lombard-street, between the hours of ten a.m. and two p.m. Coupons must be left with the bankers for examination four clear days before payment.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended October 5th (after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited), were £3,186.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share	Last Dividend.	Name.	Previous Week's Price, Oct. 3.		Price Wednesday, Oct. 10.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Oct. 10. Highest	Lowest
			TELEGRAPHS.					£ s. d.			
£1,012,880	Stock	10 0	Anglo-American	39	42	39	42	5 7 2	Jan., Apr., July, Oct.	..	..
£2,993,560	Stock	20 0	Do. Preferred	75	76	75½	76½	5 11 1	" "	76⅜	75½
£2,993,560	Stock	5/0	Do. Deferred	6¾	7¼	6¾	7¼	..	..	..	..
£184,500	100	4%	*African Direct Teleg. 4% Deb. (Reg. & Bearer)	102	105	102	105	3 16 11	January and July	..	..
130,000	£10	3/0	Brazilian Submarine	12¾	13¼	12¾	13¼	4 18 1	Mar., June, Oct., Dec.	13⅛	12⅞
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1906)	110	114	110	114	4 8 8	June and December	..	—
10,000,000	$100	$1¾	Commercial Cable Capital Stock xd	135	145	135	145	4 17 9	Jan., Apr., July, Oct.	—	..
16,000	10	8/0	Cuba Submarine	12½	12½	12½	13½	5 18 6	February and August	..	—
6,000	10	10%	Do. Preference 10 per Cent.	19	20	19	20	5 0 0	" "	..	—
12,931	5	1/8	Direct Spanish (£4 paid) xd	4½	4¾	4½	4¾	4 4 3	April and October	..	..
6,000	5	10%	Do. Preference 10 per Cent. xd	9½	9¾	9½	9¾	5 2 7	" "	..	—
£30,000	Stock	4½%	* Do. 4½% Debentures of £50 each	105%	108%	105%	108%	..	" "	..	—
60,710	20	2/0	Direct United States Cable, 1877	8¾	9½	8½	9½	5 12 4	Jan., Apr., July, Oct.	9½	8⅞
400,000	10	5/6	Eastern	15⅞	16⅛	15¾	16	4 1 3	" "	16	15⅞
70,000	10	6%	Do. 6 per Cent. Preference	16¾	17¼	16¾	17¼	3 9 7	" "	17	16¾
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	118	121	118	121	3 6 2	May and November	119½	119
£102,100	100	5%	* Do. 5 per Cent. Debentures, 1899	106	110	106	110	4 11 6	February & August	..	—
250,000	10	2/6	Eastern Extension	16	16½	16	16½	4 6 3	Jan., Apr., July, Oct.	16¼	16
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	116	120	116	120	3 6 8	February & August	..	..
£32,700	100	5%	* Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103	106	103	106	4 15 6	January and July	..	—
£95,100	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb., 1900	103	106	103	106	4 5 6	" "	..	..
£300,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.)	104	107	104	107	3 15 4	February & August	103	..
£200,000	£25	4%	* Do. 4% Mauritius Sub. Debs.	109%	112%	109%	112%	3 3 3	May and November	111	..
180,227	10	3/9	Globe Telegraph and Trust	8⅞	9½	8⅞	9½	4 15 0	Jan., Apr., July, Oct.	9½	8 15/16
180,042	10	6%	Do. 6 per Cent. Preference	15¾	16½	15¾	16½	3 13 10	" "	16¼	15⅞
150,000	10	5 0	Great Northern	20½	21½	20½	21½	3 10 1	Jan., April, and July	..	..
£190,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	103	106	104	107	4 13 6	March & September	..	..
17,000	25	12%	Indo-European	46	48	46	48	5 4 2	May and November	47⅛	..
37,548	10	5/0	London Platino-Brazilian	5	7	5	7	..	" "	..	..
£100,000	100	6%	* Do. 6 per Cent Debentures	107	110	107	110	5 9 7	March & September	..	..
£100,000	£100	4%	*Pacific European Tel. 4% Guar. Debs. "Red" 1942	104	107	104	107	3 15 6	..	..	..
11,830	8	4/0	Reuter's	3	5	3	5	..	April and October	..	..
3,381	£100 Cert.	25/0	*Submarine Cables Trust 6 per Cent.	106	111	103	111	5 9 7	" "	100	..
15,609	10	5/0	West African Telegraph	3	5	3	5	..	January and July	..	..
£249,900	100	5%	* Do. 5 per Cent. Debentures	100	103	100	103	4 17 7	March & September	..	..
30,000	10	2/0	West Coast of America	2	3	2	3		January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	101	106	101	106	7 10 11	June and December	103	..
88,321	10	9d.	West India and Panama	1⅜	1⅝	1⅜	1⅝	..		1 7/16	1⅜
34,563	10	6%	Do. 6 per Cent. 1st Preference	10¾	11¼	10¾	11¼	5 6 8	May and November	11	10⅞
4,669	10	6%	Do. 6 per Cent. 2nd Preference	9	10	9	10	6 0 0	" "	9 13/16	9¾
£80,000	100	5%	* Do. 5 per Cent. Debentures, 1917	108	111	108	111	4 11 1	June and December	110½	..
64,242	15	7/6	Western and Brazilian	8¾	9¼	8¾	9¼	..	May and November	..	..
33,129	7½	7/6	Do. 5 per Cent. Cumulative Preferred	6¼	7¼	6½	7	..	..	..	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	2¾	3¼	2¼	3¼	..		2⅜	..
£171,900	100	6%	* Do. 6 per Cent. Debs., Series "A" 1910	106	109	106	109	5 11 1	February & August	..	..
£214,800	100	6%	* Do. 6% Mort. Debs., Series "B" 1910	106	109	106	109	5 11 1	" "	..	..
$1,211,000	$1,000	7%	*Western Union 7% 1st Mort. (Building) Bonds	115	120	115	120	5 19 8	May and November	—	..
£166,900	£100	6%	* Do. 6 per Cent. Sterling Bonds	102	104	102	104	5 15 11	March & September	..	..
			TELEPHONES.								
44,000	5	10/0	Chili Telephone (fully paid)	2	3	2	3	..		..	..
224,850	10/0	2¼d.	Consolidated Telephone Const. & Maintenance	¼	½	¼	½	..	May and November	..	..
171,504	£1	6d.	Oriental Telephone and Electric (fully paid)	7/16	9/16	7/16	9/16	..	Yearly	..	..
484,597	5	3/4	National	4⅞	5⅛	4⅞	5⅛	4 17 7	June and December	5⅛	4⅞
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	15	15½	15	15½	3 17 5	" "	15¼	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	14	15	14	15	4 0 0	" "	14⅛	..
119,234	5	3/4	Do. 5% Non-Cumulative 3rd Pref.	5½	5¾	5½	5¾	4 6 11		5⅝	5 1/16
1,000,000	Stock	4½%	* Do. Debenture Stock, 4½%	109	112	109	112	4 1 3	January and July	110	..
58,000	5	1/0	United River Plate	2	3	2	3		" "	2½	..
£146,733	Stock	5%	Do. 5 per Cent. Debenture Stock	88	94	88	94	5 6 5	" "	..	—
			ELECTRICITY SUPPLY COMPANIES.								
40,000	£10	..	City of London Electric Lighting (fully paid)	13	14	13	14	..		13¾	13½
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	14¾	15½	14½	15	4 0 0	..	15½	14⅝
19,900	£5	..	Electricity Supply Co. for Spain						..	..	..
£30,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	4½	5½	4½	5½	3 12 7	—	..	..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	..		..		..	—	..	..
8,322	£5	..	House-to-House Electric	..		..		..	..	..	—
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	..		..		—	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..		..		—	..	..	—
45,000	£5	..	Liverpool Electric Supply (fully paid)	6¾	7	6¾	7	—	January and July	..	—
111,000	5	..	London Electric Supply	¼	¾	¼	¾	—	..	..	—
49,900	£10	5/0	Metropolitan Electric Supply (fully paid)	9¾	10¼	9½	10	2 10 0	..	10	9⅞
£150,000	Stock	4½%	* Do. 4½% Debs. (Bonds of £10, £20, and £10)	113	114	111	113	..	June and December	..	..
6,452	£10	..	Notting Hill Electric	5½	6½	5½	6½	..	..	..	..
19,980	£5	2/0	St. James and Pall Mall	7	7½	7½	7¾	..	..	7½	7
20,000	£5	7%	Do. 7 per Cent. Preference	8½	9	8½	9	3 17 9	..	8⅝	..
59,900	5	2/0	Westminster Electric Supply (fully paid)	6¾	6¼	6¾	7¼	3 2 1	—	7	6 11/16
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
90,000	3	1/6	Brush Electrical Engineering	2¾	3	2¾	3	5 0 0	..	3	2⅞
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	2½	2¾	2½	2¾	4 7 3	..	2½	2 7/16
£125,000	Stock	4½%	* Do. 4½ per Cent. Debentures	109	112	110	113	4 0 0	March & September	..	..
20,000	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref.	2	2½	2	2½	..	January and July	..	..
12,139	5	..	Edison and Swan United	—		—		..	..	—	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	..		..		..	..	—	..
120,000	2	..	Electric Construction	½	¾	½	¾	..	..	..	..
12,845	2	2/9	Do. 7 per Cent. Cumulative Pref. xd	1½	2	1¾	2¼	..	—	2⅛	2
91,195	2	10/0	Elmore's Patent Copper Depositing	1⅜	1⅝	1⅜	1⅝	..	—	1½	..
20,000	5	..	Fowler-Waring Cables (fully paid)	½	1½	½	1½	..	..	..	..
50,000	10	10/0	India Rubber, Gutta Percha, &c., Works	24	25	24	25	5 0 0	February & August	24 11/16	24 7/16
£200,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	102	104	102	104	4 6 7	March & September	..	—
15,995	£10	6/4	International Okonite Ordinary	..		..		..	..	..	..
16,000	£10	..	Do. 8 per Cent. Preference	..		..		—	December and June	—	—
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid)	—	¼	—	¼	—	..	—	..
78,949	5	3/6	Swan United (£3 10s. paid)	..		..		..	May and November	..	..
37,350	12	12/0	Telegraph Construction and Maintenance	41	43	41	43	4 3 9	March and July	42	41⅝
£150,000	100	5%	Do. 5 per Cent. Bonds	105	106	105	108	4 12 7	January and July	106	—
37,514	£5	—	Woodhouse and Rawson Ordinary (£3 15s. paid)	—		—		..	..	..	—
41,098	£5	..	Do. Preference (fully paid)	—		..		..	..	..	—
£63,870	10	10/0	W. T. Henley's Telegraph Works Ordinary	8	8½	8	9	5 11 1	..	..	..
£30,000	10	..	Do. Preference	..		..		..	..	..	..
			RAILWAYS AND TRAMWAYS.								
£630,000	Stock	1%	City and South London Railway	36	38	36	38	1 16 2	May and November	37½	..
7,000	10	5%	Do. 5% Perpetual Preference	13	14	13	14	3 11 5	May and November	13⅞	..
£67,130	Stock	4%	Do. 4% Perpetual Debenture	121	123	121	123	3 5 1	..	..	..
37,500	£10	1%	Liverpool Overhead Railway	8	8½	7½	8½	1 4 3	..	..	..
6,295	10	5%	Do. 5% Preference	13	13½	13	13¼	3 15 6	..	..	..
£125,000	Stock	4%	Do. 4% Debenture	111	113	111	113	3 10 10	January and July	..	..

* In calculating the yield on this security, allowance has been made for accrued interest, but not for redemption.

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

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NOTES.

An impartial and thorough discussion of the problem of replacing factory gearing by electric motors, by one who is practically conversant with this class of work and has had many years of experience in the running of an engineering works, should be welcomed by everyone who is desirous of seeing the matter placed on a sound practical footing. Mr. Thomas Richardson, in his Presidential address delivered before the North-East Coast Institution of Engineers and Shipbuilders, an abstract of which we publish this week, attacks the problem from this standpoint; and it is gratifying to find that he can speak so favourably of the transmission of power by electric current in factories and mills. In reading Mr. Richardson's address the conviction is forced on us that we are listening to no mere enthusiast, but to a man who is carefully weighing the *pros* and *cons* of the question. "Particulars such as these," he says, referring to the examples he has cited, "are always of general interest, but any radical change made in existing works involves a very considerable outlay, and extreme care is necessary to be certain that such a change would be commercially successful."

Disregarding those people who look unfavourably on the use of electromotors in any form or shape, the opinions of experts may be divided into two classes: firstly, that the utmost subdivision of the power should be carried out, each machine tool or separate plant having its own electromotor; secondly, that the power should be electrically subdivided only between the various shops, and that a single electromotor in each shop should drive the machines in that shop by ordinary belts and countershafts. On the one hand we have only half measures, on the other whole measures; but cases are conceivable where half measures would be the better of the two.

Speaking broadly, it is probable that the half measure is the more suited to existing shops or works, while the more thorough system might more economically be adopted in cases where an entirely new shop or works is to be erected. To alter every machine in a large shop, so as to enable it to be economically driven by its own electromotor, would swallow up such a large capital sum as might entirely spoil the value of the change; for the mere cost of the electrical plant would be small compared with the cost of removing the old gears and properly adapting the new. On the other hand, where an entirely new set of plant is to be erected in an entirely new building, the adoption of the whole measure has the advantages that the cost of countershafting and belting is entirely saved, and the structure in which the machines are to be placed may be made much lighter and cheaper in construction, owing to the absence of the weight and stress of the gears from the walls and columns. To engineers, however, it is unnecessary to say that each particular case must be judged according to its individual conditions; for it is very probable that many existing works might be more profitably fitted on the complete system than on the alternative plan of putting only one motor in each shop. Useful provision for this class of work is being made by more than one machine-tool manufacturing company, the electromotor being built on and adapted to the machine in such a manner as to make a most compact, handy, and efficient plant. For, indeed, whatever may be said as to the exigencies of the problem, there can be no doubt that the ideal system is one in which a corporate part of each machine is the motor which drives it, and the switch which regulates it; or, in the case of very complicated machines, there might even be more than one motor incorporated with each separate plant.

It may have been a great thing to stand on a tight-rope over Niagara Falls and cook an omelette the while; but it had been an infinitely greater thing for the acrobat to have made the Falls cook the omelette. At the banquet in celebration of the opening of the Worcester electric supply station, several of the "viands" were cooked by means of a waterfall at a distance of about three miles from the banquet hall. Of course, there is nothing really wonderful in this achievement. Nothing is wonderful when it has been explained, and any "second year student" could explain how water power may be used for electric cooking. The Worcester Corporation is doing its best to find work for its turbines and dynamos during the daytime; for not only has it thus advertised the usefulness of the electric current for heating and cooking, but it has also found actual work for the electric power at some of the Corporation works, notably at the waterworks. Worcester, too, is a town in which there are a number of various manufactories, almost every one of which requires highly-subdivided power during the daytime; and this class of power can be much more conveniently supplied by means of a number of small electric motors than by means of a single large steam engine. Altogether, the prospects of an even and fairly large day load are better at Worcester than at the average district under electric supply.

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A few more circulars such as that just issued by the Isle of Man Electric Tramway Company, and the forthcoming discussion on Mr. Wilkinson's Institution Paper on American electric tramway practice will fall through for lack of debaters; they will all be engaged in advising town councillors, drawing up reports, drafting prospectuses, and estimating *in futuro* dividends, being themselves divided between the advisability of figuring out an attractive 10 per cent. or a modest 5 per cent. per annum. The circular in question states that the Directors of the Company, having carefully considered the profits for the past season, and having consulted with the auditors, are enabled, after providing a large sum for the reserve and renewal fund, and making provision for further dividends at the end of the year, to pay an interim dividend at the rate of 7½ per cent. per annum on the Ordinary shares for the six months ending October 31st. If only it were possible to do likewise in South London!

Although the Welsbach gas burner has proved a formidable rival of electric lighting in Germany and in one or two places in this country where active agents have taken it up, it is probable that the gas companies rather than the electric supply companies will suffer from the renewed efforts which are being made to popularise it. The Incandescent Gas Light Company may well be proud that, in spite of its many disadvantages, their burner, when it is in order, is the most economical means of producing light from gas, or probably from any other artificial source. The latest circulars announce the price of the cheapest burner at 15s., the mantles at 1s. 10d. to 1s. 3d., and the annual cost of keeping a burner in order at 4s. to 5s., "or even less if the user is willing to look after the light himself." The consumption is given at 3¼ to 3¾ cubic feet of gas for "about 50 to 60 candle-power." Those who do not want 50 or 60 candle power will do well to buy a thick shade, and cut down the light to a reasonable amount, or to wait for a week or two until the candle-power falls off of its own accord, as it readily does. Attempts are made to disguise the Bunsen burner and stem and the long chimney by all sorts of shades and globes, but the inevitable ugliness of shape is realised at once when an attempt is made to fit one of these burners on a handsome wrought-iron gas fitting. One of the distinct advantages of electric lighting, which it is impossible to estimate in money value, is the convenience of switching on or off without having to hunt for matches; but with a Welsbach burner a spirit lamp or electric lighter is recommended. The one is, of course, generally empty, and the other almost invariably out of order; but, of course, such trifles are no obstacle to the publishing of startling comparisons between costs of lighting by this bilious-looking contrivance and by electric glow lamps.

The "average man," like everyone else in this world, has his uses, and when he happens to be a consumer of electric energy, it seems to us that his usefulness is of a very high order, and for this reason: He is absolutely proof against the angry eloquence of the advocates of this or that electrical nostrum. He cares not whether the current comes to his lamps *via* two, three or five wires, provided he gets it. So long as his filaments steadily glow, they may be traversed, for aught he cares, by true sine curves, battered tall hat curves, or blunted saw-tooth curves. He is absolutely indifferent whether alternators are run in parallel or on separate circuits, though he has a decided aversion to a throbbing and bobbing light, like unto the uneasy motion of a storm-tossed sea. The virtues or vices, merits or demerits, of water-tube *v.* Lancashire boilers, double *v.* single-acting engines, direct *v.* rope driving, high-speed *v.* slow-speed running, india-rubber *v.* paper insulation, are beyond his province. He only asks for light. And his usefulness lies in the very simplicity of his demand. Emphasised by threats to "go back to gas" or "to write to the papers," it brings home to us the elementary fact that the whole duty of an electric supply station is to give its customers day after day, year in and year out, all the current they desire at the pressure their lamps require. The difficulties of providing a continuous supply of electrical energy at a constant pressure are, owing to the lack of storage capacity, far greater than is the case where gas is concerned. No one, however, is under compulsion to supply electric current; but the obligation once entered into, he is under statutory compulsion to fulfil the contract. And, as a measure of this fulfilment, it is sheer waste of arithmetical brain-power to express the few odd moments during which the light is out as a percentage of the time it is not out. There, again, our faithful friend, the "average man," comes to the rescue with the painfully unscientific retort that the failure which left his dinner-table in the gloaming is not compensated for by the fact that the light is always there to assist Buttons in cleaning the boots of a winter's morning. These are truisms, we know well; but an impression which has gained strength of late, that central stations are principally intended to illustrate the glorious uncertainty of all things human, was thought to need a decisive negative.

Cable Interruption:	Date of Interruption.
Zanzibar-Mombasa	September 4, 1894.
Macao-Hong Kong	September 25, 1894.

University College of North Wales.—The calendar for the year 1894-95 is just issued, and contains full details of the educational courses at the University, which now include a day training college for men and women for training as elementary teachers.

Electrical Utilisation of Water Power.—A company has just been formed in Zurich with a capital of £30,000, to be known as the Electricitätswerk Rathausen. It is proposed to establish a central station near Rathausen, where water power to the extent of 1,200 H.P. will be utilised.

Physical Society.—The first meeting of this Society will take place on October 26th, at 5 p.m., at the rooms of the Chemical Society, Burlington House. A Paper "On the Thermal Constants of Aniline" will be read by Mr. Griffiths, and Mr. Naber's voltameter will be on view.

Lightning on an Underground Cable.—The cable running through the St. Gothard tunnel from Airolo to Goeschenen was recently severely damaged by lightning. This unusual occurrence of lightning injuring such a cable is attributed to the bad earth made by a lightning guard (?) common to the cable line and to the overhead line leading up to it.

Aluminium.—The Aluminium Manufacturing Company of Neuhausen is now turning out three tons of aluminium a day, and the selling price has come down to 3 marks 20 pfennigs,

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say, three shillings per kilogramme, or about 16 pence per pound. This is a long way from the promised twopence per pound; but, remembering that the bulk of aluminium is 3 times that of copper, for equal weights, the cost of aluminium is only 33 per cent. greater than copper, for equal bulks.

The Indo-Chinese Telegraph Line.—The connection between the India and Chinese telegraph systems will be made from Nampoung to Momein, the distance between these two places being between 60 and 70 miles only. The alignment, says the *Indian Engineer*, will thus be along the valley of the Taeping River, which is the caravan route for trade between Burma and Yunan. The posts and wire for the whole of the new line will be sent from India to Bhamo and thence onward to Nampoung, where work will be begun.

Cheltenham.—We hear from a correspondent that the Corporation are pushing ahead with the laying of mains in the principal streets, and that the station and plant are well in hand. It is doubtful, however, if the current will be available before December 1st. The light is being pushed very hard in the town by contractors, and the competition in wiring, &c., will be extremely keen, eight local firms having taken up electric lighting, and several engineers from other towns are contemplating opening branches there. We may add that the capacity of the station is only about 5,000 8-c.p. lamps fixed.

Telegraph Statistics.—In 1870 the number of telegrams transmitted in the United Kingdom was 9,350,000; in 1892 the total had risen to no less than 69,908,000. The Americans received and despatched 9,157,646 telegrams in 1870; in 1892 (notwithstanding the enormous increase in the population of United States during the 22 intervening years) the corresponding total did not exceed 62,387,298. France ranked third among telegraphing countries in 1891, her telegraphic movement in that year comprising 32,397,000 messages. Germany comes fourth, her latest annual telegraphic budget exhibiting an aggregate of 31,175,100 telegrams. Austria ranks fifth, but cannot muster a larger aggregate than 10,835,302 despatches. Italy is sixth, with 8,322,925.

The French Telegraphs.—M. Maurice Faure, in the recent discussion of the telegraph estimates by the Budget Committee, animadverted on the practice of communicating private telegrams to Government departments, and urged that this should only be done in the case of telegrams of interest to the State. The *Temps* points out that the abuse is much more extensive. "Telegraph clerks frequently divulge messages to their acquaintances, so that a whole village is informed of the contents of a telegram even before it reaches the recipient." Prefects, moreover, make copies of all messages, and "in Paris the duplicates sent to the Ministry of the Interior afford much amusement to the clerks." Expensive telegrams from distant countries to the *Temps* have been communicated to other newspapers on friendly terms with telegraph clerks. The *Temps* might have added that in Paris every telegram addressed to, or sent by any prominent man is communicated to the President and six or seven of the Ministers. It may be remembered that during the crisis of 1877 the Paris newspapers in this way professed to quote from *The Times* a telegram which, though sent to it, had not been published by it.

Horse Racing by Electric Light.—The racecourse at Maspeth, Long Island, belonging to the Newtown Jockey Club, has been lighted by electricity, and is the second American course where the electric light has been introduced, the first being that at St. Louis. The novelty is reported to have proved a complete success. The Maspeth racecourse is half a mile long, and closed in by a high fence of white board. The track is lighted at night by clusters of glow lamps suspended over the middle of the course, the light being thrown down by reflectors. The horses as they run round are followed by powerful search lights. Arc and glow lamps light up the grounds and grand stand. The electric plant includes two 115 H.P. engines, and two Edison 100-kilowatt generators. There are 200 clusters of four 32-c.p. lamps each over the track, 100 32-c.p. lamps distributed about the entrances, betting ring, offices, &c., 50 16-c.p. lamps, 28 arc lamps, and three 6,000-c.p. search lights. During the race the load is 1,050 amperes at 135 volts. The track is wired in three sections, and these sections in turn are wired so that, if one machine were to break down, alternate clusters of lamps would burn, so that the chances of the course being thrown into total darkness are very remote.

Areas of Circles.—The area of a circle = diameter squared × ·7854. To facilitate the calculation, Mr. J. Macfarlane Gray many years ago published the following remarkable rule for multiplying by 0·7854:—Multiply by ·7, repeat, double, repeat; writing each successive product one place to the right.

```
·7    = 1 × ·7
 7    = repeat
 14   = double
  14  = repeat
─────────────────
·7854 = 1 × ·7854
```

or again:—

```
432
 ·7
───
302·4
 30·24
  6·048
  ·6048
──────
339·2928 = 432 × ·7854
```

The M'Evoy Submarine Detector.—It is now a little over a year since the Russian monitor "Rusalka" foundered with all hands in a storm in the Gulf of Finland. Steps were subsequently taken by the Russian Government to discover the precise locality of the ill-fated vessel. The expedition consisted of a flotilla of several vessels, equipped with divers and all necessary apparatus, including one of Capt. M'Evoy's submarine detectors, which was specially made for the purpose. The precise position has now been localised in 30 fathoms of water by means of the submarine detector, a brief description of which has appeared in our columns. The apparatus is based on the principle of Prof. Hughes's induction balance. There are two primary coils and two secondary coils, one pair being on deck, the other in the sinker which is trailed along the bottom. The two primaries are in series, and are traversed by an intermittent current, the two secondaries are in opposition. Before being used the apparatus is adjusted so that under ordinary circumstances little or no sound is heard in a telephone placed in the secondary circuit. Three hundred feet of electrical cable were employed with the detector in searching for the "Rusalka," and the depths searched varied from 15 to 50 fathoms. The search was continued for several weeks, and the exact position of the foundered vessel was at length placed beyond all question, as every time the searching steamer passed over a given spot the electric indicator of the detector sounded loudly, thus affording evidence that a large mass of iron was submerged below. After the vessel had been located the divers descended and examined her. Although most appropriate for the purpose of searching for wrecks of iron ships, the submarine detector was not primarily designed by Capt. M'Evoy with that sole view. His main object was to provide a means of indicating the approach of iron ships to anchored torpedoes, as well as of searching for stray torpedoes, lost anchors and chains, telegraph cables, and the like. The approach of a mass of iron, such as an enemy's ironclad, to the torpedo disturbs the balance and causes the sounds to become audible in the telephone. The torpedo may then be fired electrically by means of the cable connection, the invention thus presenting itself as an important adjunct of coast defence.

Light Railways.—An interesting example of the manner in which light railways may be successfully equipped and managed is, says *Engineering*, afforded by a line of this character which has been at work for two years in the department of Loiret, in France. It has termini 22 kilometres apart, at Pithiviers and Toury, both of which are stations of existing railways. The Conseil Général, or County Council, decided to construct the line out of their own funds, primarily for the development of the beetroot industry, and also because it promised to save the roads by transferring part of the heavier traffic to the railway. After construction the line was leased to contractors, an

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arrangement being made that the department should contribute half the difference when the receipts fell below a certain minimum, the Company, on the other hand, to pay over half the excess of receipts above a specified maximum. The line essentially differs from the railways of this country. It is laid at one side of the highway, without any kind of separation from the rest of the road reserved for cart and carriage traffic. But though thus similar to, it is different from steam tramways, for the rails are of the ordinary railway pattern, laid on steel sleepers and ballasted. The gauge is only 2ft. One great advantage of this narrow gauge and the portable permanent way adopted, is that farmers and others can readily lay down a temporary siding, which can be easily moved about to any field or barn where there are a few loads to be picked up, an advantage which has been largely realised. The passenger carriages are of the tramway type, and the waggons for goods are constructed to carry 10 tons each. Stations are represented by a weighing machine and a small office to hold parcels. Tickets to passengers are issued on the train by the guard, so that the working staff is small. The cost of building and equipping the line was £1,555 per mile, and it appears to have rendered nearly all the services to the district which a line costing £10,000 a mile could have afforded. Last year it carried 27,225 passengers, and during the beetroot season it carried in two months over 15,000 tons of beetroot—a smaller quantity than will probably form the average, the crop being a very poor one. The department had to pay the contractors a small sum last year, but they hope in a few years to realise 4 or 5 per cent. on their small outlay.

Engineering as a Learned Profession.—It is not so long ago that the claim of the engineer to be considered a professional man received, says *Engineering*, but a grudging assent, and that he was treated merely as a superior kind of mechanic. That time is now past, but even at the present day the public does not exactly class his calling among the "learned professions." The lawyer, the divine, and the doctor all stand on assured ground in the public imagination, but the engineer comes under a different classification. This results, we take it, from the scant literature associated with the science of engineering. Every clergyman is supposed to have a study filled with the "Fathers," and other ponderous tomes, and it is imagined that the greater part of the time is spent in that apartment in the perusal of erudite works, both ancient and modern. The lawyer brings his books into court with him, and sometimes the benches are completely covered with records of cases and expositions of principles. Whole libraries are composed entirely of legal works, and grow daily larger with the reports of voluminous judgments, incomprehensible to the lay mind. The doctor, too, has his books, and if these are not so large and numerous, they are still more difficult of comprehension than those of the lawyer. But the public knows nothing of the engineer's books. They look upon him, if he be more than a manufacturer, as a kind of genius who arrives at his results by inspiration, aided by a certain amount of mathematics. They regard his abilities as something that he was born into, like the colour of his hair or the size of his feet, and while they admire the results of his work, they do not feel that he deserves any special personal reverence. The engineer suffers, too, in the popular esteem, as compared with the members of older callings, in having no professional manner. He is too like other men to strike the popular fancy. The judge on the bench, even the family solicitor in his office, is something above and apart from ordinary humanity. The parson never forgets his calling, and seldom discards his uniform. The doctor, although often a jolly good fellow away from home, cannot afford to gain a reputation for levity in his own district; an imposing deportment is of more use to him in securing patients than the closest study. And so it follows that all these men are called "learned." They have their books, and they never let anyone find out how much—or how little—they know of them. Their demeanour is a coat of mail against the shafts of curiosity, and they are judged by the ponderousness of their armour.

The Minimum Current Audible in the Telephone.—In a Paper read before the British Association at Oxford, and published in the *Philosophical Magazine* for September, Lord Rayleigh states that the estimates which have been put forward of the minimum current perceptible in the Bell telephone vary largely. Mr. Preece gives 6×10^{-13} ampere; Prof. Tait, for a current reversed 500 times per second, 2×10^{-12} ampere; De la Rue gives 1×10^{-8} ampere; Prof. Ferraris, 5×10^{-9} ampere for a frequency of 514. The telephones employed by Lord Rayleigh in his experiments were two, of which one (T_1) was of 70 ohms, and the other (T_2) of ·8 ohm. In order to keep clear of complications due to self-induction, in the earlier experiments a resistance coil of 100,000 ohms, constructed, as usual, of wire doubled upon itself was employed. But it was found that the sound was nearly as loud when the 100,000 ohms was included as when a 10,000-ohm coil was substituted for it. Inquiry showed that the anomaly was due to condenser action of the doubled wire. To obtain electromotive forces of the necessary harmonic type a magnet revolving in the proximity of an inductor-coil was used. The magnet used was of clock-spring, about 2½cm. long, bent so as to be driven directly windmill fashion from an organ bellows. The coil used in most of the experiments was the one employed as the "suspended coil" in Lord Rayleigh's determination of the electro-chemical equivalent of silver; it is wound on an ebonite ring, has 242 convolutions, 10½ ohms resistance, and a mean radius of 10·25cm. When the magnet was driven full speed a frequency of 307 was obtained. To extend the determinations to higher frequencies, recourse was had to magnetised tuning-forks. In making the observations the current from the inductor-coil was led to a distance by leads of doubled wire, and was there connected to the telephone and resistances. Among the latter was a plumbago resistance of about 84,000 ohms; but in most of the experiments a resistance-box going up to 10,000 ohms was employed. The attempt to hit off the least possible sound was found to be very fatiguing and unsatisfactory; and in all the results recorded the sounds were adjusted so as to be *easily* audible after attention for a few seconds. Experiment showed that the resistance could then be *doubled* without losing the sound, although perhaps it would not be caught at once by an unprepared ear. It would appear as a net result that the maximum sensitiveness to current occurs in the region of frequency 640, the current in telephone T_1 being then $4{\cdot}4 \times 10^{-8}$ ampere; but observations at still higher frequencies would, Lord Rayleigh adds, be needed to establish this conclusion beyond doubt. Attention must be paid to the fact that the sounds were not the least that could be heard, and that before a comparison is made with the numbers given by other experimenters there should be a division by two, if not by three. Lord Rayleigh concludes by pointing out that measurements with the electro-dynamometer have been made by Cross and Page of the currents used in practical telephony. The currents found were of the order 2×10^{-4} amperes.——In this connection Carl Barus points out in the October number of the *American Journal of Science* that the alleged extreme sensitiveness of the telephone warrants one in replacing the galvanometer in a shunted circuit for the measurement of electromotive force (zero method) by the telephone. Devising a special key for the purpose, he made the test, but did not find the extreme sensitiveness stated. Even in specially-wound telephones of 6,000 turns of wire, the best result he could obtain was an audibility of 10^{-7} ampere, under the following remarkable conditions:—For increments of current amounting to $3{\cdot}1 \times 10^{-7}$ on either side of zero, the telephone did not respond at all. On both margins of this silent field, however, the response came in a way to make further increments of only 10^{-7} ampere quite distinguishable in loudness. Here, therefore, says the author, is a true discontinuity, for the extent of the interval of silence is at least five times the sensitiveness of the telephone on and beyond the margins of this interval. In the great variety of experiments made this result was the invariable feature, the silent interval being in some cases even 10 or 20 times the marginal sensitiveness. He interprets this to mean that the diaphragm of a telephone when in a state of rest initially resists deformation with a kind of molecular *quiescent friction*; and that this inertness must first be overcome by the actuating field before the diaphragm responds nicely to fine gradations of stress.

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ELECTRIC MOTIVE POWER.*

BY ALBION T. SNELL.

(*Concluded from page 688.*)

While mentioning the subject of weight it may be remarked that if it be desirable to limit the weight of a coal cutter to, say, 10cwt., which is about as much as *one* man can shift about a pit with the aid of crowbars, it may be worth while to pay special regard to the making of a light machine. But if it be necessary from any cause, such as the need for a machine of greater capacity, to increase the dead weight much beyond the limit just mentioned, then it appears to the author to be a matter of little importance whether the machine weighs 20cwt., 30cwt., or even 40cwt. In either case it is too heavy to be handled without special tools, and a screw jack is as much a part of its equipment as it is of a locomotive's. In fact, with the larger type of electric machines the increase of weight is by no means an unmixed evil, for it gives increased stability, and no matter how rough the road, or uneven the dirt, the machine rides steadily through it all.

A side-wheel coal-cutter designed by the author and Mr. Major Waterhouse, of Glass Houghton Collieries, about four years ago is shown in Figs. 125, 126, and 127, which are plan, longitudinal, and end views. Much detail is left out in order to show up the main features. It will be noticed that the design roughly resembles that of the Yorkshire Engine Company's compressed air machine. But, in fact, the whole of the details have been modified to suit the increased rate of speed and to accommodate the gearing. The machine was built to hole 3ft. 6in. in a seam 34in. in height, on a *level* with the floor, this being the first machine so designed. The maximum height above the rails was 22in. The cutter made from 80 to 100 revolutions per minute in various kinds of shale and coal, no difficulty being found from their hardness or even from iron pyrites. The weight was about 35cwt. At least two men were found to be necessary to work the machine, and in soft coal with a rapid feed a third was required to keep the wheel from being fouled by the coal. The wheel was designed to run in either direction, but the inventors always arranged the cutters to feed the cuttings out at the back of the machine instead of the front, as is frequently done in air machines. It was found, however, that the wheel did not sufficiently clear itself, and that a man was required to shovel out the loose coal at the front from time to time. The power absorbed did not vary so much as was expected. The automatic feed, actuated by a worm and wheel from the first cross shaft, nicely adjusted the speed of the machine to the resistance of the cut. The motor was wound in simple series, and thus the current varied in proportion to the torque. And, since the pressure decreased slightly as the load increased, the tendency was to equalise the power absorbed and to vary the rate of feed with the degree of resistance to the cutters.

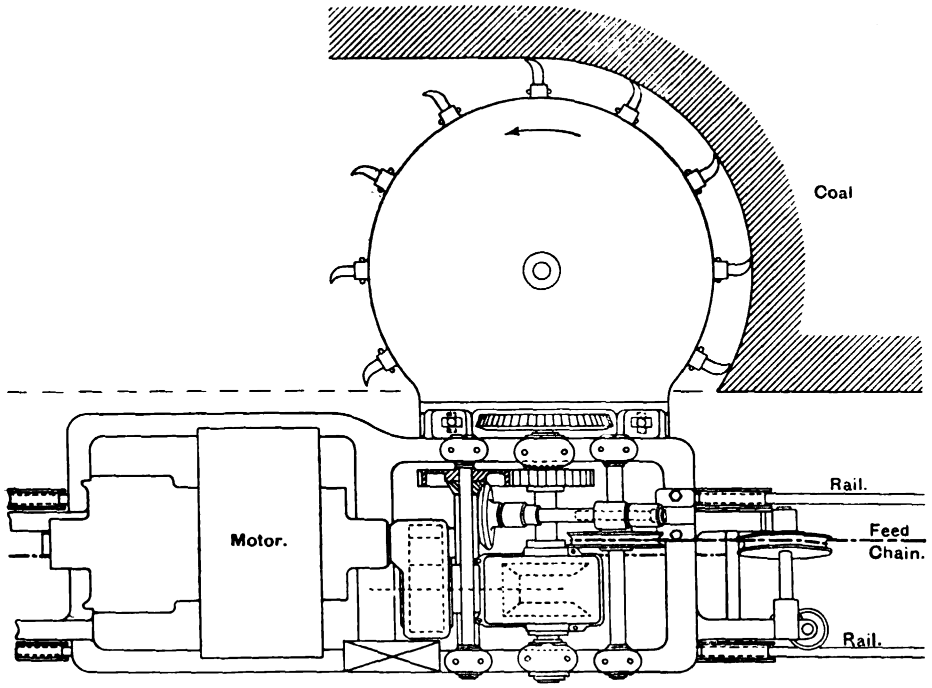

Fig. 125.—Snell-Waterhouse Coal Cutter. Plan.

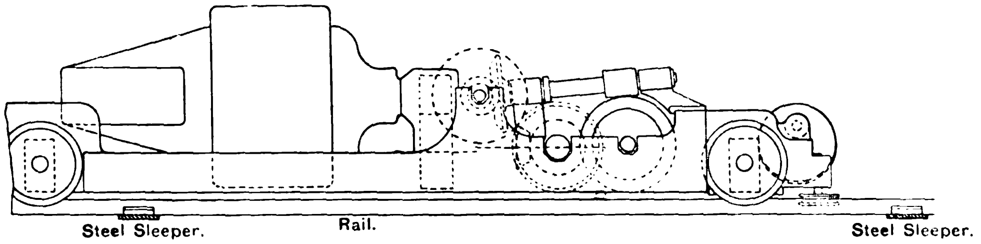

Fig. 126.—Snell-Waterhouse Coal Cutter. Longitudinal View.

The advantage of the wheel machine compared with the rotary bar lies in the low head room required, and perhaps in the enormous capacity of the wheel on long walls where the conditions are favourable. The writer, however, has never come across a machine which had anything like a chance of working continuously, and so reaching the theoretical output. This must necessarily be the case in the majority of pits, and the most useful machine is that which under the given conditions of normal working will give the largest average output, and not a maximum output for a short time under the best conditions.

The chief difficulties met with at Glass Houghton were due to the peculiar formation of the seam, which is 22in. in height

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with a thin parting near the middle. The holeing was made on the level of the floor in the fireclay, and presented no serious difficulty. But the lower coal broke away from the parting, leaving the tops in position, and frequently fouled the wheel before a cut could be made sufficiently long for the introduction of wedges. Under these conditions the time wasted in clearing the wheel more than counterbalanced any gain from the high rate of speed at which the machine holed when the coal remained firmly in position. A bar cutter might have succeeded here if more head room had been permissible, for it is obvious that the fall of coal behind the bar or even on the top of it would not be so serious as with a side wheel. But in this case the large number of iron balls in the clay were held to be an obstacle in the way of the bar cutter, and, in addition, the bar could not be made to cut *perfectly* level with the flooring as was desirable. The power absorbed varied from 10 to

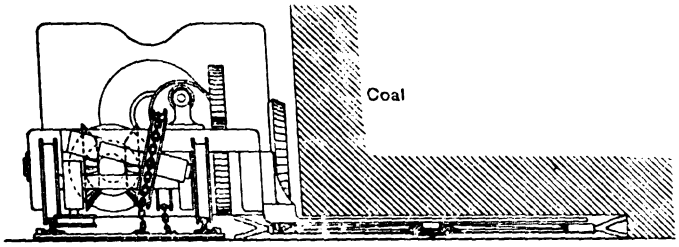

Fig. 127.—Snell-Waterhouse Coal Cutter. End View.

17 E.H.P. The motor was designed to give 15 B.H.P. at about 800 revolutions, and was of the armoured type adopted by Messrs. Lahmeyer and other Continental firms, but not much known in England. The design is well adapted for use on a coal-cutting machine, as the massive field-magnets protect the field windings and the armature from damage by falls of roof or accidental injury during working.

At the present there are a few electric side-wheel machines running in Yorkshire collieries which have been developed from the Glass Houghton one, but no particulars of their working have been published. But under suitable conditions they must give economic results.

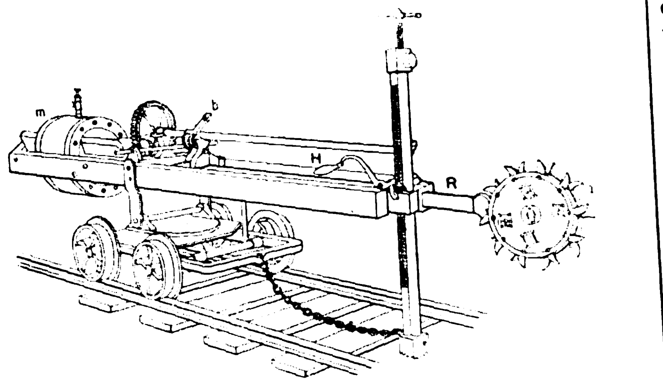

Fig. 128.—Messrs. Wantling and Johnson's Electric Coal Cutter and Heading Machine.

A smaller type rotary wheel machine of American origin is shown in Fig. 128. It is the invention of Messrs. Wantling and Johnson, and was shown at the World's Fair Exhibition, Chicago, 1893. The writer has no particulars about its performance, but it seems to be a practical machine. It is adapted for making vertical or horizontal cuts, but cannot be set to cut level with the floor. It appears to be especially suitable for heading work. The cutter wheels are shown in plan in Fig. 129. There are two wheels revolving in opposite directions to each other. Their diameter can be made to suit requirements. The sketch in Fig. 128 shows the machine arranged for heading, in which case it is always parallel with the rails. For long-wall or pillar and stall working the motor and cutter would be at right angles to the rails and the coal. The method of steadying the cutter is clearly indicated.

The Thomson-Houston "Mowing Machine" coal-cutter, presents several features entirely different to any of the preceding machines. It may be regarded as a modification of the band coal cutters. The teeth are carried on a chain which passes round an overhanging arm capable of rotation through an arc of nearly 180 deg. It appears to be suitable for long-wall working. There does not appear to be any definite information published with respect to its performances.

In spite of the apparent advantages to be derived from the application of electric power to rock and coal drills, there does not seem to be much progress made in this direction. The reasons for this are probably partly the same as those already referred to which have hindered the introduction of mechanical coal-getting, and, in addition, the cost of the conductors, no doubt, has been in many cases prohibitive. But there are also some difficulties peculiar to the work.

Driving stone drifts is about as rough work as can be imagined, and the men employed are as rough as the work. But more important than even the rough treatment is the question of ventilation. Obviously, when driving a heading, there is a tendency for the air to stagnate, and there is difficulty in removing the fumes of powder after shots are fired

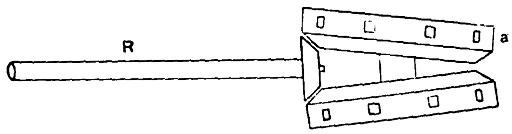

Fig. 129.—Plan of Cutter Wheels of Messrs. Wantling and Johnson's Electric Coal Cutter.

unless fresh air can be brought up to the face. Now the compressed air drill exactly meets this requirement. The exhaust from the drill causes a steady draught which cools and purifies the air, and powder fumes can always be cleared away by turning on a little air. The electric drill, on the contrary, tends, if anything, to increase the difficulty, for the power wasted in the drill raises the temperature of the air at the face of the heading. This disadvantage is probably sufficient, in many cases, to render the use of electric drills impracticable, the mere question of cost of boring (gauged, usually, by work done in well-ventilated spots) being altogether subordinated to other considerations. Of course, for a variety of purposes, such as quarrying, working in well-ventilated spots, &c., these objections have no weight. But even under the most favourable circumstances the electric drill does not seem to have made much progress.

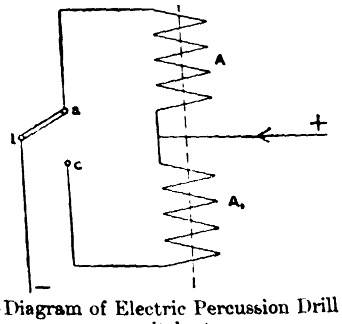

Fig. 130.—Diagram of Electric Percussion Drill with two-way switch at *a c*.

There are two main principles upon which rock drills are designed: the rotary and the percussive.

The rotary type is usually driven through gearing from a small motor. The percussion type is sometimes worked by a motor winding up a coiled spring, which at the proper moment uncoils and spends its energy upon the drill shaft; and, in others, the principle of magnetic attraction is used, the drill shaft being attached directly to the iron core of a solenoid.

Hitherto the motor-driven drills have proved to be the more successful in general work. Several firms build these machines, each having a different way of gearing the motor to the drill shaft, but the general principle is the same. The best known in this country, as well as in America, is the Jeffrey drill. It is chiefly used for working in hard coal, and is found to give satisfactory results. In general the makers design the motors to work at a pressure of 220 volts; but this can be varied to suit special requirements. The rated output of the drills for 2in. holes is

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2 H.P., but a factor of safety of two is allowed. They are stated to drill, in the hard "boney" found in anthracite mines, a 2in. hole, 6ft. deep, in from 2min. to 2½min., while in the coal they will cut a similar hole in less than a minute. One of these drills is in use at Newbattle Colliery, Dalkeith. The manager, Mr. John Morison, reports that it makes, in the hard splint coal, a 2in. hole, 4ft. deep, in the space of 5min., including the setting of the drill. This, he adds, is equal to the work of four men, while the Jeffrey drill only requires one man.

Various English firms have built electric drills for mining work, but, judging from the number in use, none of these have been so successful as the Jeffrey drill.

The reciprocating action of a solenoid is apparently well suited for actuating percussion drills. Yet the solenoid, energised by a continuous current, is the least effective means of using magnetic power through comparatively long distances. Its proper function is to attract an armature through a very short range or to hold it firmly in position.* However, in spite of this manifest disadvantage, solenoidal action offers so many advantages in the design of percussive drills that it appears more than probable that this type of drill will ultimately come into more general use than the motor type. Therefore a brief reference to the subject may be useful.

The earliest attempts to utilise the principle were made in accordance with the diagram shown in Fig. 130. The current was supplied to the centre of two coils forming the solenoid, and was passed through them successively; the changing being controlled by means of a two-way switch, indicated at *a* and *c*. The iron shaft of the drill formed the core, and was attracted first by one coil and then by the other. This is a very wasteful design, for the power absorbed during the instroke is the same as that during the outstroke. In addition to this objection is the trouble given by the contacts at the switch points.

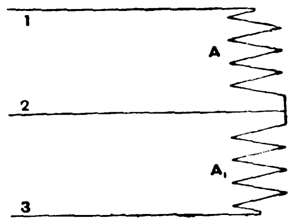

FIG. 131.—Diagram of Electric Percussion Drill, for use on a two-phase circuit. No switch required.

An improvement is possible by the use of a single solenoid drawing in a plunger against a strong coiled spring. The blow given by the recoil of the spring is very rapid, and resembles the impact of a hammer if the bit be at the right striking distance; and, further, the instroke is made comparatively slowly, and does not shake the drill carriage. In case the stroke is too short to strike the work a spring cushion is provided to receive the blow. The opening and closing of the circuit, however, remains, and practically renders the design useless.

A distinct advance is made by the use of pulsating or alternate currents, or a combination of them. There are many methods, but they all embody the following conditions: No switch is necessary, three or more wires are required, and also, in some cases, a special dynamo. The first is an absolute gain, for there is no trouble from sparking, and the two last are not serious difficulties when it is considered that these drills are only likely to be used in mines and places where it will pay to provide a suitable dynamo if the use of electric drills is deemed advisable. The simplest drill of this class is one coupled to a two-phase circuit as shown in Fig. 131; but it has the objection that the power used on the instroke is nearly as great as that on the outstroke. The number of blows given by drills of these types corresponds with the frequency of the alternator, and they are therefore adapted for delivering many quick light blows per minute rather than a few heavy blows. A frequency of from four to ten per second is found to give the best results.

A still better device is that applied in the Marvin drill. This is of the double solenoid type, and is one of the most successful in America. It is run off a special dynamo giving pulsating currents in two circuits. The connections are shown in Fig. 132. The dynamo armature in its simplest form has only one coil. One end of this is fixed to a continuous metal ring d_1, on which rubs the brush B_1. The other end of the coil is joined to a metal segment, d_2, extending for 180 deg. and concentric with d_1. Two brushes, B_2 and B_3, placed diametrically opposite to each other, rub against it. Three conductors are required; one from the middle point of the solenoid is coupled to B_1, and the ends of the coils are respectively joined to B_2 and B_3. The two coils successively carry a current, and so give reciprocating motion to the drill.

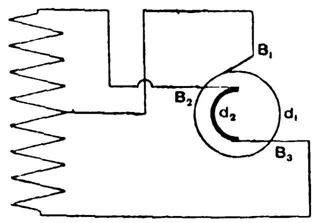

FIG. 132.—Diagram of Marvin Electric Percussion Drill. d_1, d_1, rings on dynamo; B_1, B_2, B_3, fixed brushes.

Probably the best results with reciprocating drills are likely to be obtained by the use of a combination of pulsating and alternating currents; for the instroke can then be made without much waste of power, and yet a very effective blow can be delivered at each outstroke. This principle has been applied in the Van Depoele electric percussion drill. One form of the arrangement is shown diagrammatically in Fig. 133. The dynamo may be of any continuous-current make, with an ordinary commutator, and the two usual fixed brushes at F_1 and F_2; but it requires the addition of two revolving brushes, R_1 and R_2, separated by 180 deg. The coils in the solenoid are three in number, 1 and 3, coupled in opposition to each other, having few turns relatively to the main coil 2. The connections are made as follows:—Coils 1 and 3 are in series with each other, and are coupled to the revolving brushes, R_1 and R_2; these coils are, therefore, traversed by an alternate

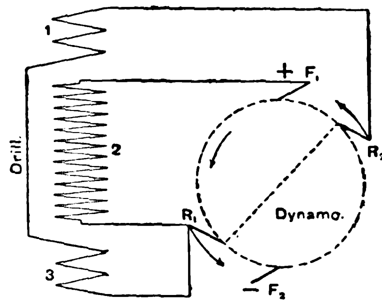

FIG. 133.—Diagram of Van Depoele Electric Percussion Drill. R_1, R_2, revolving brushes; F_1, F_2, fixed brushes; 1, 2, 3, coils of drill.

current. The coil 2 is coupled to the fixed brush F_1 at one end, and at the other to the junction of coil 3 with the rotating brush R_1; it is, therefore, energised by a pulsating current, and exerts the chief effect on the plunger with a polarity always in the same direction. The blow is made mainly by the action of the centre coil, the end coils practically neutralising each other. The return stroke is chiefly due to the resultant pull of the two end coils, as the centre one varies between zero and a maximum. At a first glance there seems to be a departure from simplicity of design without any compensating gain. But, on a closer examination, it will be seen that the design marks a considerable advance, and that the chief difficulties referred to in the early part of this section are met to a great extent.

The instroke can be made as light and the outstroke as heavy as required, both of these desirable ends being attained

* Prof. S. P. Thompson has recently demonstrated that an alternate-current magnet possesses very different properties from those of a continuous-current one. He shows that by means of an alternate current the pull of an electromagnet on its armature may be extended through comparatively long distances and may be even greater, at, say, three inches, than when closer. This important fact probably opens up a new field, and may, therefore, assist in the development of percussive drills.

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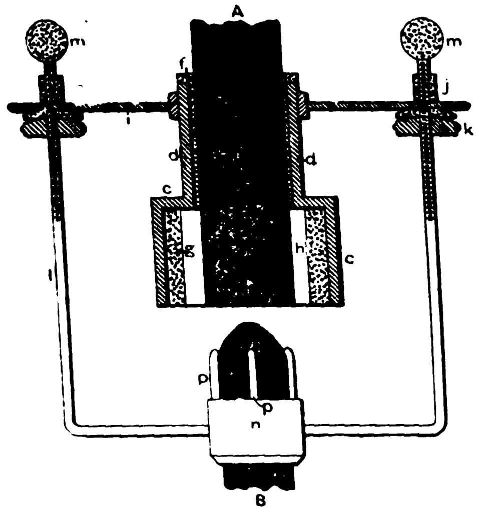
without the use of any switch or complicated gear in the drill. Also only three small conductors are required, and the dynamo gives a continuous current and can be used for lighting or motor work.

The chief difficulty likely to be experienced with the Van Depoele drill appears to lie in the heating of the iron cores from hysteresis and eddy currents. This, however, will be gradually overcome as experience suggests better methods of building the core and framing.

PROLONGING THE LIFE OF ARC LAMP CARBONS.

If it is desired to make a given length of carbon of a given diameter and supplied with a given current at a given pressure burn longer than it otherwise would, it is open to one either to alter the composition and make of the carbon itself or to alter the conditions under which it is burnt. The former mode of procedure has of late mainly occupied the attention of investigators in this country, whilst abroad, and especially in the United States (see *The Electrician*, Vol. XXXI., p. 502, and Vol. XXXIII., p. 592), the latter course has apparently received most attention.

The following is a curious device, due to Herr Francis Jehl and made by F. Hardtmuth and Co., of Vienna, and by the Allgemeine Elektricitäts Gesellschaft of Berlin. The accompanying illustration shows the "burner" in section. It consists of a metal hood, *c c*, surrounding the positive carbon A, the whole being supported by three platinum claws, *p p p*, clutching the negative carbon B. To the top of the hood are soldered the arms *i i*, which are provided with eyes and rest on the insulators *j j*. The upper portion of the apparatus is a cylindrical tube filled with insulating material, *f f*, in which the upper carbon slides easily. At the lower end there is a fireproof lining, *g g*. The upper carbon should project one to three millimetres beyond the hood, and for the purpose of this adjustment the rods *l l* are provided with a screw thread and nut, *k*. The insulating knobs *m m* prevent short circuits in the event of the apparatus coming into contact with the upper carbon.



The efficacy of this expedient depends upon the formation within the hollow chamber *h h* of a layer of more or less stagnant air, which takes the place of the constant stream of hot air which, under ordinary circumstances, always rises from the heated carbons, greatly increasing their rate of consumption.

According to tests by Prof. Schlenk, the consumption in a given time in the case of a 6-ampere arc without the Jehl device amounted to 14·1mm. for the positive and 15·5mm. for the negative (which was presumably of smaller diameter), against 4·9mm. and 10mm. respectively when the hood was used. Again, 9-ampere arcs using an 18mm. cored carbon and a 12mm. plain carbon, each 200mm. long, can be made to last 25 hours with the hood and using a 13mm. lower carbon, as against 9½ hours.

The first cost, average life, and attendant bother, must be taken into consideration before the practical engineer can arrive at the *net* gain obtained by the adoption of the Jehl hood.

A LUMINESCENCE LAMP.

Under this name Herr H. Ebert describes, in the current number of *Wiedemann's Annalen*, a lamp in which luminous paint is utilised to convert the energy of high-frequency alternating currents into light. The oscillations, which are specially adapted to this purpose, are regular and only slightly damped. They have a peculiar power of producing fluorescence and phosphorescence in a degree which is high when compared with the energy consumed. But great as is the luminosity of the phosphorescent body, it is not perceptibly heated by even the strongest alternating currents, and hence the energy consumed is so slight. The lamp consists of a glass tube containing a cake of luminous paint, such as that supplied by Messrs. Schuchardt under the name of "greenish-blue luminous paint." The tube is then sealed and mounted in a glass globe, which is highly exhausted and provided with tinfoil rings on the outside, carrying hooks for the conducting wires. As soon as electric oscillations impinge upon the tinfoil, cathode rays are formed in the interior normal to the surface of the glass, which, though only slightly luminous in themselves, produce vivid luminescence phenomena in the tube.

In order to obtain an idea of the economy of these luminous processes, which is exceedingly great, the author instituted a series of measurements; "but," he says, "it would lead too far to give all the details. I shall therefore only add some remarks concerning the results obtained, and reserve a further treatment of these questions to a future occasion.

The luminosities were measured by means of Glan's spectrum photometer, and compared with von Hefner-Alteneck's standard amyl-acetate lamp. Luminosities of $\frac{1}{30}$th to $\frac{1}{10}$th of an amyl unit were found. In determining the electric energy consumed such direct methods of measurement in the case of these high-frequency currents met with difficulties already emphasised from other quarters. Since, however, it was only a question of determining the order of magnitude, this energy was calculated.

The amount of energy present at each discharge on the secondary condenser was calculated with sufficient accuracy from the capacity of the terminal condenser and the effective potential, after allowing for the damping. It was further assumed, as the least favourable case, that the "luminescence lamp" introduced consumed all this energy alone. That this is not the case is apparent on placing another lamp or a simple exhausted tube beside it; it also shines, and the luminosity of the first lamp is only slightly reduced. Thus we obtain a superior limit of the amount of energy, while the energy actually consumed is sure to be much less. Yet it appears that in this manner it is easy to construct bright lamps which only consume *millionths of watts*. The economy of these lamps is correspondingly favourable. On comparing the brightness of these lamps in the visible spectrum with that of the amyl-acetate lamp, and calculating for both sources the *total* energy required for their maintenance (for the amyl-acetate lamp it is best to use the numbers given by E. Wiedemann or Tumlirz for the total radiation), it appears that this "high-frequency lamp" requires about 1,500 or 2,000 times less total energy than the standard lamp named. The "useful effect" is therefore very high."

The apparatus used for obtaining these high-frequency currents was a Lecher wire combination, provided with one bridge. The source of energy was an induction coil, an influence machine, or a sufficiently highly transformed alternate current. The dimensions of the primary and secondary circuits were chosen so as to insure the least possible amount of damping. The secondary condenser had an electrostatic capacity of $1{\cdot}1 \times 10^{-5}$ microfarad. The oscillations had wave-length of about 42m., and a frequency of about seven million per second. The logarithmic decrement of the oscillations in the secondary circuit was 5×10^{-4}. Thus, any given oscillation impulse would pass to and fro 20,000 times before falling to the 2·7th part of the original amplitude. By increasing the number of sparks, which does not require a large increase of energy, the pressure between the two branches of the secondary circuit may be kept in almost continuous alternation, since the damping is so small that the oscillations due to the next spark begin before those started by the last have died out. As regards practical difficulties to be overcome, the principal one would be the enormous inductive resistance offered to high-frequency currents by copper mains. But the transformation to the high frequency might take place at the lamp itself, especially as condensers of only small capacity and inductance could be employed.

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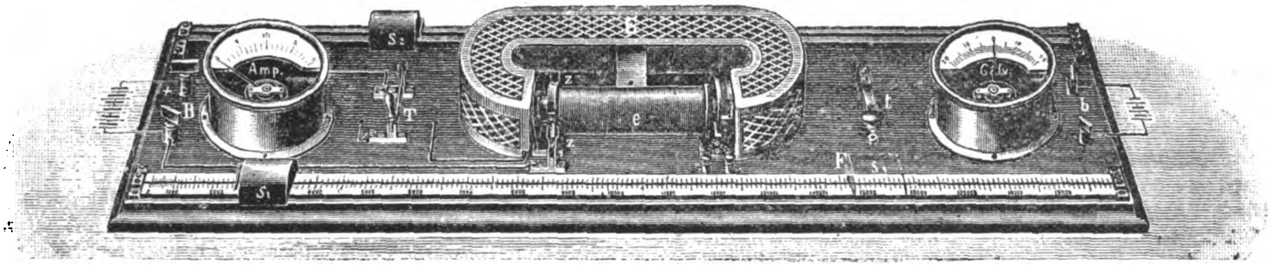
A MAGNETIC TESTING MACHINE.

In this instrument, which is made by Hartmann and Braun, the property possessed by bismuth of altering its resistance in a magnetic field is taken advantage of. A thin wire of chemically pure bismuth is prepared and insulated, wound into a flat coil non-inductively, and soldered to two flat copper strips held together in an ebonite holder, furnished with terminals; the coil being protected from injury by mica plates. If such a coil be placed in a magnetic field, the alteration of its resistance is a measure of the field; and a field of 1,000 corresponds to an alteration of resistance of about 5 per cent. The coil is only 1mm. thick, and can be introduced into narrow slits.

resistance; the measuring bridge being so arranged as to give the field directly in C.G.S. units. The measurement is performed as follows: a piece of the iron under test, as nearly as possible of the exact dimensions of the standard piece is taken, 200mm. long and 25mm. thick and is put through the loose coil, and placed between the electromagnet poles in such a manner as to be tight up against the left-hand pole. A source of E.M.F., preferably an accumulator giving current up to 15 amperes, is connected to the terminals B; and to *b* two or three cells are connected. Then the travelling contact S_1 of the front measuring wire is moved to zero on the wire, the key *t* is pressed, and the galvanometer brought to



The figure shows the apparatus. An oval magnet is fixed to the base board, one long side of which can be removed, and replaced by the test bar; on the board is also an ammeter with a strong switch, T, for measuring the magnetising current, and on the other side are a galvanometer and key, *t*, for measuring the zero by moving the slider S_2. Then the magnetising current is put on by closing T, its amount read on the ammeter, and a new balance obtained on the galvanometer by the slider S_1 and the key *t*. The field is then read on the front scale by the position of the slider S_1.

OPENING OF THE ELECTRIC SUPPLY STATION AT WORCESTER.

The formal inauguration of this important undertaking by the Corporation of Worcester took place on the 11th inst., a technical description of which has already been given to our readers. By invitation of the Mayor (Mr. G. H. Williamson) the members of City Council and other citizens, together with a number of electrical engineers, met at the Guildhall in the morning, and, preceded by mounted police, drove in brakes to the generating station at Powick. On arriving there the Mayor was presented with a gold key by the building contractor, Mr. Rowbotham, wherewith to open the large entrance door. This having been done, the party entered the generating station, where all the arrangements had been made for starting the machinery. The Mayor, in addressing the party, after dwelling on the fact that every ratepayer was a shareholder in this new enterprise, remarked that they would have a profitable business on the co-operative principle, and at the same time they would be selling a commodity which was a distinct advantage to the health of those who used it in preference to gas for illuminating purposes, and also would be a cheaper substitute. The Mayor then proceeded to deal with the proceedings taken in connection with the work, especially complimenting Mr. Preece on his great ability in preparing the scheme and advising them, the Brush Company on the manner their share of the work had been done, Mr. Caink (the city engineer), Mr. Rowbotham (the builder), and others who have been connected with the undertaking.

Mr. W. H. Preece, having spoken on the great advantages of having water power, remarked that a diagram showing the load on a station at different times of the day invariably pointed to the heaviest hours as being between 4 p.m. and 9 p.m., thus showing that for the remaining 19 hours the machinery is virtually idle, but it must be kept going. The result, he pointed out, was that the cost of electric lighting was much enhanced by the waste of fuel during those hours; whereas here, water running to waste, as the waters of the Teme had done for centuries past, gave them just the very agency that they required to keep the light going at a minimum of expense.

Mr. W. M. Mordey and Mr. Geipel, of the Brush Company, also spoke, the Mayor then starting one of the turbines, amid loud cheers, wishing "Success to the electrical works of Worcester" and "To the future reduction of rates."

The almost complete absence of noise in the working of the machinery was the subject of much remark. The Mayor then proceeded to the switchboard, and turned on the station lighting. After an inspection of the engine room and boiler house, the party left the station and drove to the waterworks. There an inspection of the electrical machinery being erected to pump water to the higher levels of the city took place, the party being addressed by Mr. Hughes, the Chairman of the Water Committee, Mr. Mordey, and the Mayor. The motors at the waterworks are supplied with power from the Powick water-power station.

Upon returning to the Guildhall, luncheon was provided by the Mayor in the Council Chamber, at which Sir Douglas Galton and others spoke. Luncheon over, the party proceeded to the Public Hall, where the Electrical Exhibition was opened by the Mayoress; a reception, at which there was a large attendance, being subsequently held.

The Exhibition, which has proved very attractive, includes examples of almost every application to electricity, thirteen firms taking part in it.

Later in the evening the Mayor entertained some 300 guests at a banquet held in the Guildhall to celebrate the inauguration of the electricity works.

A very pleasant evening was spent, thus bringing to a close one of the most eventful days in the modern history of the "faithful city," Worcester being thus named because of its loyalty to the Royal House of Stuart.

We may mention, in conclusion, that the lighting of the streets, Guildhall, and several private consumers, amounting to an equivalent of nearly 5,000 8-c.p. lamps, has proved most successful, and has worked without a hitch both on the opening night and since with water power entirely as its motive power. Our thanks are due to Mr. F. R. Davenport (Mr. W. H. Preece's representative) for particulars of the inauguration and working of the plant at the Worcester electric supply station, which will, we hope, prove to be not only one of the most interesting, but also one of the most successful stations in the kingdom.

BOOKS RECEIVED.

"Catalogue of the Michigan Mining School, 1892-1894."

"The Glasgow and West of Scotland Technical College Calendar. Session 1894-5." Price 1s. (Glasgow: R. Anderson.)

"City and Guilds of London Institute." Programme of Technological Examinations, Session 1894-95. Price 10d. net. (London; Whittaker and Co.)

"The Practical Designing of Structural Ironwork." By Henry Adams. Price 8s. 6d. (London: E and F. N. Spon. 1894.)

"Physical Measurements." By Dr. F. Kohlrausch. Third edition. Price 12s. 6d. Translated from the seventh German edition by Thomas Hutchinson Waller, B.A., and Henry Richardson Procter, F.I.C. (London: J. and A. Churchill.)

"Electric Transmission of Energy." By Gisbert Kapp. Fourth edition. Price 10s. 6d. (London: Whittaker and Co. 1894.)

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WATER-DRIVEN DYNAMOS.

On a former occasion we discussed the considerations which are involved in deciding whether a particular mill-site is worth using for the supply of electric power. We observed that there are but few mill-sites in this country where the conditions are at all favourable to the requirements of an electric generating station; and we remarked that when this side of the question has been settled, and the mill-site has been adopted, there still remains the question of the best way to arrange the hydraulic and electrical machinery. Probably the wide difference of opinion which might be expected from the engineering profession, as to the suitability of any given mill-site, would be as nothing to the range of views which would be advanced with regard to the best type and arrangement of machinery to adopt. As only one small electric supply station in this country, namely, that at Buckingham, is driven by old-fashioned waterwheels, and as this is an instance where the plant had been already erected before the electrical engineers took over the mill-site, it may fairly be supposed that engineers would be unanimously in favour of turbines.

But, to begin with, there are several different types of turbines, for the best makes of each one of which an astonishingly high efficiency is claimed by its maker; and, in the next place, there are a great many ways in which any given type of turbine may be set, in one and the same fall. It is this question of turbine setting which, from the electrical point of view, is of special importance. Whether, shall the turbine be placed so as to drive direct on to the dynamo shaft—most efficient of settings, but often awkward to arrange—and if so,

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shall the shaft be horizontal or vertical; or, shall the difficult knot be cut by sacrificing the direct-drive and employing all manner of gearing? Not merely fanciful considerations, but vital questions of economy are involved in the choice between these three plans.

Thus far, the practice in British water-power stations has been wholly in favour of the use of gearing; although it is by no means evident that this solution is the best possible one. There have been two causes which have influenced this choice. Firstly, the British mill-site is, even at its best, but a sorry business; so low in head, as a rule, and so liable to flood and frost and drought. From this cause it has been almost a necessity, and in some places quite a necessity, to use what are called "drowned" turbines—*i.e.*, turbines which can work below the level of the tail water, and which have all their passages full of water. It is easy enough to have a drowned turbine, but it is another thing to have a drowned generating station. Hence the difficulty of working by a direct-drive between the turbine and the dynamo on such falls as that at Worcester—falls where the drowning of the tail race is a regular occurrence which must be taken into account in the design of the station. But, it may be said, why not let the drowned turbine work directly on to the undrowned dynamos by means of a vertical shaft, as they do at Niagara? The answer which British water-power practice gives to this question is that there are other things to be taken into account. There is the ever-present necessity for steam plant, to meet the exigencies of frost and drought; and English engineers have not yet seen their way to building a steam engine which will drive a dynamo on a vertical shaft, although the very similar problem of so driving a vertical spindle centrifugal pump has long ago been solved. The experiment might be tried; it is by no means self-evident that it is better to stick to existing models and use the complicated and power-wasting gears, such as are to be found at Worcester and other places. However, in this need for steam plant, we may see the second of the two causes which have led to the adoption of geared plant wherever water-power has been used in this country for electric supply. Nor is the gearing of that simple kind which is to be found in the decadent practice at some steam-driven stations. A mere single drive with ropes is credited with from 6 to 10 per cent. "solid loss," as Mr. RAWORTH put it at the Institution of Electrical Engineers last session. What "solid loss," then, must be expected when there is not merely a single change of speed by rope or belt drive, but double or treble change with the use of bevel cog wheels and countershafts? We cannot accept as an answer that the waste of energy is unimportant, because "water power costs nothing." Water power costs nothing only in the same sense that coal costs nothing to the man who has previously purchased the freehold of a coalfield, and has sunk capital in developing it.

Nevertheless, whether the practice be good or bad, these are indubitably the causes which have developed the present type of British water-power station; a type which may be defined as a geared turbine station, with geared steam engines for reserves of power. Hitherto it cannot be said to have been a successful type; but it remains to be proved whether the element of failure is inherent in the mode of using water-power or in some other cause. We can never expect, in this country, to be able to adopt the type of water-power station which is common in Switzerland, Italy, and other countries where mill-sites are highly favourable; nor, it would seem, do engine builders think it worth while to so modify auxiliary steam plant as to render our own unfavourable mill-sites capable of being utilised in other than the present imperfect manner.

REVIEWS.

Die Prinzipien der Mechanik. In neuem Zusammenhange dargestellt. ("The Principles of Mechanics." Exhibited in a new form.) By HEINRICH HERTZ. (Leipzig: J. A. Barth. 1894.)

Although nearly a year has elapsed since the memorable death of Heinrich Hertz, fresh proofs are still continually afforded us of the marvellous insight into the intricacies of pure science which he displayed. The work which culminated in the almost complete verification of Maxwell's electromagnetic theory, would have been, in itself, more than sufficient to rank the name of Hertz with the greatest names in the annals of science; but, in addition to this, he has shown evidence of the most remarkable versatility in all scientific problems. We have hitherto known him as having been the greatest exponent of the powers of experimental research of his time; we now are shown his capabilities as a mathematician.

In the volume under consideration we have the result of his researches during the last three years of his life, which forms, indeed, a worthy sequel to the work which preceded it. The principles of mechanics are investigated by a new mathematical process, which is so perfectly arranged that all the results which have hitherto been obtained by independent methods of treatment in different hands, are brought into concordance as particular cases of the results of this treatment. Nor is this all. In most other treatises on mechanics, appeals are made to experience, by the aid of Newton's laws of motion, and the doctrine of the conservation of energy. In this book, Newton's first law is the only fact assumed from experience; the other two laws of motion, and the conservation of energy, are deduced from it. The results, too, are of such generality that some of them appear to be beyond the test of present experience, and their verification must be left to future research. It is unfortunate that, in a work of such magnitude, the finishing touches should not have been given by the author's hand; but the fact that the editing of the book has been delegated to Dr. P. H. Lenard, who has himself conducted a large number of important investigations in the same direction as Hertz, is sufficient guarantee of the care with which this has been carried out.

After a few introductory remarks by the editor concerning the intentions of the author with respect to the publication of the work, a preface is given by the late von Helmholtz, who was mainly instrumental in turning the thoughts of Hertz, when a student, in the direction in which he was afterwards to attain such brilliant results. This preface treats chiefly of the life and character of Hertz, with a history of his researches; and in addition gives a short account of the progress of the science of mechanics, and the evolution of the system adopted in the book.

In the introduction, the author gives an exceedingly interesting and valuable dissertation on the methods of scientific investigation, and enunciates the principles, which should guide us to the selection of the method most suited to the extension of our knowledge, and by which we may judge of the value of the conclusions derived. Three chief methods of treatment of the subject of mechanics are discussed in relation to these principles, the first being the customary method, in which the subject is historically treated, commencing with the principles of Archimedes, and thence to those of Galileo, Newton and Lagrange; the second, in which the conception of energy is fundamental, in addition to space, mass, and time; and the third method, in which space, mass, and time are fundamental independent conceptions, and that of force or energy is taken as a starting point. Of these three methods, the author discards the second, and considers the third most suitable. This method is adopted in the book.

The work is divided into two parts: the first, "On the Geometry and Kinematics of Material Systems," being devoted, as its title indicates, to the consideration of the relations of the fundamental conceptions of space, mass, and time, in accordance with the third method of treatment. In the

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first chapter these quantities are defined, space and time being considered as conceptions of our inner consciousness, whilst mass is defined as being made up of mass particles, each of which is "an attribute by which we distinguish between a known point of space at a given time and a known point of space at any other time (Ein Massenteilchen ist ein Merkmal durch welches wir einen bestimmten Punkt des Raumes zu einer gegebenen Zeit eindeutig zuordnen einem bestimmten Punkte des Raumes zu jeder anderen Zeit)."

The second chapter deals with methods of fixing the position of points in space, and the configuration of systems, together with the analytical treatment of finite displacements, in which the peculiar notation of the book is introduced. Each problem is considered in two ways; with respect to Cartesian co-ordinates, and to generalised co-ordinates. The notation is admirably adapted to the subject, but might possibly be even further improved by the introduction of vector methods, which would in most cases obviate the necessity for the duplication of results, and would assist the comprehension of their physical meaning. These methods, however, do not seem to have made the same advance in Germany that they have here. The third chapter gives the same treatment of infinitely small displacements.

The fourth chapter is devoted to the consideration of the possible and impossible displacements of material systems, and requires careful perusal. It commences with definitions of different classes of systems, and their relations; and gives their equations of condition, introducing the principle of virtual displacements. In Chapters 5 and 6, the conditions for the straightest and shortest paths are investigated by the method of undetermined multipliers, and also surfaces of position and their orthogonal trajectories, leading to Jacobi's law.

In the sixth and last chapter the Kinematics of systems are considered, in an account of the vector quantities of a system, and their components in various directions. The motion of systems, their velocity, momentum, acceleration, and energy are investigated; and, in conclusion, the elementary forms of Lagrange's equations are deduced.

The results given in this book, as the author states, appear very unusual when compared with experience. It must, however, be remembered that they are entirely deduced from our fundamental conceptions of space, mass and time; and do not in any way depend on experience, which, therefore, cannot be adduced in confirmation or contradiction of the results.

In the second book, entitled "The Mechanics of Material Systems," in accordance with the treatment indicated in the introduction, the results of the first book are assumed; and are brought into accordance with experience, by assuming a principle deduced from experience. Space, time, and mass are first re-defined with respect to our practical measurement of them, including the definitions of the first book; and material systems are also re-defined in accordance with these new definitions. In the second chapter the fundamental principle of the book—viz., Newton's first law of motion—is introduced, and this principle is discussed in its bearing on the results of the first book.

The third chapter treats of the motion of free systems, and first establishes Jacobi's law of least work, and the principle of the smallest time integral of energy. The differential equations of motion are then established, in Lagrange's forms for generalised co-ordinates, and in Poisson's and Hamilton's forms. Systems with internal constraint are then discussed, and D'Alembert's principle deduced. The motion of Holonomous systems is investigated, and also the theory of dynamic models.

In the fourth chapter constrained systems are dealt with, and force is introduced as being "the independent influence which the one, of two connected systems, exercises on the motion of the other, following the fundamental principle," from which Newton's third law is deduced. Motions of systems under the influence of external and internal forces are also investigated.

The fifth chapter is devoted to systems with virtual masses, and first treats of cyclical motion and its properties. This part is the most interesting and important to electrical students, as from these systems Maxwell's dynamic analogies to currents in circuits were deduced. Expressions are obtained for the equations of motion, corresponding to the laws of currents in circuits, and the energy and work of the system, corresponding to those of a current. Conservative systems are also treated of, and the usual result of the constancy of the sum of kinetic and potential energy deduced. Hamilton's potential functions are also studied.

In the sixth and last chapter discontinuous motions are discussed, and the theory of impulses. The equations of motion are studied for systems with external and internal impulses, and also for connected systems under the same circumstances.

In conclusion, the author considers the effect of the accuracy of the fundamental principles on the results deduced, and also the defensibility of applying these principles to systems under constraint.

The plan of the whole work appears to be most admirably adapted to the logical sequence of the theorems. It may almost be said that the science of mechanics has, in this book, been reduced to the same rigidity as that of geometry in Euclid.

The applications of such a work are not far to seek. It will probably give a new impulse to the mathematical treatment of molecular physics, which is at present pushed to the limits of the methods hitherto known. Such extensions, too, will probably prove the surest way of verifying or disproving the conclusions given. The problems which most immediately suggest themselves are those of the sciences of Thermodynamics and of Electromagnetism, and last, but not least, the problem of the constitution of matter. It is to this end that all our scientific investigations are tending, and it will be the greatest tribute to this, the last work of Heinrich Hertz, if, by its means, we are enabled to advance further towards that goal.

THE CHEMICAL THEORY OF ACCUMULATORS.—V.

BY E. J. WADE.

The thermo-chemistry of the discharge phenomena having been considered, it remains to examine it in its more purely chemical aspect. To begin with, the occluded gas theory may be put aside as having no evidence at all to support it, while, as has been already mentioned, the results of the experiments of Gladstone and Tribe, Frankland and others are directly against it. This practically limits the discharge reactions to the formation of one or both of two classes of compounds, namely, oxides (lower than PbO^2) and sulphates.

Now, it is a perfectly well-established property of the oxides of lead that none of them, with the exception of the peroxide (PbO^2), can exist unacted upon in solutions containing more than a very small percentage of free sulphuric acid. Litharge or massicot (monoxide PbO) is directly converted into lead sulphate with the liberation of water.

$$PbO + H^2SO^4 = PbSO^4 + H^2O.$$

The sesquioxide (Pb^2O^3) and minimum or red lead (Pb^3O^4) behave as if they were mixtures of monoxide and peroxide; that is to say, they break up into mixtures of sulphate and peroxide.

$$Pb^2O^3 + H^2SO^4 = PbO^2 + PbSO^4 + H^2O.$$
$$Pb^3O^4 + 2H^2SO^4 = PbO^2 + 2PbSO^4 + 2H^2O.$$

It is true that these reactions do not take place with great rapidity, and that a considerable time may elapse before the final portions of oxide are completely acted upon; but this is due to the protective powers of the insoluble sulphate, which, as fast as it is formed, clogs up the pores and impedes further access of acid to the interior of the mass; and this effect will naturally become more marked as the proportion of sulphate present increases.

In view of the above facts it seems unreasonable to suppose that oxides are formed or exist in lead cells in the presence of free sulphuric acid, as to do so implies that their chemical properties or affinities are then entirely modified in some way or another.

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Undoubtedly very incomplete sulphating, accompanied by the formation of large quantities of monoxide, did occur in many of the earlier forms of pasted cells, and occasionally in more recent ones, but a close examination would reveal the fact that in all such cases the supply of acid in the pores of the active material was insufficient, owing, either to the solution being too weak, or to imperfect diffusion from the active material itself being too dense and used in too large unbroken masses, such as are obtained when a considerable quantity of it is packed round a central conducting core or into a hollow receptacle. (This does not necessarily imply that comparatively large blocks of active material may never be used, for if they are sufficiently porous they may be far more efficient than a more subdivided material which does not possess this property in so high a degree.) The inevitable result of discharge under these circumstances is, that almost the whole of the acid is very soon withdrawn from the electrolyte immediately surrounding the inner surfaces of the electrodes, and then a formation of a mixture of monoxide and sulphate does certainly take place; but this cannot be considered to in any way represent the normal working conditions.

While, however, the assumption of the formation of oxides is opposed to all chemical knowledge, it appears at first sight that, as far as the positive electrode is concerned, it is equally opposed to the laws of electrolysis to assume a direct formation of sulphate, and in order to reconcile these two conflicting points of view the theory was propounded that although sulphate is the ultimate product, the reaction takes place in two stages; first a reduction of the peroxide to monoxide, which is a normal electrolytic action, and then an immediate conversion of the monoxide into sulphate by a heat-producing "secondary" or "local" action. With the exception of Mr. Swinburne, who has been an uncompromising advocate for the direct sulphating of the positive from the very first, this view has been the one most generally held since the publication of Messrs. Gladstone and Tribe's researches in 1883, and probably still remains so at the present time.

The electrolytical difficulty lies chiefly in comprehending how it is possible to obtain any E.M.F. from a cell in which the same compound is formed at both poles, much less for it to be proportional to the *sum* of the two effects; and the case is considered as if it were similar to that of two plates of zinc both dissolving in sulphuric acid to form zinc sulphate and neutralising each other's E.M.F. The objection is, however, only a superficial one, based on loose and erroneous news of what is essential for a galvanic action and the generation of an E.M F., and gives way when carefully looked into.

Consider the following electrolytic equations:—

$$\mathrm{Zn}\,|\,\mathrm{SO^4\,H^2}\ \ \mathrm{SO^4\,Cu}\,|\,\mathrm{C} = \mathrm{Zn\,SO^4}\ \ \mathrm{H^2\,SO^4}\ \ \mathrm{Cu}\ \ \ \mathrm{C} \quad (1)$$

$$\mathrm{Zn}\ \ \mathrm{SO^4\,H^2}\,|\,\mathrm{SO^4\,Cu}\,|\,\mathrm{SO^4}\,|\,\mathrm{C} = \mathrm{Zn\,SO^4}\,|\,\mathrm{H^2\,SO^4}\,|\,\mathrm{Cu\,SO^4}\,|\,\mathrm{C} \quad (2)$$

$$\mathrm{Zn}\,|\,\mathrm{SO^4\,H^2}\,|\,\mathrm{SO^4\,Zn}\ \ \mathrm{SO^4}\ \ \mathrm{C} = \mathrm{Zn\,SO^4}\ \ \mathrm{H^2\,SO^4}\ \ \mathrm{Zn\,SO^4}\ \ \mathrm{C} \quad (3)$$

$$\begin{array}{l} \mathrm{Pb}\ \ \mathrm{SO^4\,H^2}\,|\,\mathrm{O}\ \ \ \mathrm{Pb}\ \ \mathrm{SO^4}\ \ \mathrm{C} = \mathrm{Pb\,SO^4}\,|\,\mathrm{H^2}\ \ \mathrm{O}\ \ \ \mathrm{Pb^4\,SO}\,|\,\mathrm{C} \\ \qquad\qquad\qquad \mathrm{O}\,|\ \ \mathrm{H^2}\,| \qquad\qquad\qquad\qquad |\,\mathrm{O}\ \ \ \mathrm{H^2}\,| \end{array} \quad (4)$$

The first is that for the reactions taking place in a Daniel's cell, in which the zinc is immersed in dilute sulphuric acid and a carbon electrode used to receive the deposited copper; modifications of the most usual practice which can be, and, indeed, actually are sometimes made, without in any way interfering with the principles of the cell's action. As is well known, its E.M.F. and the resultant energy liberated are due to the difference between that generated in the formation of zinc sulphate at one pole, and that absorbed in the decomposition of an equivalent amount of copper sulphate at the other pole.

Equation (2) represents the same combination with the addition that free sulphion (SO^4) is supposed be present at the carbon electrode to combine with the copper which would otherwise be deposited. What may be termed a double depolarisation now goes on, the copper sulphate acting as a depolariser with respect to the hydrogen of the hydrogen sulphate (sulphuric acid) and the sulphion as a depolariser with respect to the copper of the copper sulphate; and the ultimate result is the *formation* of a compound at both poles—zinc sulphate at the one, and copper sulphate at the other; while the whole energy and E.M.F. due to the formation of zinc sulphate is now realised.

In equation (3) the copper sulphate is replaced by zinc sulphate solution. This does not affect the E.M.F. of the cell, which is still simply that of the formation of zinc sulphate or about 3 volts and yet *identically the same compound is now being simultaneously produced at both poles.* Of course, such a cell is not practical, because sulphion cannot be obtained in a free state and certainly could not exist as such in an aqueous solution; but if it is replaced by chlorine and, at the same time, zinc chloride substituted for zinc sulphate, and hydrogen chloride for hydrogen sulphate, a perfectly possible combination is obtained whose action may be represented by the following equation:—

$$\mathrm{Zn}\,|\,\mathrm{Cl^2\,H^2}\ \ \mathrm{Cl^2\,Zn}\,|\,\mathrm{Cl^2}\ \ \mathrm{C} = \mathrm{Zn\,Cl^2}\ \ \mathrm{H^2\,Cl^2}\,|\,\mathrm{Zn\,Cl^2}\ \ \mathrm{C}, \quad (5)$$

and one which also forms the same compound—now zinc chloride—at each electrode. The combination may be yet further simplified by doing away with the acid altogether, and placing the zinc direct in the zinc chloride solution without practically affecting its E.M.F. or the compound produced—still zinc chloride at both poles—

$$\mathrm{Zn}\ \ \mathrm{Cl^2\,Zn}\,|\,\mathrm{Cl^2}\,|\,\mathrm{C} = \mathrm{Zn\,Cl^2}\,|\,\mathrm{Zn\,Cl^2}\,|\,\mathrm{C}\,; \ . \ \ . \quad (6)$$

but it now corresponds to one—the "Upward" cell—which has been used with some considerable success for small lighting installations and other purposes, and gives an E M.F. of about two volts per cell in spite of this double formation of zinc chloride. Theoretically, the E.M.F. of such a combination lies between 2·1 and 2·4 volts, according to the strength of the solution.

To return to equation (4) which represents the discharge of a lead storage cell on the assumption that lead sulphate is formed at both electrodes; a backing of carbon instead of lead for the lead peroxide being supposed in order to facilitate comparison with the other equations. The peroxide acts as a depolariser towards the hydrogen of the acid, half of its oxygen being abstracted, and a further portion of acid acts as a depolariser towards the mon-oxide so formed, with the production of lead sulphate and water; but there are no grounds for discriminating between the two actions and saying the one is electrolytic and the other not, any more than there would be for treating the combination of zinc and copper with sulphion in equations (2) and (3) or with chlorine in equations (5) and (6)—the similarity of whose reactions will at once be observed—as mere heat-producing secondary actions.

The fact is, the whole tendency of modern theories of galvanic and electrolytic action is to show that the old time distinctions between "primary" and "secondary" actions is purely artificial and cannot be maintained. Only a few months back Ostwald emphasised this point in a Paper, reproduced in *The Electrician* for June 29th of the present year, on "Modern Electro-Chemical Theory and its Bearing upon the Practice of the Future," and showed that the whole of the reactions, *as indicated by the ultimate products at either pole*, must be considered equally electrolytic. The specific example selected to illustrate the subject was singularly apt, being the stock textbook one of the electrolysis of a solution of potassium sulphate, which was always said to be first split up into potassium and sulphion by a primary electrolytic action and then these substances combined with water to form potassic hydrate with the liberation of hydrogen, and hydrogen sulphate with the liberation of oxygen, by a secondary chemical action. Now, however, the only action that can in any way be considered as secondary is the gradual combination that will take place, *not at the electrodes* but in the body of the solution, between the free potassic hydrate and free sulphuric acid to reform potassium sulphate.

As regards the negative electrode, no difficulties stand in the way of assuming its direct conversion into sulphate; in fact, this appears to be the only action possible. It is well known that in strong solutions of acid, it takes place by local action with a liberation of hydrogen, exactly in the same way as zinc is acted upon, and the tendency must exist, therefore, in weaker solutions. Doubtless, however, low oxides and hydrates will also be produced should the solution be abnormally weakened

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in correspondence with the modifications that take place at the positive electrode under these conditions.

So much, then, for the *a priori* arguments based on deductions from general chemical and electro-chemical principles, and which are all in favour of the double sulphating theory of discharge. How, now, is this conclusion supported by direct observation and experiment?

Owing to the difficult nature of the chemical analyses involved, extremely few reliable and systematic investigations are available. Those, to which frequent reference has already been made, of Messrs. Gladstone and Tribe and of Dr. Frankland in 1883, both proved that sulphate was formed in increasing quantities as the discharge proceeded, and was the only normal product at either electrode. Very few details are given as to the precise nature of the cells, but small pasted plates, specially prepared for the purpose, appear to have been employed. Seven years later Prof. Ayrton made public the results of some experiments performed under far more practical conditions, which fully confirmed the above conclusions. Cells of a well-known type (E P.S. 7L, 1888 type) were used, and were charged and discharged at their normal working current. At various periods during these processes portions of the active material were abstracted from both electrodes and subjected to analysis by Mr. Robertson; while at the same time all changes in their colour, degree of hardness, &c., were carefully noted. All the figures are given, however, in terms of the *percentage* composition of the paste, and, in no case, were any quantitative analyses made in the sense of determining the *total* quantity of sulphate formed or peroxide reduced, so it is impossible to institute any comparison with the amounts calculated from the ampere-hours obtained. The same result may be arrived at, however, by considering the amount of acid withdrawn from the electrolyte, as indicated by changes in its specific gravity; but the liquid must be kept uniform by stirring or other means, and even then the results will only be approximately correct, as the acid in the plates will never be quite the same strength as that surrounding them, unless they are exceptionally thin. Such observations have been made by Frankland, Shenck and Farbaky, Kohlrausch and Heim, Ayrton and many others, some of which agree fairly well with the hypothesis of the formation of normal sulphate, while others show considerable discrepancies, and have been used to support arguments in favour of basic sulphates; but it is more probable that they are really due to experimental errors from the cause given above.

The real arguments in favour of the formation of basic sulphate lie in quite another direction. The difficulty of forming a perfectly satisfactory physical conception of the way in which large quantities of lead sulphate can be alternately produced and broken up during the processes of discharge and charge, was referred to in the second article of this series, and the direction in which an explanation must be sought suggested; but it is now time to examine into the question a little more fully.

In the first place it must be borne in mind that the active material in all electrodes, whether of the Faure, Planté, or any other type, is obtained by its reduction, either chemically or electro-chemically, from other compounds more bulky than itself, and exists in a state of molecular subdivision far finer than could be produced by any mechanical means. The electrolyte may be considered, therefore, as having a more or less free access to almost every individual molecule of which it is composed, and at the commencement of discharge the formation of sulphate will take place more or less uniformly throughout the whole mass. Now, one of the most frequently observed facts with regard to lead storage cells has been the large percentage of material that remains unacted upon at both electrodes at the end of a discharge. In some early experiments of Mr. Swinburne's he found this to be over 90 per cent., and the proportion differs probably with every different type of cell, but 50 per cent. appears to be the maximum proportion that is ever converted into sulphate during a normal discharge, even under the most favourable conditions; that is to say, every molecule of sulphate at both the positive and negative electrodes has left, as a backing, a molecule of peroxide and metallic lead respectively; and, on recharging, the current is by their means distributed to every portion of the electrode. The sulphate, being so intimately mixed with the unreduced material, cannot impart to it its characteristic white colour, but only causes the electrodes to assume a lighter tint. If, however—owing to over discharging or to local action while at rest, especially when partially discharged—still more sulphate is formed, it must necessarily begin to aggregate into masses which will be more distinctly visible and more difficult to reduce in proportion as their size increases, because the conductive backing is destroyed and the current has no means of reaching them, and hence the formation of that irreducible "white sulphate" so disagreeable to all who have had practical experience of lead storage cells.

This appears to be the most probable explanation of the physical behaviour of the cells, if only the normal lead sulphate $PbSO^4$ is assumed to be produced; but it can be made more complete and satisfactory if the formation of other sulphates is allowed to be possible.

In this case, considering the positive electrode first, every molecule of normal sulphate formed may be supposed to further enter into combination with a molecule of unreduced peroxide to form the basic sulphate $PbSO^4, PbO^2$. The combination is in all probability an extremely feeble one, just a stage beyond the most intimate mixture; but it will, no doubt, endow the sulphate with a certain degree of electrical conductivity, and render its subsequent reduction far more feasible, while the resultant colour will also be something between that of its two component parts. According to this theory "sulphating," commonly so called, now consists in the breaking up of each molecule of the basic sulphate to form two molecules of normal sulphate,

$$\left.\begin{array}{l}PbSO^4\\PbO^2\end{array}\right\} + H^2 + H^2SO^4 = 2\,PbSO^4 + 2\,H^2O,$$

and takes place when the supply of uncombined peroxide runs short, the action being made evident by the appearance of the non-conducting white compound.

This theory is substantially that advanced by Dr. Frankland, who believes he has isolated such basic sulphates; but they break up so easily into mere mixtures that no positive proof of their presence in cells has ever been obtained, while many think they do not exist. Indirectly, however, a good many facts seem to lend support to the possibility of some such compound being formed at the positive electrode.

In the first place all lead salts enter into basic combinations with the greatest ease, a fact which Mendeléeff has emphasised in his well-known treatise on chemistry.

Secondly, it is extremely significant that a positive electrode should be practically exhausted when at most only 50 per cent. of its peroxide is converted into normal sulphate, for this is just the percentage corresponding to the conversion of the *whole* of the peroxide into *basic* sulphate. Up to this point the discharge process will have been greatly facilitated, and have proceeded pretty easily owing to the whole mass remaining more or less conductive; but now a formation of normal non-conductive sulphate sets in which rapidly covers all the free surfaces with an insulating film, and almost entirely stops any further action. An analysis made by Mr. Robinson of some sediment that fell from some positive plates discharged down to a potential difference of 1·6 volts in one of Prof. Ayrton's experiments gave a composition almost identical with PbO^2, $PbSO^4$; and in the course of some other analyses he observed that the residues left after dissolving out the peroxide with nitric acid, although presumably pure normal sulphate, were a brownish yellow colour, and only became white after boiling with the acid, which is very suggestive of basic salts.

As regards the negative electrode, it is almost invariably assumed that only normal sulphate is produced during discharge, and yet it is here more especially that such an action is most difficult to understand, for, troublesome as it may be to oxidise lead sulphate, it is many times more troublesome to reduce it, except in almost infinitesimal quantities.

M. Darrieus has indeed recognised this difficulty, and endeavoured to explain it by propounding the theory that the formation of sulphate at the negative electrode takes place in two stages. First, suboxide of lead (Pb^2O) is formed, presumably at the expense of the water in the electrolyte—and then this

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substance is acted upon by the acid, and converted into a mixture of normal lead sulphate and metallic lead, the latter serving as a nucleus to the former and not being further attacked; but such an explanation does not really advance matters any further than the simpler one given above, which assumes a direct formation of lead sulphate round a metallic nucleus.

Although such a suggestion does not before appear to have been made nor, indeed, such a compound isolated, yet it would be a real help in this connection to assume the formation of a sub-sulphate of lead (Pb^2SO^4) corresponding to the sub-oxide Pb^2O. This latter substance is with difficulty distinguished from a mixture of monoxide and metallic lead (in fact, it is described as such in some text-books) when under the action of chemical re-agents; and, in the same way, the sub-sulphate would act like a mixture of normal sulphate and metallic lead when subjected to analysis. It would, too, in all probability, have a considerable conductivity and, therefore, be easily reduced on charging, while its colour would no doubt be some shade of grey. "Sulphating" would consist in the conversion of a molecule of sub-sulphate into two molecules of normal sulphate,

$$Pb^2SO^4 + SO^4 = 2PbSO^4,$$

and only when this had taken place would it be possible for that formation of peroxide to begin which causes such a rapid drop of E.M.F.

Particulars are given in Prof. Ayrton's Paper as to the variations in hardness of the active material during discharge, and it will be found that while the positive paste became exceedingly hard, that at the negative gradually became softer, a fact which does not seem compatible with the formation of one and the same compound, *i.e.*, normal lead sulphate, at both electrodes, but rather favours the theories just given.

(To be concluded.)

NOTES ON ELECTRIC TRAMWAYS IN THE UNITED STATES AND CANADA.*

BY H. D. WILKINSON.

(Continued from page 703.)

This leads me to the question of the use of city water mains and gas pipes as return conductors. At Milwaukee, Wisconsin, where this was first brought under my observation, I was informed by the city engineer, Mr. G. H. Benzenberg, that considerable difficulty had been experienced. City water mains and service pipes had become corroded in from two to three years, the action being most marked near the power stations. An attempt was made by the passing of an ordinance to stop the tramway companies connecting their rails to any pipes whatever; but the matter had gone too far, and the benefit to the latter companies in reducing volt losses by so doing was so marked that the practice was still carried on in spite of this ordinance. The matter was at length remedied by obliging the companies to make good connections to the water mains at the nearest points to the power house where the current left the pipes, such connections being taken right on to the switchboard return. The point proved was that pipes were affected at points where the current left them, like anodes in an electrolyte, and that protection could be afforded by putting a conductor instead of the electrolyte to earth. In this way pipes in an affected district could be thoroughly protected, but at considerable expense. It was evidently better to put such conductors to the rails direct, and not connect to pipes at all.

I saw several specimens of lead and cast-iron pipes that had been corroded and cut out, and have reproduced a photograph of some of the larger pipes in Fig. 9. Mr. Benzenberg informed me that the matter was cropping up in several cities, and that at the meeting of the Association of Waterworks Engineers last September great prominence was given to the subject.

I was, unfortunately, unable to visit Boston and Cambridge and see the extensive electric tramway systems and the enormous power houses there; but, partly by communications with Mr. Morse, and partly from Boston engineers who visited the Exposition, I was informed of some of the experience gained on these points in those cities.

The amount of return current to deal with can be imagined when it is known that the West End Railroad Company have an output of 12,000 H.P. This is distributed from three stations, of which the one at East Cambridge alone has an output of 6,000 amperes. Considering, also, that of 270 miles of track more than half is of 56lb. and 70lb. rails, laid years ago, and either bonded indifferently or not at all, it is not surprising that pipes and cables which were metallically connected to the rails in places should be affected. The information I have from authentic sources is that the water and gas mains and lead-armoured telephone cables suffered to a very great extent. The Bell Telephone Company tried earthing their cables by connecting them to lead plates buried in manholes, but this afforded no protection from the very heavy currents passing.

A curious experience was gone through in this city in reversing the direction of current. The supplementary wires resorted to as a means of increasing the conductivity of the track became corroded to such an extent that when a car passed an affected section a difference of potential was set up between rails and earth sufficient to cause shocks to people and horses. This effect was so great towards the end of the year 1891 that the West End Railroad Company reversed their current, making the rails positive and the trolley wire negative. The current then left the station by the earth connection, including all piping in the station, and the condenser pipes were attacked. Other troubles arose at fresh points, where the current left the city pipes to get on to the rails, and to obviate these the current was again reversed, making the trolley

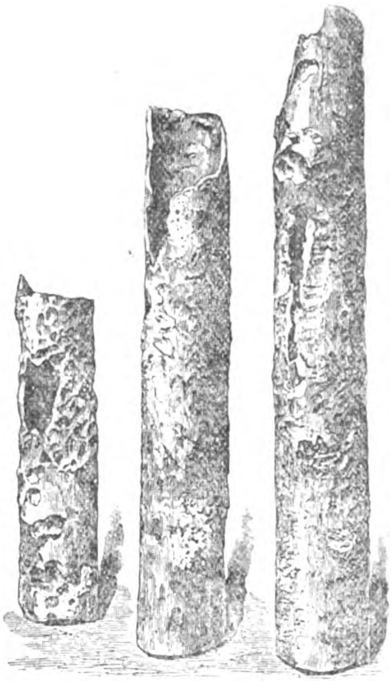

Fig. 9.

wires positive again. The action was then noticed in places near the power house where the current left the pipes, and this was overcome by making heavy copper connections to the pipes in these places, and carrying the same to the negative poles of the generators in the power house. It was also found that gas pipes had to be treated in the same manner, and soldered connections were made between gas and water pipes in all large buildings and in places in the streets.

Where the return currents reached 12,000 to 15,000 amperes the ground along the track was found to be heated, and return feeders from heavily loaded points had to be used. These were tapped down near the station to underground pipes, as it was found that if this was not done the pipes entering the station were at a difference of potential—sometimes as much as 5 volts—sufficient to heat an iron wire between them, with consequent danger of fire.

Mr. Morse, in a comprehensive Paper on this question before the New England Water Works Association at Boston, Mass., in January, 1893, describes having tried covering pipes with cracked stone, and in muddy places bedding them in cement, as a protection; but this was costly, and of no use unless done completely over the whole pipe system.

The trouble with electrolysis in this city I take to be due to the exceptionally large outputs and indifferently bonded rails. The city has purchased experience at heavy cost, but which has been of benefit to others. The adoption of return feeders and good bonding on later lines, with freedom from these troubles, has been one

* This Paper will be discussed early in the course of the next session of the Institution of Electrical Engineers.

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result. At the same time the congested condition of current density has raised the question of some other means of distributing current to cars. One method about to be tried in Boston and Cambridge is the three-wire, or zone, system. The rail or earth return would then be the neutral wire, and the sections of trolley-wire would be alternately positive and negative. The section of the trolley and feed wires within a circle of, say, one mile of the power station would be at 500 volts positive potential, and the outer sections 500 volts negative. Further, this section might be again divided into half or quarter-mile zones, or further sub-divided, thus practically preventing any flow of current in the earth. By this means the potential and volume of current would be distributed more evenly over the circuit, and there would be less concentration of current at power houses. The current would return by the insulated feeders. On the other hand, there would be a current flowing through the rails or earth from the cars on one section to cars on another; but this would supply power to twice as many cars as on the two-wire system. On rare occasions, if all cars happened to be banked on one section or a set of sections at one potential, the action would be like a two-wire system, and the current return by rails and earth to the station. The spark, on passing an insulated junction between trolley wires of opposite potential, could easily be deadened by a small high-resistance shunt across the break. The general advantage of such a system cannot be pronounced upon until it has been tried; but, as far as the return current is concerned, it appears to offer considerable relief.

I should mention here that in Boston the experiment was tried of welding the fish-plates to the rails, thus making a permanent and reliable electrical joint. The Johnson Company, after obtaining good results on 3,000ft. of experimental track, were empowered to weld 16 miles for the West End Street Railroad Company, and during two years the rails have shown no tendency to buckle. During this winter, however, I learn that the rails have broken into sections of a few hundred feet, due to contraction, the fractures always occurring near the weld. I believe, however, that this is the right method, and may still be modified to give successful results. The bond should be made outside the fish-plates, allowing a loop for contraction, and the poles of the welder should be arranged to distribute the heat gradually from the weld, and so prevent abnormal strain of the metal. The absence of dissimilar metals in the joint ensures its permanency as long as the rail itself lasts, both as regards local action and expansion.

Reviewing the circumstances attending electrolytic action, as far as I have been able to gain information on the spot, I find that these troubles have chiefly been traced to insufficient conductivity at the rail joints, and to the want of proper return conductivity in the shape of feeders. When traffic on the lines increases, or extensions take place, and the increased power is drawn from the same supply station, either the bonds must be increased in sectional area (if they have not been put in at first of sufficient size for ultimate demands), or return feeders must be run to relieve the bonds, otherwise the consequence will be that the current will be crowded out of the rails into the earth. This is what has actually taken place on some systems in the States, and the current has been allowed to take its own course until the heating of rail joints and bonds has drawn attention to the want of conductivity. This crowding out occurs on the main or trunk lines, into which several branch lines converge. On simple lines, or those from which no branch lines radiate, it is less liable to occur, as even with an excessive volt loss per mile the density of current is well within the capacity of ordinary single bonds. Take, for instance, a line of three miles of double track between A and B (Fig. 10), and consider it first with no branch lines. Say we have a three-minute service of cars, and the average speed, allowing for stoppages, is $7\frac{1}{2}$ miles per hour. The cars will then be three-eighths of a mile apart, and there will be eight cars on each track. With two motors per car the current will be about 25 amperes at maximum speed; but some cars will be starting, and using 100 amperes, and we may take a time average right through of 50 amperes per car. The maximum current returning to the power station from A will then be 800, and the maximum at B 100 amperes. The resistance of copper bonds varies according to method of bonding, length and size of bond wire, and whether it is double or single. Per mile run of rail the bonds may be from one-sixth to twice or three times the resistance of the rail. Taking a 70lb. rail with low-resistance bonds, say of No. 000 gauge, 12in. long, and fixed double, we shall have the resistances per mile of rail 0·0344 ohm of bonds (176 to the mile) 0·0056 ohm—total, 0·04 ohm, or 0·01 ohm for the double track. The voltage loss will therefore be 1 volt per mile per 100 amperes. Working this out for the varying strength of current on different portions of the return, we have a loss of 10 volts on $1\frac{1}{2}$ miles from A to P, and 4 volts on an equal distance from P to B—total, 14 volts.

Suppose, now, a branch line is laid from P to C, also of $1\frac{1}{2}$ miles, with cars at same speed, and same rate of service. This will then absorb 4 volts, but the loss between P and A on the trunk line will be increased to 19 volts; and if another similar branch, P to D, is added, the loss on the trunk line becomes 28 volts, or a total of 32 volts on the whole. When it is considered that with a theoretical continuous rail without bonds this loss is only reduced by 5 volts, it will be seen that to prevent waste of energy, quite apart from reducing current density, we must connect return feeders to the rails on the trunk line.

Now, considering the current density, we have in the trunk line, when the two branches are in operation, a current of 1,300 amperes at P and 2,400 amperes at A. The maximum current per rail is therefore 600 amperes, and this on 7 sq. in. gives a density of 86 amperes per square inch of rail (equivalent to 510 amperes per square inch of copper). This could be increased four or five times before any sensible rise of temperature would take place in the rail; but, considering the bonds, whose sectional area per rail is 0·262 sq. in., we find we have a density of 2,290 amperes per square inch. It would probably take very little increase of current beyond this to cause heating of the bonds and crowding out of current into the earth; and yet the bonds on many lines in the States have less sectional area than the one cited, and the currents are from twice to four or five times as great, producing far higher densities in the bonds than they can carry. I am convinced that this is the cause of most of the electrolytic troubles in the States. Trunk lines, into which a number of branch suburban lines feed, are frequently of considerable length, and cars necessarily move slower in consequence of their accumulation on one line. Not only on account of the number of cars, but also because of their slower speed and frequent restarting, the current put on to the rails is very much increased, and the density in the bonds becomes far more than they can carry. We have seen that it is not a question of resistance or conductivity of the bond, as the voltage loss beyond that on a perfectly continuous rail is only increased by about one-sixth of that lost on the rail, and therefore the increasing of the conductivity confers no appreciable benefit so far as reducing voltage is concerned. The question is one of sectional area of bond with reference to the ultimate maximum current it is expected to carry, and this, I think, should not exceed 2,000 amperes per square inch.

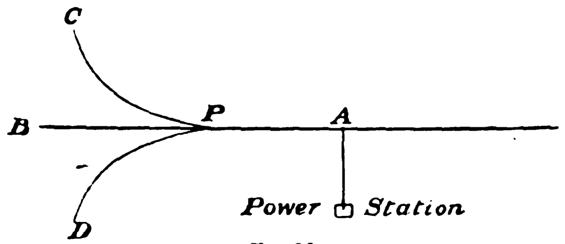

Fig. 10.

The sectional area of the bond refers as much to those portions in contact with the rail at the joint or joints, as to that of the single or double-bond wire itself.

I cannot leave this portion of my Paper without a tribute to the pioneer work and enterprise of our transatlantic cousins. They meet every difficult squarely in the face, and in spite of all obstacles "get there all the same." Our designs must necessarily comply with more conditions than are exacted in America; but when our difficulties have been the same our friends have generously been ever ready to impart their experience.

I will only touch upon one of the Board of Trade Regulations, viz., rule 7, similar to which is rule 9 of the Draft Regulations for Underground Electric Railways. In its draft form rule 7 exacted that the original or recorded resistance of the return should be maintained constant, with a maximum allowable increase of 15 per cent. In its amended form the same idea is carried out; but the element of current strength is included, namely, the product of resistance with current—that is, the difference of potential between extreme ends of the line—and this must not exceed 7 volts. The framing of the rule, I take it, was aimed at securing a low density of current in the rail, thus preventing the crowding out of which I have spoken, and placing the pipes of gas and water companies beyond all harm. It seems to me that this end is not altogether accomplished, because with a given difference of potential, however low, it is possible to have a very high density in the bonds, with a very low one in the rails. In other words, under complete compliance with the rule the bonds may be carrying far too high a density and shedding their current into the earth. Referring for a moment to the example considered above, a heavier rail might be laid with bonds of less sectional area and still not alter the difference of potential at the ends of the uninsulated return. A 90lb. rail would have 0·0268 ohm per mile—that is, 0·0076 less than the 70lb. rail—and this difference could be made up of smaller bonds of less carrying capacity. By using single bonds of No. 00 gauge (0·104 square inch section) instead of double of No. 000 (0·131 square inch section), this is obtained very closely, and we have the resistance per mile of rail 0·0268 ohm, of bonds 0·0142—total, 0·0410, or 0·01

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ohm for the double track, as before. The difference of potential at the ends of the uninsulated return for the same currents is, therefore, unchanged; but the densities are very different. That in the rail is reduced to 66 amperes per square inch (equivalent to 400 amperes per square inch of copper), while that in the bonds is increased to 5,760 amperes per square inch—nearly three times more than the limit I alluded to. Some of this density is relieved, of course, by the conductivity of the fish-plates; but this is of such a variable and unreliable nature that it should not be reckoned upon. Density, of course, can and should be relieved by return feeders, and these would be necessary on most lines of any extent to keep the volt loss within the required limit; but even with return feeders and low density in the rails I have shown that there might still be too great a density in the bonds, if these were not of sufficient section. Further, it appears to me that a limit of volts per mile would be equally effectual and more workable than a certain limit for lines of all lengths and traffic.

Having endeavoured to put before you the results of my observations, I may say that I am convinced that bonds should be of sectional area proportioned to load, which will materially lessen cost of return feeders; and, secondly, at points on the rails chosen with regard to load, return feeders should be connected of such section as to relieve the density of current in the rail. By return feeders I do not mean supplementary wires or connections to water pipes, but metallic conductors either above or below ground; not necessarily insulated, but connected direct from the rails to the power station. Supplementary wires are of no use unless increased in section as the current increases, so as to keep an approximately constant density, and this I have never seen done; while making connections to water pipes is a makeshift at best, and one that shows a want of good design. I believe that by designing the return circuit of electric tramways in the manner I have indicated we shall keep clear of electrolytic troubles upon gas and water pipes, and ensure an unhandicapped career for electric traction in this country.

I now come to systems in which the return is insulated from earth; namely, those using the overhead double trolley and the underground conduit. I was much interested in the double-trolley system working in the city of Cincinnati, Ohio, and wished to ascertain whether the insulation from earth was well maintained, and of sufficient benefit to warrant the use of such a system. I received the greatest courtesy during my stay in that city from Mr. George Hornung, civil engineer; Mr. H. P. Bradford, of the Cincinnati Inclined Plane Railway Company (using single trolley); Mr. Kilgour, of the Consolidated Street Railway Company (using double trolley); and Mr. Wm. J. Clark, of the General Electric Company, with whom I visited the power houses and inspected the lines. I shall not easily forget my first impressions of double-trolley working, as I passed through Fourth-street to Fountain-square, in the busiest part of this city, on the morning after my aarival; cable cars, double and single-trolley cars, and horse cars followed each other in rapid succession, often on the same track; but the most startling thing was the immense amount of trolley and span wires suspended over the roadways, with all the necessary adjuncts of insulators, guard wires, frogs, and separators. I watched several of the double-trolley cars rounding curves, and observed that the trolleys frequently jumped off the wires, and that the conductor on the car had to keep his eyes on the trolleys and steer them with the cord on passing curves.

A good deal of extra complication was due to the presence of single-trolley wires along double-trolley tracks, and the necessary use of span wires in the narrow streets of the city. Out in the suburbs, however, the double-trolley construction was seen to better advantage, as the wide roads allowed for centre-pole construction. The rumour prevailed in other cities that the double-trolley system was on its last legs; but, so far from that being the case, I found that the Board of Affairs of the city had just granted the Company powers to lay 50 additional miles of double-trolley track, the mileage then in operation being about the same in extent. No doubt the rumour arose from the fact that this was the only city in the States (with the exception, I believe, of a small line at Rochester) that employed the system, and the history of its rise in Cincinnati was remarkable. The first to be put down was a single-trolley line, which was opposed by the telephone company on the ground of interference. Litigation resulted in favour of the latter company; but the tramway company appealed on two or three judgments to higher courts, and eventually got a verdict in their favour. During the progress of this litigation a new tramway company was financed by those most largely interested in the telephone company, with the view of proving that double-trolley was the only way out of telephone interference, and to force the hands of the single-trolley company. Mishaps in winter, however, in the earliest days of its adoption, favoured the final appeal above alluded to, and ended in metallic returns being put on telephone lines instead. The position remains unaltered to-day, and both trolley systems prosper.

I found that the insulation of the double-trolley lines was good, so far as the overhead construction was concerned; but that it frequently broke down at the motors, thus putting one or other trolley line to earth. To show what kind of insulation existed, my friends and I boarded a single-trolley car, stopped it, and pulled the trolley arm off the single wire on to one of the double-trolley wires; the lamps lit up inside the car showing an earth on one main of about 200 volts. The leak was not sufficient, however, to run the car, but it appeared that in wet weather this was frequently done. Again, in the Hunt-street station, an earth indicator was permanently fixed, consisting of two rows of five lamps, in series. Each row was connected between one of the trolley wires and earth, and I observed during my visit to this station that one of these rows was lighted up to nearly full candle-power. The light was fluctuating slightly, which appeared to indicate that the earth was on a moving car; at all events, I was informed that such earths were of frequent occurrence, and went off as suddenly as they came on, but did not affect good working. Earths on a line were "spotted" after all cars were home for the night by switching off one section after another while full power was kept on. The leakage current on two lengths of twelve and nine miles of double track joined in multiple with all cars off, was 12 amperes, under the full pressure of 500 volts.

The cost of street work in America for double-trolley construction is about £650 per mile, the items being as follows:—

	£	s.	d.
100 iron poles	£260	0	0
100 hangers	17	0	0
100 solder cars	5	0	0
70 strain insulators	4	9	8
3,000 feet span wire	12	0	0
10,560 feet No. 1 copper trolley wire	84	9	8
5,280 feet No. 0000 feed wire	211	4	0
25 3-foot cross arms	0	15	0
50 glass insulators	0	12	0
200 sacks of cement	12	0	0
15 loads broken stone	4	10	0
5 loads sand	0	15	0
Labour and superintendence	45	0	0
	£657	15	4

This is about one-third more than the cost of single-trolley construction; but against this must be put the dispensing with bonds.

While this system is out of place in cities and confined thoroughfares, and, indeed, wherever span wires must be used, I believe it offers some advantages for heavy passenger traffic or goods traffic in suburban districts. It offers immunity from leakage currents to earth, for such can only take place when more than one earth is on the line. There is, therefore, no anxiety as to electrolytic action on pipes, even with the heaviest currents, no interference with telephones, and it is not necessary to bond the rails. With neat iron poles and ornamental cross brackets the line is not at all unsightly in the centre of the road. On some lines the appearance is improved by clusters of incandescent lamps, with reflectors, on every second or third post, and all feeder cables kept underground. The only objection to the system is the amount of overhead work at curves, turn-outs, and crossings; but it certainly holds its own in Cincinnati for smooth and rapid transit, and has proved itself a commercial success. On the table are some photos of the city for members to examine, showing some of the overhead construction. I have here also a specimen of the Kisinger splicing tube, by which breakages in trolley wires are rapidly repaired (Fig. 11). I witnessed two breakages in one street, which took only five minutes each to repair by means of these tubes. The broken ends are pulled up and put in the tube, and then the dogs slipped in through the slot. When the tackle is slacked off the ends are locked, and an excellent electrical joint made without soldering. For working at the wires an emergency waggon with folding ladder is used, and joints have been made in 3½ minutes, including picking up broken ends from the street.

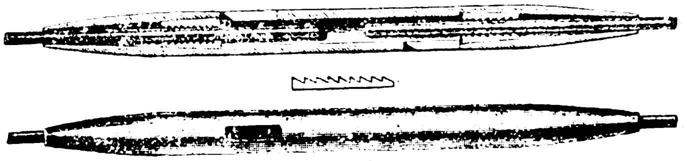

Fig. 11.

I now pass to the consideration of underground conduit lines, also using an insulated return.

During my stay in Chicago, the extensive plant of the North Side Tramway Company, consisting of gas motors fixed to special cars, suffered almost complete destruction by fire. As there had been serious complaints of the noise and smell of these gas motors, the Company endeavoured to get a clause revoked in their franchise which prohibited their using an overhead trolley line. Their intention to equip their line in this manner, however, met with

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great opposition from property holders, tradesmen, and insurance companies, and the clause was not struck out by the City Council. Previously, however (in March, 1892), in consequence of this clause, the Company had equipped about a mile and a quarter of their line electrically with an underground conduit on the Love system. I found this in successful operation last year, and made a few notes on it, which, I hope, may prove of interest. The illustrations (Figs. 12 and 13) show sections of the line construction and roadway. The depth excavated below the road level is only

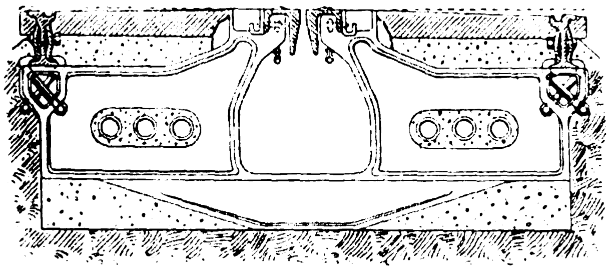

FIG. 12.—Yoke.

2ft., involving no trouble or expense while laying the track in diverting pipes along the route, as is so often necessary in laying a cable track.

The slot rails are in 32ft. lengths, and bolted to the yokes every 4ft. Pockets, or small hand holes, are provided in the road over every bolt, so that, if required, the rails can quickly be removed, and the conductors and insulators exposed to view. The slot rails are spaced for a ⅝in. slot, and shaped with 5in. inside lips, so as to shed water into the conduit clear of the wires. The track rails are held by claw bolts to the yokes, as shown, and the whole construc-

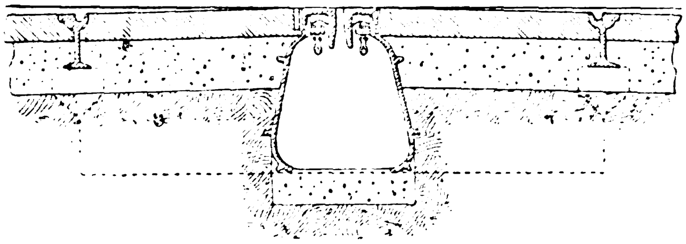

FIG. 13.—Conduit.

tion rests on a bed of 6in. concrete, and is packed round with concrete as a bed for the stone blocks of the roadway. In the webs of the yokes spaces are left for laying pipes to contain feeder wires, the conductors being in sections of 500ft. The conductors are of bare copper rod, nearly half an inch diameter, grooved longitudinally, and suspended from loose-fitting gun-metal clips, or ears, as shown (Fig. 14). The stalk of each clip is secured to a block of pressed mica or other insulating material, B, which is suspended from two shoulder bolts bolted to the yoke. To allow for expansion of the conductors, the blocks are free to move about 2½in. on the

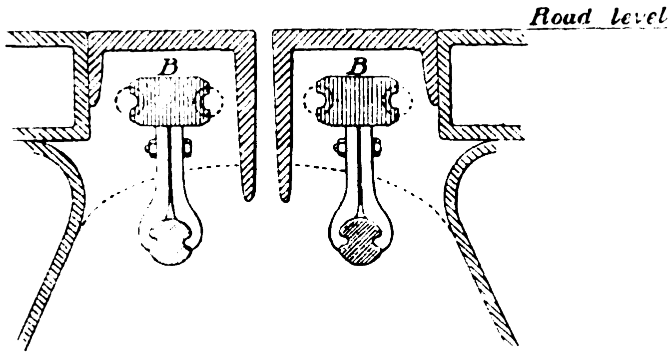

FIG. 14.

rods. With the trolley wheels travelling in the direction of the arrow, it was found that the blocks shifted a little in the reverse direction every time the trolley wheels passed, and it was necessary to put stops at S (Fig. 15). The insulators are fixed to every alternate yoke, at a distance apart of 9ft. on the straight run. On curves, however, they are closer together, and stronger supports are used, the conductor being circular in section, and clipped in ears having circular jaws, as shown in Fig. 16, which are afterwards filed round below, so as to offer no resistance to the trolley wheel.

The trolley wheels bear upwards on the underneath side of the conductor, exactly as in overhead lines. The illustration (Fig. 17) shows the arrangement with spring for keeping tension on trolley wire, and back stop for keeping the wheel in place on the wire. The plate travelling in the slot and supporting this gear is of ½in. steel, and 4½in. wide. The trolley arms are jointed to take lateral as well as vertical movement, and thus follow every change of direction of the conductors.

The line in Chicago is in the form of a triangle a little over 1¼ miles long, with three straight lengths and three curves, and in one place it crosses over the cable line. The motor cars (which also carry passengers) haul the trailers with passengers left by the Lincoln-avenue cable cars and North Halstead-street horse cars round Fullerton and Webster avenues. This was the first line on this system, and, as might be expected, some difficulties were met

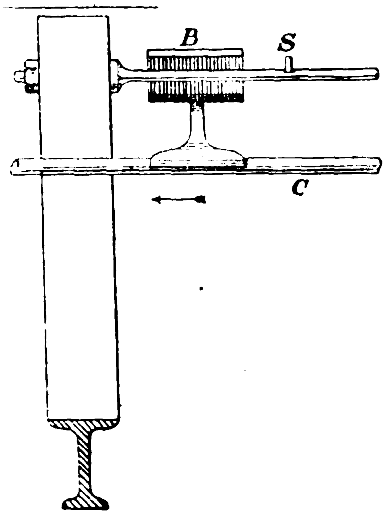

FIG. 15.

with. These were chiefly due to the breakage of insulators, expansion of conductors, and snow and ice in the conduit. Boys were also a nuisance, stuffing wire into slot, which jammed the trolley wheels and short-circuited. I found that in July last there had been five stoppages, two in August, and none at all the following three months. Two of the stoppages were, however, due to burnt-out armatures. Brushes were used attached to cars for sweeping out water and dirt from the conduits into sump-holes every 100ft., which were afterwards pumped out by hand. Water gave no trouble at all, except when it froze in the conduit. Wide extremes of temperature are met with in Chicago, being 15° to 20° below zero in the winter, to 90° in the shade in the summer, and expansion gave a good deal of trouble at first, especially at curves, where the conductors sagged till they nearly touched the side of the iron conduit, upon which the trolleys made earth and short-circuit by touching the sides. This was overcome by dividing the conductors

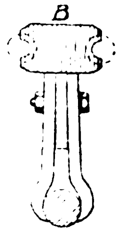

FIG. 16.

into sections of 500ft. to 600ft., and covering the adjacent ends with a long sleeve. Powerful compressed springs on either side of the sleeve were used as shown in the illustration (Fig. 18), which drew the ends together and took up the expansion.

At the Milwaukee Convention Mr. M. D. Law read a Paper on this system as now operated in the city of Washington (district of Columbia), in which he mentioned the improvements introduced by the Rock Creek Railway Company using the system in that city. I subsequently saw this line at Washington, and found the construction perfected in many details, and the system giving completely satisfactory service, uninterrupted since its inauguration in March, 1892. The line was a credit to this well laid out city, and anyone who could see the smooth and regular running of the cars, with no overhead wires, would say there was a great future for such a system in city traffic. The line of the above Company extends some 6½ miles in the suburbs with the overhead trolley system, but at the city boundary it changes

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to underground trolley. The change from one to the other only involves fixing the trolley bar, and switching off the earth connection, which I timed to take 20secs. The line then continues along U-street for 1½ miles with double track. On the return journey, close to the junction, the cars have to take a sharp curve, and take an ascent of 1 in 40 at the same time, which they do easily. The insulators and supports at the curves are all strengthened, and the conduit is made 20in. deep by 14in. wide, the extra width allowing ample clearance between the wires and the sides of the conduit. The yokes are also put at 4ft. centres instead of 4ft. 6in., and the conductors are of ⅝in. hard-drawn copper. A separate power house was erected to supply the underground system, as it was desired by Mr. Law and Mr. Herbert Claude, the engineers to the Company, to thoroughly test the system. Leakage to earth, as shown by a voltmeter between the conductor and earth, was only 0·1 per cent. even in the stormiest weather, and the ammeter remained dead at zero when the full E.M F. was on and the cars all off. In the wettest weather it was a common thing to

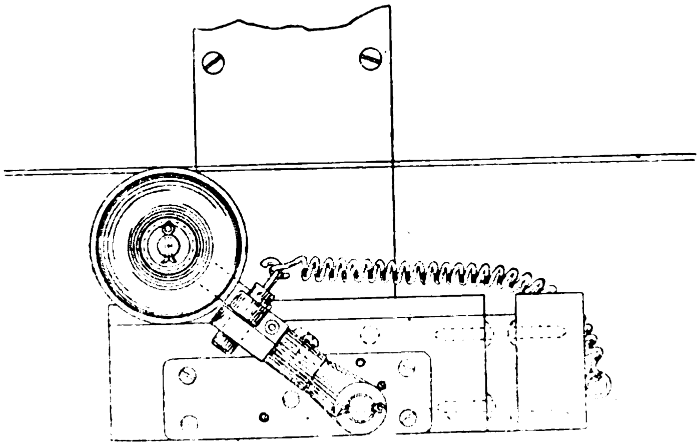

Fig. 17.

find dusty insulators and perfectly dry conductors on removing the slot rails, this condition being due to the natural draught in the conduit and the umbrella nature of the slot rails. On two or three occasions, however, severe rain storms had flooded the conduit and immersed the wires; but the cars ran without delay. With four fully-loaded cars on the line the drop was only 3 volts. The trolley wires were in sections, with main and return feeders, switches, and cut-outs to each section, placed in manholes every 500ft. on the straight run.

I have here copies of two Bills which have recently passed the House of Representatives, authorising an extension of tramways in the city of Washington, in which the system of underground conduit I have just described is to be used. The section of the Act incorporating the Washington Traction Company which refers to the system reads as follows:—

Sec. 2. "That the motor power shall be the underground electric, such as is now in use on the U-street branch of the Rock Creek Railway, on all of its road east of Rock Creek, while the

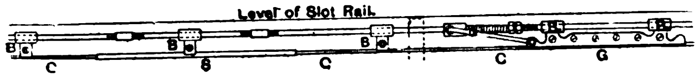

Fig. 18.—S = Copper Split Sleeve into which the ends of Copper Conductor C C are drawn, by action of Spiral Spring, and Slipper Grip G to take up for expansion. B B = Insulating Blocks or Carriers with Grooves, riding loose on Upper Rod, and gripping Copper Conductor as shown in end elevation at B B, Fig. 14. G = Slipper Grip fast on Conductor, but loose on Rod above.

overhead trolley shall be used upon that part of the route northwest of Rock Creek *until such territory shall be built up* and the District Commissioners shall deem it proper that the wires shall be placed underground."

The other Act empowers the Brightwood Railway Company of this city to extend their lines within the city, using the above system.

It has been proposed to use synchronous, two-phase, or three-phase motors for tram-cars, chiefly with a view to economy in the transmission of energy, but also with the object of avoiding electrolytic troubles. There are advantages to be considered in the use of alternating currents, but it would involve the carrying of line and return close together in the neighbourhood of telephone lines. A tram-car fitted with a three-phase motor, said to be the first one so fitted, was exhibited by Messrs. Siemens and Halske in the Electricity Building at the World's Fair. The motor was four-pole, of 20-H.P. nominal, but capable of working up to 60 H.P. at 500 to 600 volts and 1,400 revolutions. The reduction gear was enclosed in oil.

I now come to some points in power house plant. Most of the stations I visited had large cross or tandem compound horizontal condensing engines, the average units being of 500 H.P., driving 200-kilowatt generators by belts. These were usually compound machines, to give 500 volts on open circuit to 550 on full load, and had the intermediate connection taken from the brushes to the switchboard for coupling machines in parallel. In allowing for "drop" a good deal depends upon the site of the power house. In the heart of a city, where there are a large number of pedestrians and vehicles, the cars must of necessity travel at slow speed, and do not, therefore, require the full pressure, while in the suburbs speed is a matter of importance for business men coming into and leaving the city; and in Cincinnati it was particularly necessary to keep the pressure up, owing to the hilly nature of the suburbs. The power houses, I found, were built in the suburbs in situations most suitable to deliver highest pressure where most required. Short circuits being of very frequent occurrence, magnetic cut-outs were placed on the feeder and dynamo mains at the switchboard, and in some cases on the machines as well.

With built-up flywheels of the ordinary type it is well known that the maximum linear speed of the rim must not exceed a certain limit of, say, 6,000ft. per minute. Centrifugal force, acting radially outwards, tends to bend those portions of the rim lying between spokes, putting the outside of the rim in tension, and the inside in compression. What the stresses due to bending actually are need not be gone into here, but it is evident that the safe factor between bending moment and circumferential tension of the rim rapidly diminishes as the limiting velocity is exceed, and from this cause wheels occasionally fly to pieces without any previous warning. The large amount of energy stored in these 25ft. and 30ft. flywheels answered the purpose of keeping the volts up under sudden increase of load, but were somewhat a cause of anxiety when short-circuits came on. Either the magnetic cut-out did not act quickly enough, and the inertia of the driving power kept the dynamo up to speed, and forced it to a burn-out, or the engine raced to a dangerous extent on the quick withdrawal of full load. Some instances of these came under my own observation. At the Hunt-street power-house in Cincinnati, where there are intermediate lines of countershafting between engines and dynamos, I noticed some repairs being effected, and was informed that seven pulleys on one line of countershafting had flown to pieces on the occasion of one main engine racing, and that the broken pulleys had smashed an equivalent number of dynamos which they were driving. I was then shown an ingenious arrangement that had since been added to the Corliss cut-off gear, in preparation for the next occasion of racing, by which steam could be instantly cut off the engines by pulling a cord which came over a pulley on the ceiling. These cords were dropped down at various points in the station, so that a man, say at the switchboard, could instantly stop any engine. Pulling the cord released a weighted lever, which moved a cam into such a position under the trip gear that steam was completely shut off during the whole of the stroke. At the time of my visit to the Atlantic-avenue Street Railroad power house in Brooklyn broken parts of one of the large fly-wheels, together with a generator, were just then being taken out through an opening in the station wall, which, with part of the roof, had been demolished by the flying pieces of a racing engine. The facts were fully reported in the American Press at the time, and the engineer in charge was highly spoken of for the manner in which he endeavoured to avert the catastrophe. On account of the uncertainty of cut-outs it was generally considered that the generators should be under-engined, thus allowing a margin for overload.

(*To be concluded.*)

ELECTRIC POWER IN FACTORIES.*

Closely associated as I have been all my life with an engineering works started more than half a century ago, and increasing in size with the growth of the trade of the district until it has become one of the largest marine engine works on the North-East Coast, I have had by tradition and experience continually before me the difficulty of always keeping up to date with machinery and meeting the demands of labour, and, great as this task often has been in the past, I can recall no time so discouraging and difficult as the present. We have had to contend with bad trade, with disputes between capital and labour; but I remember no period when we

* Abstract of Presidential Address delivered before the North-East Coast Institution of Engineers and Shipbuilders by Thomas Richardson, B.A.

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have had pressure from both troubles to contend with at the same time, making the successful carrying on of industrial concerns an impossibility. Those of you who are directly associated with the engineering and shipbuilding industries will readily appreciate that the subject of economical production is one to which more than usual prominence has lately been given by the recent almost complete stoppage of work on this coast, by one of those disastrous disputes between capital and labour which are now so frequent. Another factor which is year by year becoming more prominent is the competition of foreign countries, and the unfortunate doctrine which is so often sensationally made use of as to our superior capacity as handicraftsmen is by no means so true now as formerly. The extended and universal adoption of machinery has been the chief cause of this levelling up; and particularly is this the case in the engineering industry, where the scope for the application of machinery is practically unlimited. It is not enough, however, to apply machinery, but to develop it, as the one remedy for survival is continuous evolution; although the unconscious fascination, which is often associated with old tools and old methods, often renders the evolution dangerously intermittent. It is apparently this fascination, combined with an unselfish desire to satisfy the cravings of the shipowner for propelling machinery requiring the least possible consumption of coal, which is responsib'e for the fact that, whilst we build engines and boilers consuming 1½lb. of coal per indicated horse-power per hour, we drive the machinery in our workshops at an expenditure of fuel four to six times greater in amount. This is, of course, attributable to the use of a number of high-pressure non-condensing engines distributed over a large area, and supplied with steam through long lengths of piping from a central group of boilers. This, then, is a field in which economies are to be obtained, and one of the best solutions appears to be the application of electrical driving.

In the able address of Prof. Kennedy before the Institution of Mechanical Engineers this subject was very fully dealt with, and at the late meeting of the Iron and Steel Institute of Brussels a very interesting and instructive Paper was given by Mr. Selby Bigge, which conclusively showed the importance and possibilities of the system. At the risk of rendering this address narrow, and more in the form of a Paper, rather than general, I propose to give some illustrations of the application of electrical driving, both in this country and abroad, hoping that a *résumé* of what has actually been accomplished may promote a discussion which will thoroughly ventilate the question and be fruitful in beneficial results. With the late disastrous record of the shipbuilding and engineering industries as an example, it is highly improbable that any capitalist will start a new shipyard amongst us, so that we may be sufficiently selfish to consider the application of electrical driving to existing works only. The first question to consider, therefore, is that, having boilers grouped in one place from which steam is led to engines distributed over a large area, what economy can be expected from substituting those engines with electric motors supplied with power from a central station, and will the results justify the expenditure? We are all thoroughly aware that condensation does occur in steam pipes, and that the present engines are uneconomical, but a broad view is generally taken of the matter, and little has been done to ascertain what the results really are. It is for this reason that the experiments and developments made by Mr. Panton, of Messrs. Dorman, Long, and Co., of Middlesbrough, in conjunction with Mr. Selby Bigge, are of the greatest value, and particularly so as they have resulted in complete success. The original steam-driven machinery comprised punching, shearing and bending machines, cold saws, &c., all of which were distributed over a large area and driven by six engines capable of indicating the following powers, viz. :—27, 14, 14, 14, 16, and 9. These engines were disconnected and replaced by motors of 10½, 3½, 5, 3½, 3½, and 3½ H.P. respectively, the driving gear consisting of a belt from the motor direct to the flywheel of the machine. The most noticeable case is where a large bending machine formerly driven by an engine having a cylinder 10in. diameter, with a stroke of 12in., is now efficiently worked by a 3½-H.P. electric motor. The current for these motors is generated by a 50-H.P. Pieper dynamo driven by an ordinary horizontal engine, the steam being obtained from two Lancashire boilers which were already in use in connection with the steam driving of another portion of the works. Formerly the six engines in question were supplied with steam by two boilers, which are now dismantled, with the result of a net saving of 30 tons of coal per week and the entire labour in connection with stoking and upkeep.

Another striking advantage is that, the speed of the motors being practically constant under all loads within their capacity, the machines driven by them are always running at the desired speed, and are, therefore, in a condition for producing the greatest possible amount of work. In reviewing this plant we have the advantage of ascertaining the approximate loss resulting from condensation in a long range of steam pipes, and the working of small high-pressure engines under conditions usually found in ironworks and shipyards. It will be apparent, however, that the generation of power at one centre admits of an economy beyond this; viz., the use of a modern high-pressure triple-expansion condensing engine, with a consumption of 12lb. to 14lb. of steam per indicated horse-power per hour, instead of a consumption of from 40lb. to 60lb., as frequently is the case at present. It is evident that the loss in such a case as that of Messrs. Dorman, Long and Co. may be termed a maximum, on account of the machines working in the open air; and the steam pipes led underground; but the results from ordinary cases of shop machinery are often sufficiently startling to warrant more attention being given to them than they usually receive. For purposes of comparison we will consider the results obtained from two works of about equal driving power, one having an electric installation and the other steam.

One of the most complete installations of electrical driving in the world as applied to large industrial establishments is that of the National Arms Factory at Liége, Belgium. These works were built in the year 1889, and are of very large extent, employing 2,000 hands, the daily output of finished rifles being 250. Some idea of the system adopted, and the value of machinery for economical and rapid production, may be formed when it is considered that there are about 58 parts in a complete rifle and bayonet, involving in their production about 750 operations; yet so great has been the development of machine tools used in this manufacture that, of the 750 total operations, only 6 per cent. are performed by hand labour. Another feature is that a large percentage of the machines are automatic, and advantage is taken of this by placing several in the charge of one operative.

The whole of the machinery is driven by electric motors receiving their current from one central dynamo coupled direct to a Corliss condensing compound engine having two cylinders and indicating 500 H.P. at 70 revolutions per minute, with a boiler pressure of 90lb. The auxiliary feed and condensing water is supplied by a pump driven by a 10-H.P. motor, receiving its current from the main generating dynamo, and placed on the canal bank 2,840ft. distant and 117ft. below the level of the engine. The water, after being used in the condenser, is discharged into a tank placed 40ft. high, from which it passes through finely perforated pipes in the form of spray into an open reservoir on the ground level, and by this means is reduced in temperature so as to be again available for condensing purposes. The generating dynamo is placed between the high-pressure and low-pressure engines, and the armature, being on the main shaft, acts as a flywheel. The armature, which is 16ft. in diameter, was constructed in place. The electromagnets are 20 in number, and there are 40 pairs of brushes, 20 on each side. The capacity of the dynamo is 3,000 amperes at 125 volts, and the makers guaranteed an efficiency of 90 per cent. The current from this powerful generator is distributed to about 31 motors, ranging from 3 to 50 H.P., placed in different sections of the works. The machines used in the manufacture of rifles are necessarily of light design; consequently the motors are arranged to drive line shafting only, and although the total length of main shafting exceeds 4,000ft. and the total length of belting is about 11 miles, there are no indirect main drives, a motor driving one line of shafting only, the object in view always being the reduction of loss by friction.

Each motor is provided with an ammeter, and as those in charge know the amount of power required to drive the machines when being worked to their desired capacity, any increase of that power at once indicates that there is a waste in friction, whilst any decrease indicates that the machines are not doing sufficient work; and when it is remembered that the revolutions of the motor are practically constant under all loads within their capacity, it is impossible to imagine an arrangement which so exactly fulfils the requirements of maximum economical reduction.

Compare this with the wasteful arrangements so common in shipyards and engine works, where engines, often already fully loaded, have to drive still another new tool, and the "make-the-best-of-it" policy of giving just a little later cut-off is adopted. The result generally is that the mean revolutions of the main shaft are not only decreased by any variation in load, but are, in addition, highly sensitive to the variations of steam pressure. This is, however, a diversion, and referring again to the Liége factory, there is also a 300-H.P. Willans engine, coupled direct to a dynamo, which generates the current necessary for recent extensions.

It has been found by careful experiment that the consumption of steam in the Corliss engine is about 14lb. per indicated horse-power per hour, whilst the losses are 10 per cent. in engine friction, 10 per cent. in the dynamo, 2 per cent. in lines, and 15 per cent. in motors, or a total efficiency of 63 per cent. at the motor, driving pulleys of the indicated power of the generating engine. The whole of the electric installation was made and fitted by the International Electrical Company of Liége from the designs and under the direct superintendence of Mr. H. Pieper, the managing director and electrician-in-chief of the Company, and we have an ample testimony of the efficiency of the entire plant in the fact that, although the works have been running over three years and

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a-half, there has not been one single stoppage of the main dynamo during working hours, and no accidents of any kind whatever.

Particulars such as these are always of general interest, but any radical change made in existing works involves a very considerable outlay, and extreme care is necessary to be certain that such a change would be commercially successful. It is, therefore, essential in the first instance to ascertain what are the conditions existing at present; so we will take as an example an average old-established marine engine works, of which there are many in this district, the majority of them having been added to year by year to meet the demands of trade, and where extensions have generally been the result of a compromise between what was desired and what existing conditions would allow.

The works in question are steam driven, the boilers being arranged in one group, and supply steam at 60lb. pressure to 31 engines in different parts of the works. Eight of these are used for driving the machinery in the various sections of the works, and 23 are auxiliaries in connection with cranes, hydraulic pumps, and the like. The driving engines are of various powers and of designs which may be taken as representing a fair average of those used for the same purpose in similar works.

Table I.

Engine.	I.H.P.		Length of steam pipe in feet.	Water trapped in lbs. per hour.	Weight of steam.				
					Calculated from diagram.		20 % for cylinder condensation.		Lbs. per I.H.P. per hour, including water trapped.
	Loaded	Light.			Lbs. per hour.	Lbs. per I.H.P. per hour.	Lbs. per hour.	Lbs. per I.H.P. per hour.	
No. 1.	48·0	17·2	680	270	2,227	46·2	2,672	55·6	61·0
„ 2.	93·9	23·4	695	260	2,502	26·6	3,002	31·9	34·7*
„ 3.	44·0	20·2	833	190	2,365	53·7	2,838	64·5	68·9
„ 4.	28·9	15·0	969	130	1,562	54·0	1,874	64·9	69·3
„ 5.	56·2	20·0	511	110	1,890	33·6	4,268	40·4	42·2
„ 6.	75·7	22·8	971	27	2,580	34·1	3,096	40·9	41·4†
„ 7.	9·3	6·5	1,210	125	445	46·4	534	55·6	68·8
„ 8.	15·6	7·8	1,068	75	700	45·0	840	53·8	58·5

No. 1 is a beam engine fifty years old, and is used for driving about 50 lathes, planing, slotting, and drilling machines of various sizes. With an average daily working load the indicated horse-power is 48, whilst running the shafting only, and with the machines all standing it is 17. Steam is supplied through 680ft. of piping, and the water discharged from an automatic steam trap close to the engine stop-valve amounts to 270lb. per hour. The weight of steam used by the engine and as measured from the diagrams at the average daily load, viz., 48, is 2,227lb. per hour, to which should be added 20 per cent. for moisture in suspension, thus making a total, including the water condensed in the steam pipe, of 61lb. per indicated horse-power per hour. No. 2 engine is a modern two-cylinder horizontal, with variable expansion gear worked by the governor. The machines driven consist of two dynamos for works lighting, as well as a large number of average-sized tools.

It will be seen from the table that the average working load when driving the dynamos is 93·8 H.P., but driving during the day the average horse-power is reduced to 38.

Nos. 3 and 4 are single cylinder inverted machines, and afford a good example of the wasteful effects of overloading.

Nos. 5 and 6 are old-fashioned horizontal engines, in which the governor works an ordinary throttle valve, and both have been in use for about thirty years.

Nos. 7 and 8 are small inverted cylinder vertical engines running at 150 revolutions.

The wasteful effect of this system of driving is shown by the consumption of steam, which averages 50·9lb. per indicated horse-power per hour, and to this has to be added the condensation in the steam pipes, which is 7 per cent., bringing the total up to about 55lb. per indicated horse-power per hour, and even this is by no means exaggerated, as it is probable that the condensation in the pipes exceeds that indicated by the traps. In comparing the two systems at this stage, and allowing 10 per cent. for engine friction in each case, and a total electric loss of 27 per cent. for dynamo conductors and motors, we require 45lb. of steam per effective horse-power at the main driving pulley of the steam installation against about 20lb. for the electric. Taking the total at 500 effective horse-power (which allows 125 average for the 23 auxiliaries) in each case, and an evaporation of 8lb. of water per pound of coal, the consumption of coal would be 36 tons per day for the steam and about 13 tons for the electric. In the steam installation under consideration the water is obtained from the waterworks main at considerable cost; whereas under similar conditions, with a condensing engine, the cost would be much less.

Another feature of value is the reduction of labour, which for stoking alone would be about one-half, whilst still further reduction could be made in the engine driving and greasing staff, as whilst steam engines require constant attention, the motors can be practically left to themselves, except for starting and stopping, as should anything go wrong with the motor it would be immediately detected in the central-station engine-room by the indicator corresponding to the particular motor at fault. It will be evident that we have dealt with the greatest source of economy by the concentration in one highly efficient plant for the generation of power for the whole of the main driving of the machinery of the works. It will be interesting, however, to consider the relation between the power at the main driving pulleys and that absorbed by the machinery in doing actual work. Referring again to the driving engines 1 to 8 (Table II.), it will be seen that the loss in driving the shafting, belts, pulleys, &c., range from 25 per cent. to 70 per cent., or an average for the six engines of 43 per cent. These experiments have been confirmed by some made by Mr. Westgarth, and referred to by him at a meeting of the Cleveland Institution of Engineers. Mr. Westgarth found that in an engine and boiler works he experimented on of the total power developed by the steam engine 59 per cent. was absorbed by the shafting and gearing, and in one of the workshops where two long lines of shafting were used for driving a comparatively small number of machines the power absorbed was 75·6 per cent. of the total. In another workshop where the shafting was well laid and rope gearing used for the main drives the percentage was 42. The average of the whole experiments is therefore about 50 per cent., consequently it appears that half the mean power would be saved if all the machines could be driven by independent motors instead of by line shafting. This in an existing engine works is, of course, impossible; but there are many instances where long drives may be divided with great advantage, whilst the independent driving of large tools would be another very desirable feature.

Table II.

Engine.	L'ngth of shafting in feet.	No. of pulleys.	Length of belts in feet.	I.H.P.		Loss per Cent.
				Loaded.	Light.	
No. 1	370	·153	4,292	48·0	17·2	35·8
„ 2	782	113	2,263	93·9	23·4	25·0
„ 3	515	283	3,582	44·0	20·2	46·2
„ 4	571	335	4,831	28·9	15·0	52·0
„ 5	691	79	1,401	56·2	20·0	35·6
„ 6	381	22	464	75·7	22·8	30·0
„ 7	117	49	1,210	9·3	6·5	69·9
„ 8	242	70	1,429	15·6	7·8	50·0

An example of what may be termed ideal electric driving is that of the Bedson Wire Company of Middlesbrough, where the installation is the most perfect and complete that has as yet been attempted in this country. Every process connected with the manufacture of wire is carried out by means of electricity, the wire drawing, galvanising, spinning, and barb fencing machines, overhead and locomotive cranes, hydraulic pumps, induced draught fans, lathes, centrifugal pump, are all independently driven by electric motors. Owing to the entire absence of shafting and belting, the construction of the building is very light, and the convenience of the whole plant is most noticeable. The current is generated by a 600-H.P. dynamo driven direct by a three crank triple condensing engine with boiler of 160lb. pressure. A special tunnel, 350 yards in length, has been constructed for the conveyance of the conductors, and branches are taken from these to the 50 motors, which vary from 5 to 40 H.P. each. The lighting of the works is most complete, the greater part being carried out on the inverted arc principle, which is so perfect that there is an entire absence of shadows. The original plans for driving these works electrically were prepared by Mr. Selby Bigge, who appears to have given considerable attention to the question of electric driving. Before definitely deciding to put down such a novel plant, several experiments were necessary, for which purpose special machines were designed by Mr. Bedson, the Managing Director of the Bedson Wire Company. These experiments were made at Liége by Mr. H. Pieper, and were so successful that after an exhaustive series of tests the Directors of the Company decided to adopt the electrical installation in its entirety.

A novel feature in connection with the boilers at Messrs. Bedson's works is the application of Messrs. Ellis and Eaves's well-known system of induced draught. This is the second application of the system to land boilers, the first having been made at the Atlas Works, Sheffield, originally arranged with Lancashire boilers. These have gradually been replaced by ten single-ended boilers of the marine type, the advantages claimed being as follows:—

1. Considerable economy compared with the Lancashire boilers with Galloway tubes.

* I.H.P. with the dynamos not at work = 38·3.

† The small amount of water trapped here is due to the trap being placed very near to that of No. 3 engine.

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2. Considerable reduction in space occupied.
3. Absence of smoke.
4. Greater elasticity of power.

In ordinary work, by maintaining a vacuum of 3in. at the fan, the combustion is at the rate of about 35lb. per square foot of grate surface, and one single-ended boiler can readily evaporate as much steam as three Lancashire boilers 27ft. by 7ft. with ordinary chimney draught. Where the demand for steam varies in a works the system is a great convenience, and this is especially the case for electric light installations. It is evident that with this system of draught, or with any other efficient system, the assumed consumption of 13 tons per day could be still further reduced.

From the comparison which I have made we may fairly conclude that the saving gained by the substitution of electrical driving in an old-established works would be considerable. Whether this saving would justify the outlay in all cases would have to be settled by those who have their capital invested in works suitable for its adoption. I may say, however, with reference to the firm of which I am a member, that for some time we have had the matter under consideration, and the various investigations and experiments made by Mr. D. B. Morison, and of which are those enumerated in this address, have so convinced us of the commercial possibilities of the system that we have now on order a small plant prior to further developments hereafter.

I have endeavoured to confine myself in my remarks to a plain statement of what has been accomplished by making use of electrical power to drive machinery, and have not gone into any of the possibilities the future may reveal. We have known the science of engineering to advance at times, as it were, by leaps and bounds, and, from the rapid strides that this comparatively new energy has made within the last few years, we may have reasonable expectation of still further development in this direction.

ON THE PROPAGATION OF ELECTRO-MAGNETIC WAVES IN ICE, AND ON THE DIELECTRIC POWER OF THIS SUBSTANCE.*

BY R. BLONDLOT.

In a previous communication† I enunciated the following theorem: The length of the waves which an electromagnetic oscillator is capable of emitting remains the same whatever the insulating medium in which the experiment is conducted; in other words, the wave-length depends only on the dimensions of the oscillator, in the same way as in acoustics the length of the waves emitted by a tube depends only on the length of the tube. The corroboratory experiments described in the above-mentioned communication related to castor oil and essence of turpentine. The law was perfectly true for these two substances, and everything tends to the belief that the same would be the case for other dielectrics. There was, however, some doubt with regard to one—namely, ice—owing to the exceptional properties attributed to it. M. Bouty's experiments, in fact, give ice a dielectric power of 78; that is, incomparably greater than that of all other substances.‡ Thinking that the law relating to wave propagation could not be applicable to a dielectric so different to all others, I decided to put the question to the test of experiment, to carry out which I took advantage of the intense and prolonged cold of the winter of 1892-93. M. M. Dufour assisted me in carrying out these experiments, which were rendered difficult and even painful by the low temperature, and I have to thank him for his extreme kindness on this occasion.

The method I employed was the following, identical, with the exception of a few modifications necessitated by the solid state of the dielectric, with that used by me in the case of castor-oil and essence of turpentine.

The electromagnetic waves were transmitted along two tinned copper wires 2·5mm. in diameter, stretched horizontally and parallel to one another at a distance of 0·8m. A resonator of gilded copper, the same as I used in the experiments with liquids, was installed at a fixed place between the wires. The portion of the wires beyond the resonator was contained in a wooden trough 4m. long. The trough being empty, it was sought to find the place where a movable metallic bridge had to be put across the wires beyond the resonator in order to make the spark disappear; the distance between the resonator and the bridge is a quarter of the wave-length natural to the resonator. The exact position of the bridge could be ascertained. This done, I surrounded the condenser portion of the resonator with a water-tight parchment bag filled with boiled distilled water. I then froze the water. The air layer of the condenser was thus replaced by a sheet of ice. Determining the wave-length once more, it was found to be much greater than in the first experiment. It had become about 141/100 of what it was at first. I then filled the trough with water, which I froze, then I again determined the position of the bridge, for which the resonator spark disappeared. To do this I broke and progressively cleared away the ice from the end of the trough furthest from the resonator, and I ascertained that the position was exactly the same as in the first experiment when air was everywhere the dielectric.

The experiment, repeated four times with the capacity of the condensers varied on each occasion, always gave the same result. The theorem with regard to the wave-length is therefore as true for ice as for other dielectrics. Consequently, as I showed in my previous communication, Maxwell's relation, according to which the specific inductive capacity is equal to the square of the index of refraction, is true for electromagnetic undulations through ice.

These somewhat unexpected results induced me to determine the dielectric constant of ice, making use of electromagnetic undulations. In fact, the experiment described above gave me the necessary data for this. If we denote by λ and λ' the wave lengths corresponding to a given resonator, when placed respectively in air and in a substance of specific inductive capacity K, we have $\lambda'/\lambda = \sqrt{K}$. As I stated above, I found $\lambda'/\lambda = 141/100$ from which we get in round numbers $K = 2$. The experiment repeated a dozen times always gave the same result. I estimate that the relative error does not exceed 1/20, since the layer of ice was almost free from air bubbles.

It only remains to explain how it was that MM. Bouty and A. Pérot arrived at quite other values for the dielectric power of ice. In the first place in M. Bouty's method, the charge and discharge of the condenser were far slower than in my experiments. Is it not probable, therefore, that the physical magnitudes measured by M. Bouty and by me were very different? In any case we at present know too little about the dielectric properties of bodies for us to be astonished at the divergence, however wide, between numbers obtained by two methods so dissimilar. Secondly, the results* given by M. A. Pérot, who worked by the method I have just described, are erroneous, as he has since admitted owing to an important omission in his calculations. Correcting this mistake, M. Pérot's experiments result like mine in a number near to 2 for the dielectric power of ice.

* From the *Comptes Rendus*, Vol. CXIX., No. 15.
† *Comptes Rendus*, July 25, 1892.
‡ *Comptes Rendus*, March 7, 1892.
* *Comptes Rendus*, June 27, 1892.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *October* 5, 1894.

A New Alternating System.—The General Electric Company has just announced a new alternating system, under the name of the "Monocylic" system, for the simultaneous operation of incandescent lights and motors where the importance of the former predominates. The details have not been made public in full, but the generator is described to be similar to an ordinary alternating lighting generator, with the addition of a supplementary or "teaser" coil leading to a third ring on the armature shaft, from which a third or power wire is led. The motors are of the induction type, and are connected with a transformer, to which are led the two main wires and the third, or power, wire. This power wire is described as being small in size, as it only needs to carry a current sufficient to start the motors. The motor system seems really to consist in the employment of two-phased line currents, which are converted by a transformer into three-phased currents, the motor being started up as a three-phased motor, and, after arriving at synchronism, is worked as a synchronous induction motor. In this connection it is interesting to note that the phase-transforming principle described by Electrician Scott, of the Westinghouse Company, this spring, has several claimants for priority, and the same system seems to be used in the motor transformers of the "monocylic" system.

Death by Electricity.—At the meeting of the American Electro-Therapeutic Association last week, Messrs. Houston and Kennelly read a Paper on "Some Experiments on Death by the Alternating Current," in which they strongly contest the conclusions of D'Arsonval in regard to the possibility of reviving a criminal electrocuted according to the methods employed in New York State. While endorsing his suggestion that a person

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shocked by electricity should be treated as if drowned, they remark that it is quite another matter with reference to a criminal subjected to a current of from five to eight amperes in strength. The conclusions arrived at from experiments in their laboratory are: First, that the passage of a sufficiently powerful alternating current through the body is followed by instantaneous, painless, and absolute death. Second, that consequently, where electrocution is properly carried out, there is no possibility of the resuscitation of the criminal. Third, that in cases of accidental contact, where the current passing is not excessive, it is quite possible that death may be apparent only, and that the method of artificial respiration suggested by D'Arsonval should then be followed. At the meeting of the same association, Prof. Dolbear, in a Paper on "The Physiological Effects of the Constant Current," stated that physiological functions of all sorts are electro-magnetic in their last analysis.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

NEW BOOKS AND EDITIONS.

The 1894 Edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK contains 1,000 closely-printed pages, and several new and useful features have been added. The price of this edition of the Directory and Handbook is now 5s. post free; abroad 5s. 6d. *The 1895 edition is in active preparation.*

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free.

"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell, with this title, will be ready in a few weeks. It will contain the latest information respecting the application of electric energy to mining purposes, in which the author has had much experience. The book is well printed, on good paper, and will contain nearly 250 illustrations, a large proportion of which have been specially made for the book. The price is 10s. 6d., post free 11s. (abroad 11s. 6d.). Orders can now be sent in.

"THE WORK OF HERTZ."—The lecture delivered by Dr. O. J. Lodge at the Royal Institution on June 1st is reprinted with corrections and additions, and many original illustrations, price 2s. 6d. net.

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. (abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application to the Publisher.

"ELECTROMAGNETIC THEORY," by Oliver Heaviside, is now ready, price 12s. 6d. (abroad 13s.). Prospectus on application.

TENDERS INVITED.—The Corporation of Sunderland invite tenders for wiring the Town Hall for the electric light, including the supply and fixing of cables, casings, switch and fuse boards, lamps, &c. Specifications, schedules, and general conditions may be obtained from the borough electrical engineer, and tenders must be delivered not later than 5 p.m. on Thursday, November 8th. Further particulars appear in our advertisement columns.

——— The Postmaster-General invites tenders for the supply of red fir telegraph poles, and for creosoting the same. Forms of tender, containing all particulars, can be had on application to Mr. Charles E. Stuart, Controller of Stores, Telegraph-street, London, E.C. Tenders have to be in by noon on Wednesday, the 31st inst.

——— Mr. John Annan, manager for the liquidator in J. W. Hobbs and Co. (Limited), invites tenders for the supply and erection of boiler house plant, engine house plant, switchboard, instruments, &c., for the electric light and power installation at the large block of hotel buildings now erecting on the Salisbury Estate, Victoria Embankment, and Strand, London, W.C. Plans and specification, &c., can be obtained of Mr. R. Hammond, consulting engineer, Ormonde House, Great Trinity-lane, E.C., on and after October 5th; and tenders must be sent in before Friday next, October 26th.

——— The Lighting Inspectors of Hapton (Lancs.) invite tenders for the electric lighting of the village and of so much of the township of Hapton as they may think necessary. Tenders must be in by the 27th inst.

TENDERS ACCEPTED.—At Tuesday's meeting of the London County Council the following report from the Fire Brigade Committee was submitted:—"We reported on July 24th that, as the contract with Messrs. H. Binko and Co. for the maintenance of the electric bells belonging to the brigade would expire early in August, we proposed to invite tenders for the maintenance for a further period, and that we had authorised the chief engineer to arrange for the work to be done by workmen directly employed by the Council until the new contract should be entered into, and the Council approved our action. We have now to report that the cost incurred in maintaining the bells, including the substitution of new batteries for defective ones, and the execution of repairs to the wires and apparatus, has been about £95. Six firms were invited to submit alternative tenders for the maintenance of the bells for one or three years, but only five responded, their prices being as follows:—

	One year.	Three years.
A. W. Jackson	£325	£285 0 0
Julius Sax and Co. (Limited)	325	303 6 8
Strode and Co.	330	330 0 0
J. D. F. Andrews and Co.	400	350 0 0
Nicholson and Tyler	1,050	1,000 0 0

The result of inquiries made by the solicitor with regard to the lowest tenderer appears satisfactory, and we recommend that the tender of Mr. A. W. Jackson to maintain for three years at the rate of £285 a year the electric bells belonging to the brigade be accepted."—This was agreed to, but with the proviso that the contract should be for one year only.

TENDERS ACCEPTED.—The tender of Messrs. Siemens Bros. and Co. (Limited) for the supply of conductors for the three-wire system, at £1,290, and that of Messrs. W. G. Bagnall and Co. for overflow mains and exhaust pipes for engines, at £75, have been accepted by the Stafford Town Council.

SALE BY AUCTION.—Messrs. Wheatley Kirk, Price, and Goulty announce in our advertisement columns the sale, at an early date, of the surplus plant and stock belonging to the London Electric Supply Corporation (Limited), at the Deptford Works.

BANKRUPTCY.—A receiving order has been granted in the estate of William Hopkin Akester, electrician, of 897, Fulham-road, London, S.W.

J. E. H. GORDON AND CO., LIMITED (IN LIQUIDATION).—We learn from the liquidator of this concern that there is no prospect of a dividend for the Ordinary creditors. The chief assets of the Company are electric light stations in Ireland, which have cost considerable amounts of money; but of which, in spite of strenuous efforts on the part of the liquidator, only one has been realised, and that for a small sum.

EXTENSION OF PLANT.—The proprietors of the City Terminus Hotel, E.C., have placed an order with Messrs. Robey and Co., of Lincoln, for a boiler and duplicate system of main steam piping, as designed by their electrical engineer, Mr. W. Durtnall, under whose control their electric light installation has been erected with complete success.

NEW FIRM.—Messrs. S. Haynes and Co. have started in business as art metal workers at 2, Longford-street, London, N.W. Mr. Haynes was, we understand, formerly with Messrs. Verity, of Regent-street, London, W. The business of the firm will be to supply the trade only with art metal work to requirements.

HOOKHAM METERS.—A new issue has been made by Messrs. Chamberlain and Hookham of the particulars and price list of Hookham meters. The list contains admirable illustrations of this well-known meter, and the letterpress includes a report by Mr. James Swinburne, and a reprint of an article on "Permanent Magnet Circuits," by Mr. Hookham, from the *Phil. Mag.* Instructions are given for setting up and starting the meter, and details of its special use in charging secondary batteries.

MESSRS. O. BEREND AND CO.—This firm send us copies of their new lists "A" and "S." The former deals with the "Daylight" incandescent lamps supplied by the firm, of which prices and particulars are given, with trade discounts. Illustrations of fancy lamps, which are made to order, and of high-voltage single-filament lamps are also included in the catalogue. Special attention is called to a single-filament 16-c.p. lamp made to work on a 250-volt circuit. The "S" list deals with switches, cut-outs, resistances, and other apparatus for electric light and power installations; this is very fully illustrated. These lists can be obtained by the trade on application to the offices of the Company, 61, Fore-street, E.C.

COX-WALKER'S SPECIALITIES.—A new catalogue is issued of these specialities, which include English-made telephones, electric dinner or alarm gongs, electric bells, fire alarm apparatus, lightning conductors, &c.

FIRE AT NORTH WOOLWICH.—A fire occurred at Messrs. W. T. Henley's works in Store-road, North Woolwich, on Wednesday night, with the result that the lead-covering shop was seriously damaged, but we are able to state that this damage will be fully repaired in about a week. No other part of the extensive works was injured, and business will be in no way interfered with.

PRESENTATION.—A smoking concert was given on Friday evening at Brighton by the employés of the old Brighton and Hove Electric Light Company, at which Mr. Willett, the engineer, was presented by his former colleagues with a handsomely-fitted portmanteau on

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the occasion of his leaving the district to assume the post of electrician on Capt. McCalmont's new steam yacht.

Electro-Harmonic Society.—The next smoking concert will be held at the St. James's Hall Restaurant on Friday next, the 26th inst., at 8 p.m.

An Alleged Nuisance.—On Tuesday the Crystal Palace District Electric Supply Company (Limited) were summoned at the Greenwich Police Court at the instance of the Lewisham District Board of Works, for causing an effluvium to issue from their works at Springfield, Wells-road, Sydenham. Witnesses were called to prove that from time to time offensive vapours had been proceeding from a shaft at the Company's works; whilst, on the other hand, it was contended that the smell did not come from the Company's premises. A resident said that since the issue of the summons there had been an improvement; but Mr. Offor, the Managing Director, said there had been no alteration whatever in the fuel consumed, so that the smell complained could not have come from their works. The summons was eventually adjourned *sine die.*

Birmingham.—Col. W. M. Ducat, R.E., held a Local Government Board enquiry on Tuesday in the Council Chamber with regard to an application by the Corporation for sanction to borrow a sum of £55,741 for various purposes, including £1,000 for the electric lighting of the Market Hall. The Town Clerk said that this work had already been done, as the Corporation were anxious to have the light ready for the winter. No opposition was offered to the application, which will be reported upon in due course.

Bolton.—The Gas Lighting and Electricity Committee of the Town Council, on Friday, decided to issue a circular to the ratepayers, containing information as to the terms and conditions upon which the Corporation would be prepared to supply the electric current to premises within the borough. The electrical engineer reported that the works at the station in Spa-road were so far advanced that a preliminary trial of the electric lighting plant would very shortly be held.

Bow (London, E.).—The Vestry have decided to defer until after the next election the consideration of the electric light proposals of the Poplar District Board of Works.

Brechin.—At a special meeting of the Police Commission on Monday it was decided to support the application of the Scottish House-to-House Electricity Company to the Board of Trade for a Provisional Order. It was stated that the Company had agreed to at once take the necessary steps to obtain a Provisional Order at their own cost and responsibility; to lay down a thoroughly efficient plant for the electric lighting of the town; to allow the Local Authority, if desired, to acquire the undertaking at the expiry of ten years from the time of the introduction of the electric light into the burghs, and in the event of the Local Authority wishing to take over the undertaking at that period, then the Authority would, after 5 per cent. per annum had been deducted on a capital of £10,000, for depreciation, maintenance, &c., be entitled to receive 10 per cent. of the net profits of the undertaking until the undertakers earned 6 per cent. per annum and 20 per cent. upon all profits above 6 per cent. It was also agreed that the maximum charge should be 8d. per unit, and the Company further undertook to supply the electric current to the burgh at 25 per cent., light for light, below the present rate for gas in Brechin, viz., 4s. 7d. per 1,000 feet.

Bristol.—The negotiations for supplying the electric light to St. Mary Redcliff Church have come to a successful close, and the work of extension will be at once proceeded with.—On Monday a meeting of the Stoke's Croft and North-street Ratepayers' Association passed a resolution urging the Electrical Committee to extend the electric light in the direction of Stoke's Croft as far as Ashley Chapel as soon as possible.

Derby.—The Assembly Rooms at Derby have recently been lit by electricity. The building was originally designed by Adams towards the end of last century, including the interior decorations, and it was desired by the trustees that the very handsome candelabras should not be disturbed. These have been reconstructed by John Davis and Son, of Derby, into electroliers; the lamps resemble the candles they originally contained. Other electric lamps are fixed round the room into specially-designed brackets with floral decorations, thus reserving the general character of the decorations.

Douglas (Isle of Man).—The Town Commissioners at their meeting last week had before them a recommendation of the Health Committee that the lighting of the public lamps during the autumn and winter be handed over to the Douglas Gas Light Company on the usual terms. After some discussion this was agreed to; but an addition to the resolution was also carried that the Committee be instructed to make inquiries with regard to electric lighting, and submit a report thereon at the earliest opportunity.

Dublin.—The residents of Moore-street have been for a long time dissatisfied with the paving and lighting of the thoroughfare and at a meeting last week appointed a deputation to wait upon the Paving and Lighting Committee of the Corporation to urge that the roadway be made up, and that the electric light be introduced for the street lighting. The deputation accordingly waited upon the committee on Friday, with the result that the electric light is to be extended to Moore-street, the question of paving to be considered later on.

Elmore Copper.—We are asked to state that a number of steamships have been recently fitted with Elmore copper seamless steam pipes, including the following:—For W. Doxford and Sons, "Bencliffe" and "Caelens"; for Bertram Haswell and Co., "Queen Olga" and "Elderstein"; for Short Brothers, "Cordova" and "Tartar Prince"; for the Edwards Shipbuilding Company, "Canterbury"; for the Marquess of Londonderry, "Vane Tempest." It is stated that the Company's Leeds works have been kept busy with important orders for the Government, the railway companies and marine engineers.

Exhibition Award.—The Willans engine has gained a gold medal at the Lyons Exhibition.

Great Yarmouth.—The Town Council have decided to light the Town Hall by electricity, at an estimated cost of £300, and to extend the electric light to the Fish Wharf.

Hove.—At a meeting of the Hove Commissioners on Thursday last week, it was resolved to provide a silence box for the telephone in the basement of the Town Hall. It was stated that the electric light in the hall had been tested, and the result was held to be satisfactory; some minor alterations would be effected, and then the system adopted would be found to be a great success.

Kensington (London, W.).—The Select Electric Lighting Committee of the Vestry reported at the last meeting that they had had under consideration a letter from the Board of Trade asking them for any observations they might wish to make upon the amended description of the scheme by which the House-to-House Electric Light Company proposed to supply electric energy within the district of the Vestry; but that before doing so they had directed the Vestry Clerk to apply to the Company for information on various points. The matter was referred to the Electric Lighting Committee.

Leeds.—In reference to our Trade Note of last week relative to the newly-opened Medical School and College Hall of the Yorkshire College, we are requested to state that, whilst the electric lighting of the former building was carried out by Mr. Churton, the electric lighting of the Yorkshire College has been done entirely by Mr. Wilson Hartnell.

Liverpool.—At the meeting of the Markets Committee of the Liverpool Corporation on Tuesday it was urged by some of the members that the markets themselves were "the pink of perfection," and all that was necessary was the electric light. The Chairman agreed, saying he thought the improvement would soon have to be undertaken.

Llangollen.—A firm of electrical engineers having sought the permission of the Local Board to make an experiment in the lighting of the town by the electric current, the clerk was instructed at the last meeting to ascertain whether an order of the Board of Trade was necessary to the proposed experiment.

Londonderry.—Last week's meeting of the Lighting Committee of the Corporation was occupied for two hours in the consideration of the present condition of the electric lighting scheme. The meeting had before it an offer from Messrs. Siemens Brothers to re-lay one of the circuits, which they have found is not able to stand the amount of insulation resistance mentioned in the specification. Mr. Christie, the resident electrical engineer, said that Messrs. Siemens were going through the whole of the circuits and testing them carefully. In reference to the matter of the clause which was struck out from the specification after it had been approved by Dr. Hopkinson, Mr. Blake, the Corporation's electrical engineer, under whom the scheme was introduced, said that this clause was impracticable, and was inserted not by him, but by Dr. Hopkinson in the original draft specification. All the contractors had struck out this clause. It was ultimately proposed that a deputation should proceed to London to interview Messrs. Siemens Brothers and Dr. Hopkinson, but no decision was come to on the proposal. We understand the light is now working satisfactorily, and that no further failures have been reported.

Medical Battery Company (Limited).—We regret to learn that the business of Harness's Medical Battery Company has been re-registered with a capital of £15,000, under the title of the Medical Electrical Institute (Limited). The Directors may rely upon their proceedings being closely watched by the medical and electrical press, and it will be interesting to follow the steps taken by the Company to justify the two first words of its title.

Morecambe.—A complaint of an alleged nuisance created by the works of the Electric Light Company has been referred by the Local Board to the Medical Officer of Health.

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Monmouth.—The Town Council held on Tuesday a special meeting for the purpose of inspecting various suggested sites for works in connection with the combined scheme for drainage and electric light.

Moss Side (Lancs.).—The School Board have had before them on one or two occasions the question of lighting the Princess-road School, and at the last meeting, after some discussion on the relative meritt and cost of the electric light and gas, the subject was referred to the Sites Committee for consideration and report.

Nottingham.—It has been decided by the Lighting Committee of the Town Council to light the Great Market-place by the electric light.

Portsmouth.—At the meeting of the Town Conncil on Thursday last week, the Electric Lighting Committee submitted a report dealing with their receipts and expenditure since the starting of the works. They recommended that application be made to the Local Government Board for permission to borrow £1,800, balance of the £60,000 which was authorised by the Council for the carrying out of the electric light installation. In moving the adoption of the report, Alderman Ellis said there was every probability of the Committee paying its way on the first year's working.

Royal Aquarium.—The Directors of the Royal Aquarium, Westminster, London, have got together a very interesting exhibition of pictorial posters by French and English artists, in which the fancies of the latter have been allowed full scope. It would appear that amongst the present-day fads is one for the collection of these "works of art," and collectors have lent many of their choicest specimens for this exhibition, for which a superbly-illustrated catalogue is in preparation, edited by Mr. Edward Beller. The exhibition opens at the end of next week.

Stafford.—The foundation stone of the electric light station was laid on Wednesday by the Mayor, Councillor G. Wormall.

St. Pancras (London, N.W.).—The Vestry deem it desirable to acquire the freehold of the King's-road central station site; and for this purpose, as well as to meet the contracts in connection with the destructor buildings and appliances, the central electric station buildings, electrical machinery and mains, a sum of £65,000 would be required. Application is to be made to the London County Council for a loan of this amount, repayable by equal instalments of principal and interest combined in 42 years.

The Telegraph Wire Export Trade.—As compared with the corresponding period of last year, an exceedingly brisk tone characterised the export trade of this country in telegraph wire and apparatus connected therewith last month, the exports amounting in value to £49,820, as against only £32,865 in September, 1893. The prevailing activity is more clearly shown by comparing the figures relating to the exports during the first nine months of the year. During the nine months ended September last the value of the exports of these materials has reached a total of no less than £1,304,894, as against only £766,224 in the corresponding period of 1893, and £800,440 in the first nine months of 1892.

Tonbridge.—At the meeting of the Local Board last week it was resolved to apply for a Provisional Order. The Holloway Electricity Supply Company (Limited) have already given notice of their intention to apply to the Board of Trade for similar powers over the Local Board's district.

Trentham (North Staffs.).—The Duke of Sutherland is having very extensive alterations made on his Trentham estate, at a cost of between £20,000 and £30,000. The work includes the electric lighting of the house, the dynamos being driven by water-power obtained from the river Trent.

Walsall.—At the meeting of the Town Council last week, the Gas Committee reported that the Local Government Board had refused to approve of the arrangement whereby it was proposed to pay £2,250 out of the loan for electric lighting purposes to the credit of the gas undertaking for the site of the central station at the Wolverhampton-street gas works, and the Committee had therefore decided to charge the electric light department £90 per annum as rent for the site of the station.

Warminster.—The Committee of the Local Board appointed to carry out the extension of the electric light reported at the meeting last week that they had instructed the surveyor to obtain tenders for the supply of a dynamo to run 7 2,000-c.p. arc lamps, six new lamps, a mile of cable and the necessary lead piping. This was approved by the Board, and the clerk was instructed to apply to the Local Government Board for permission to borrow the money.

Whitechapel (London, E.).—The District Board of Works on Monday decided to inform the Secretary to the City of London Electric Lighting Company that the site they offer to the Board for a power station will not be required, as in their present destructor premises excellent accommodation is afforded. By the utilisation of the waste heat in the destructor premises, the Whitechapel authorities hope to justify their provision of electric light, which they can supply at 5d. per unit, as against 8d. charged by the City Company.

Windsor.—At the last meeting of the Town Council, Alderman Dewe, Chairman of the Electric Lighting Committee, said that they had received a report from Mr. Shoolbred, who had been requested to report on the question of the electric light. He estimated on the capital account an expenditure of £18,500, and on the profit and loss account an expenditure of £1,680, and the probable receipts, at 7d. per unit, would come to £2,187, showing a loss on the first two years' working of only £443. He proposed that Mr. Shoolbred's report be printed and circulated, and that the question be considered at a future meeting of the Council, and that in the meantime application be made to the Board of Trade for a Provisional Order. After some discussion, this was agreed to.

Worcester.—The Electrical Exhibition, which will remain open until Saturday next, is proving a far greater attraction than was anticipated, the electrical cooking and the telephones connected to London theatres being among the most interesting features.——The Union Club is among the latest customers for the electric light, the premises being wired by the New British Electrical Installation Contractors (Limited).

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by Mr. J. C. Chapman, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

Note.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

September 25, 1894.

18,196. Siemens Bros. and Co (Limited). London. Improvements in current collectors for overhead electrical conductors. (Siemens and Halske, Germany.)

18,202. H. V. Coad. London. Improvements in and connected with primary batteries.

18,206. W. Walker, Jun., and F. R. Wilkins. London. Improvements in utilising residual products obtained in working certain kinds of voltaic batteries.

18,217. L. J. Blake. London. Improvements relating to the transmission of telephonic messages between the shore and a lighthouse, ship, or other signal station.*

September 26, 1894.

18,273. J. Imray. London. Improvements in electric motors. (La Société Anonyme pour la transmission de la force par L'electricité, France.)

18,288. C. Riordon. London. Improvements in secondary or storage batteries.*

18,389. J. H. K. McCollum. London. Improvements in electric motors

September 27, 1894.

18,297. D. Mathien. London. Improved electric apparatus for strikin bells and the like.*

18,328. G. E. Fletcher. Stockport. An improved method of duple telegraphy.

18,339. E. G. Acheson. London. Improvements in and connected with carbons for electric lamps or for other purposes.*

18,359. B. Willcox. London. Improvements in or connected with electrical elevating mechanism. (The Eisenwerk, late Nagel and Kaemp, Actien Gesellschaft, Germany.)

September 28, 1894.

18,427. M. Hutin and M. Leblanc. London. Improvements in electrical traction and apparatus therefor.*

September 29, 1894.

18,480. W. N. Jaskey and E. S. Else. London. Improvements in automatic electrical gas lighters.*

18,501. W. T. Kerr. London. Improvements in or relating to incandescent electric lamps.

18,507. C. O. Duetschmann. London. A quick break electric lampholder.

18,552. W. S. Pendleton. London. Improvements in electric arc lamps.

October 1, 1894.

18,542. H. W. C. Cox and Richard J. Crowley. London. Improvements in facsimile telegraphs.

18,559. A. W. Gamage. London. An improvement in electric conductors.

October 2, 1894.

18,661. The Acme and Immisch Electric Works (Limited) and E. F Moy. London. An improved frame or holder for detachable electric fuses.

18,662. The Acme and Immisch Electric Works (Limited) and E. F. Moy. London. An improvement in switches for electric circuits.

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18,663. J. S. ROBBIN. London. Improvements in apparatus for lighting buildings.

18,673. H. F. MOUQUIN. London. Improvements in electric mechanism for winding and synchronising clocks.*

October 3, 1894.

18,696. F. H. STARLING. Nottingham. Improvements in instantaneous quick-break double-pole switches.

18,722. J. G. W. BERKHOLTZ. London. New or improved apparatus for firing off flashing signals.*

18,743. A. H. BAGNOLD. London. An improvement in conductors for overhead electric conductors.

18,753. J. M. MCMAHAN. London. Improvements relating to the transmission of telegraphic signals, and to apparatus therefor.

18,754. J. M. MCMAHAN. London. Improvements in and relating to the transmission of telegraphic signals, and to apparatus therefor.

18,755. J. M. MCMAHAN. London. Improvements in and relating to apparatus for intermittently closing and interrupting electric circuits.

18,767. D. BATES, T. HARDEN, and O. L. PEARD. London. Improvements in automatic switches for transformers or other electrical appliances.

October 4, 1894.

18,809. F. KING. London. Improvements in or connected with secondary or electric storage batteries.

18,814. BASILE A. BALASNY. London. Improvements in electric batteries.

October 5, 1894.

18,860. G. KIRBY CHAMBERS. London. Improvements in the automatic connection of conductors conveying alternating currents of electricity.

18,910. P. JENSEN. London. Improvements in and relating to vessels for electrolytical purposes. (Hans Cappelen and Diderik Cappelen, Norway.)*

18,933. H. T. HARRISON. London. Improvements in apparatus for making and breaking electric circuits.

October 6, 1894.

18,999. W. P. THOMPSON. Liverpool. Improvements in electric fuses for mines and like purposes. (La Société M. Gaupillat and Company, France.)

October 8, 1894.

19,065. H. A. TOBIAS, W. H. CADMAN, and R. J. CROWLEY. London. Improvements in or relating to the production of electricity.

October 9, 1894.

19,121. J. E. WOOLVERTON. Glasgow. Improvements in electric arc lamps.*

19,150. W. H. BECK. London. Improvements in the method of, and apparatus for, the electro-deposition of metals. (C. R. Fletcher, United States.)

19,155. A. J. BOULT. London. Improvements in or relating to arc lamps. (P. Laminne, Belgium.)

19,157. H. LE R. BRIDGMAN. London. Improvements in, or relating to electric battery plates.

19,176. L. M. ERICSSON. London. Improvements in, or connected with, telephone indicators, or annunciators.

19,184. J. R. DAVIS. London. Improvements in electric heaters.

19,185. F. STEVENS and R. R. KESTEVEN. London. Improvements in electric switches, or circuit breakers.

19,186. L. G. ROWAND. London. Improvements in electric thermostatic fire-alarms.*

19,191. F. A. VON ALIMONDA and N. VON ALIMONDA. London. Improved means for securing the conducting wire to the carbon electrode in elements of galvanic batteries.*

October 10, 1894.

19,220. W. D. WHYTE and D. MUIRHEAD. Glasgow. Improvements in and relating to electric ship logs.

19,247. G. F. KENYON and E. MOORHOUSE. London. Improvements in electrical ceiling roses.

19,285. M. V. LUIS and E. C. ELGOOD. London. A novel construction or arrangement of electric and gas chandeliers. (L. Priebe, Germany.)

19,286. L. B. ATKINSON. London. Improvements in electric motors, and appliances connected therewith partly applicable also to electric generators.

October 11, 1894.

19,291. D. F. ADAMSON and C. D'O. HUTCHINS. London. Improved electric signal device.

19,343. C. D. ABEL. London. Motor vehicles for railways and tramways driven by gas or oil motor engines in combination with electromotors and accumulators. (The Gasmotoren Fabrik Deutz, Germany.)

19,362. J. S. RAWORTH. London. Improvements in electrical safety devices.

19,364. C. CONNORS and W. L. DAVIES. London. Improvements in electromotors and like electromagnetic apparatus.

October 12, 1894.

19,421. F. B. BEHR. London. A method of hauling by electricity, and apparatus for that purpose.

SPECIFICATIONS PUBLISHED.

NOTE.—All Specifications can now be obtained at the uniform price of 8d. each.

1893.

17,172. BAYNES. Covers for junction boxes for electrical distribution.
18,175. FRANZ and OTTO. Telephone switchboards.
18,734. OLSEN. Electric meters.
20,625. BARNETT. Carbon electrode connections.
22,186. TYER. Lock and block electric apparatus for railways.
22,395. POWNALL, P. E. and R. B. Electric systems and apparatus.
23,283. PENSON. Connecting electric conductors.
23,309. HUTIN and LEBLANC. Continuous-current dynamos.
23,331. CUTTRISS. Electric current regulators, &c.
23,337. HOLDEN. Electric meters.
23,385. JEWELL and ZIMMERMAN. Galvanometers.
24,243. LAUDER. Electrical arc lamps.

1894.

4,170. THOMPSON (Bradley). Alternating-current motors.
4,171. THOMPSON (Bradley). Alternating-current motors.
5,299. ROCKLIFFE and OTHERS. Brushes for preparing metals for electroplating, &c.
5,754. LAUDER. Electrical arc lamps.
6,212. CATTORI. Electric railways.
7,145. COWPER, COLES, and WALKER. Electro deposition of zinc.
10,044. THEODOLI. Luminous electric changeable writing.
13,377. JENSEN (Störmer). Electrolytically treating salts.
13,794. EISENHUTH and OTHERS. Electric conduits.
14,607. LAMB. Electric cable traction apparatus.
14,642. FEENY (Dubero and another). Electric battery.
14,651. DYMOND (Trudeau). Electrical heating devices.
14,922. FIELDER. Electrically operating semaphore signals.
15,276. KILIANI and OTHERS. Diaphragms for electrolytic purposes.
15,900. SIEMENS BROS. AND CO. (Siemens and Halske). Shunt arc lamps for alternating currents.
16,002. HOUSE and OTHERS. Refining metals by electrolysis.

RECENT FRENCH PATENTS.

229,858. PESCHARD. Certificate of addition to patent for an electro-hydraulic system.
238,558. HEILMANN. New method of elastic suspension of electric motors used for traction.
238,584. JOHNSSON. Electric gas lighter.
238,596. FRANK. Magneto-electric telephone.
238,609. BLASNY. Incandescent electric lamp.
238,612. CORBIN. Apparatus for the industrial treatment of aqueous solutions of various chemical compounds, particularly alkaline chlorides and alkaline earth, by the electric current.
238,626. THEODOLI. System of changeable luminous electric writing, and apparatus therefor.
238,633. CRANEY. Improvements in electrical apparatus.
238,698. HIGHAM ELECTRIC COMPANY. Improvements in electric arc lamps.
238,703. NÉTY. Continuous-current induction coil.
238,708. CRANEY. Improvements in electrolytic apparatus.
238,712. SPERRY. Improved method and apparatus for stopping the movement of mechanism actuated by electricity.
238,717. LAVILLE. New primary battery.
238,742. EPSTEIN. Process for keeping in working condition the positive plates of secondary batteries.
238,772. SOCIÉTÉ DES CUIVRES DE FRANCE. Process for the deposition of metals on revolving surfaces by electrolysis, called the "Paul David" process.
238,773. HAEFLIGER, VOGT AND CO. Electric fire alarm.

COMPANIES' MEETINGS AND REPORTS.

Brazilian Submarine Telegraph Company (Limited).

The following is the report of the Directors for the half-year ended June 30, 1894, to be submitted to the forty-second ordinary general meeting to be held at Winchester House, E.C., on Wednesday next, October 24th, at noon :—

The revenue for the half-year ended June 30 amounted to £94,679. 16s. 4d., and the working expenses to £20,269. 9s. 11d. After providing £12,880 for debenture interest and sinking funds, and £1,736. 9s. 10d. for income tax, there remains a balance of £59,793. 16s. 7d., to which is added the sum of £2,207. 9s. 2d. brought forward from December 31st last, making a total of £62,001. 5s. 9d. A quarterly interim dividend, amounting to £19,500, has been paid, and £15,000 transferred to the reserve fund. The Directors now recommend the declaration of a final dividend of 3s. per share, making, with the interim dividends, a total dividend of 6 per cent. for the year, and also the payment of a bonus of 1s. per share, both free of income tax, which, together will amount to £26,000, leaving a balance of £1,501. 5s. 9d. to be carried forward. The dividend and bonus

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will be payable on the 25th instant. On July 31st last the sum of £18,700 was transferred to pay off 187 bonds, the balance of the 1884 issue. The receipts for the half-year include the sum of £1,500 dividend to December 31, 1893, on the Company's shares in the African Direct Telegraph Company (Limited).

The various sections of the Company's line are in good working order.

Sir Henry D. Gooch, Bart., has resigned his seat at the Board, but it is not considered necessary to fill the seat at present. Sir John Pender, G.C.M.G., M.P., and the Hon. W. St. John Brodrick, M.P., retire at this meeting, and being eligible for re-election as Directors, offer themselves accordingly. The auditors, Messrs. Deloitte, Dever, Griffiths and Co., and Messrs. Gane, Jackson and Jefferys, also offer themselves for re-election.

Venezuela Telephone and Electrical Appliances Company (Limited).

The fourth annual report of the Directors, to be submitted to the general meeting of the Company, to be held at the Company's offices, 37, Lombard-street, E.C., on Tuesday next, at noon, is as follows:—

The accounts for the twelve months ended June 30th show a profit of £7,413. 5s. 11d., to which must be added the balance of £1,558. 9s. 7d. standing to profit and loss account. After providing the interest on the First and Second Mortgage Debentures, amounting to £4,393. 8s. 6d., the Directors have written off the sum of £1,711. 15s. 3d. from the discount and expenses on Debenture issues. This leaves a balance of £2,866. 11s. 9d., out of which the Directors recommend that a dividend on the Company's share capital be declared for the year ending June 30, 1894, at the rate of 4 per cent. per annum, which will absorb £2,800, and that the balance of £66. 11s. 9d. be carried forward. The Company's property having been fully maintained—as set forth by the General Manager's certificate at the end of the balance-sheet—the Board do not consider it necessary, at the present time, to make any allowance for depreciation of plant.

In the last annual report, the Directors informed the shareholders that the switchboard capacity in Caracas had been further increased by 200 numbers, and it with great satisfaction that they report that, owing to the steady growth of the business, the capacity is now being still further increased by another 200 numbers, thus providing accommodation in that city for 1,800 subscribers.

Mr. Edgar A. Wallis, the Company's general manager in Venezuela, being at present in England, will attend the general meeting, and make his report to the shareholders in person.

Sir Douglas Fox retires from office as a Director, and, being eligible, offers himself for re-election; as also do Messrs. Price, Waterhouse and Co., the auditors.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1894, pages 274-300, *&c., &c.*]

AKTIENGESELLSCHAFT FUR FERNSPRECHPATENTE.—Under this name a Company has been formed in Berlin, with a capital of £62,500, to acquire and dispose of patents relating to telephony.

ARIEL ARC LAMP SYNDICATE (LIMITED).—This Company has just entered into an agreement with Samuel Sealy-Allin and Charles S. G. Lloyd for the acquisition of the Provisional Specification dated July 4, 1894, No. 12,946, for a patent for "improvements in arc electric lamps," in consideration for the allotment as fully paid of 1,500 shares, of £10 each, to Samuel Sealy-Allin, and 400 shares to Charles S. G. Lloyd.

tists, chiropodists, Turkish and other bath proprietors, &c. The first Directors are Charles G. Elers and John Oliver (nominated by Ordinary shareholders), Arthur L. Poulter and Leopold J. Greenberg (nominated by Preference shareholders), and William B. Jones and Augustus Fleet (nominated by Second Mortgage Debenture holders). Registered office, 52, Oxford-street, London, W.

CHARLES JOYNER AND CO. (LIMITED).—This Company was registered on October 12th, with a capital of £35,000 in £10 shares, to acquire and take over as a going concern the business of manufacturers of and dealers in fittings connected with lighting by gas, oil, or electric light, carried on by Charles Joyner and Co. at Birmingham, and to carry on the business of manufacturers of and dealers in lamps, electroliers, ceiling roses, switches, shade and lamp holders, and other electrical fittings, &c.

MEDICAL ELECTRICAL INSTITUTE (LIMITED).—This Company is formed with a capital of £75,000, divided into 25,000 Seven per Cent. Preference Shares of £1 each and 20,000 Ordinary Shares of £2. 10s. each. Objects: To purchase, or otherwise acquire the lease, goodwill, rights, privileges, contracts, copyrights, trade-marks, patents, assets, and property of the Medical Battery Company (Limited); to carry into effect an agreement dated October 16th, between the Medical Battery Company (Limited) (in liquidation), and Herbert Banyard (for this Company); to provide for and carry out, under the control and superintendence of a duly-qualified medical man, the treatment of diseases by means of galvanic, electric, and magnetic appliances, batteries, baths, medical and other apparatus, and by massage, hydrotherapic inhalation, mechanical exercise (Dr. Zander's or any other system), chemical, dental, and other processes, and to carry on the business of manufacturers of and dealers in all kinds of galvanic, electric, magnetic mechanico, therapeutic, gymnastic, and other appliances, chemists and druggists, den-

STALYBRIDGE FOUNDRY COMPANY (LIMITED).—This Company was registered on October 10th with a capital of £15,000 in £10 shares, to acquire the business of ironfounders carried on at the Britannia Iron Foundry, Ashton-under-Lyne, Lancs., and to carry on the business of iron, steel, and brass founders, mechanical and electrical engineers, metal workers, &c.

AURORA ELECTRIC LIGHTING & DISTRIBUTION COMPANY (LTD.).—The annual return of this Company, made up to October 1st, has been filed; 5,935 shares have been taken up out of a capital of £25,000 in £1 shares, of which 5,000 have been issued as fully paid. Upon the remaining 935 shares the full amounts have been called and paid.

BABCOCK AND WILCOX (LIMITED).—The annual return of this Company, made up to October 2nd, was recently filed. The capital of £240,000 is divided into 10,000 £6 per Cent. Cumulative Preference and 14,000 Ordinary shares of £10 each. All these shares have been taken up, and 3,333 Preference and 4,666 Ordinary shares have been issued as fully paid. The full amount has been called on the remaining 6,667 Preference and 9,334 Ordinary shares, resulting in the total payment of £160,010.

BICKLE AND COMPANY (LIMITED).—The annual return of this concern, made up to October 3rd, was recently filed. 2,030 shares have been taken up out of a capital of £50,000, in £10 shares, and 1,000 of these were issued as fully paid. Resulting from a call of £10 per share on the remainder, £10,203 has been received, leaving £97 as yet in arrears.

BUENOS AYRES ELECTRIC LIGHT COMPANY (LIMITED).—The annual return of this Company, made up to July 3rd, has been filed. The Company has a nominal capital of £100,000, divided into 9,986 Ordinary shares of £10 each, and 70 Founders' shares of £2 each. All the latter have been taken up, but no calls have been made thereon.

CALIFORNIAN ELECTRIC POWER AND MINING DEVELOPMENT SYNDICATE (LIMITED).—The statutory return of this Company, made up to September 18th, and recently filed, shows that only the seven signatories' shares have been taken up out of a nominal capital of £30,000, in £1 shares. No calls have as yet been made upon these shares.

CITY NOTES.

BIRMINGHAM CENTRAL TRAMWAY COMPANY.—By an error a City Note in our last issue announced that the proposal made by the Directors of this Company to reduce the capital from £500,000 to £300,000 was passed unanimously. This was not the case; the Directors' resolution was rejected. Another extraordinary meeting to consider the proposal has been convened for Wednesday next.

CITY AND SOUTH LONDON RAILWAY.—The traffic returns of this Company for the week ended October 14th were £921, as against £851 in the corresponding period of 1893, being an increase of £70. The total receipts for the half-year amount to £12,931, as against £12,146 for the corresponding period of 1893, an increase of £785.

ISLE OF MAN ELECTRIC TRAMWAY COMPANY (LIMITED).—The Directors have issued a circular in which they state that, having carefully considered the profits for the past season, and having consulted with the auditors, they have, after providing a large sum for the reserve and renewal fund, and making provision for further dividends at the end of the year, decided to pay an interim dividend at the rate of 6 per cent. per annum on the Preference, and of 7½ per cent. on the Ordinary shares for the six months ending October 31st.

MILDE TELEPHONES AND ELECTRIC SUPPLY COMPANY (LIMITED).—The following letter deals with the attempt to obtain capital for this Company, referred to in our issue of Oct. 5th:—"Sir: Our attention has been called to a prospectus of the Mildé Telephones and Electric Supply Company (Limited). We beg to inform you that Mr. Charles Mildé has not consented to be a Director of that Company under any circumstances, as the articles of our firm will not permit it.—CH. MILDE, FILS AND CO., 26, Rue Laugier, Paris."

NEW GERMAN ELECTRICAL SYNDICATE.—It is reported that a Company is about to be formed in Berlin, under the auspices of the Diskonto-Gesellschaft and other leading financial houses of Berlin, for the purpose of financing electrical undertakings. The president is to be Herr Baurath Lent, of the Diskonto-Gesellschaft.

ST. JAMES AND PALL MALL ELECTRIC LIGHT COMPANY (LIMITED).—The electric current sold during the quarter ended September 29th last amounted to £6,935, as against £4,820 for the corresponding period of 1893.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended October 12th (after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited), were £3,093.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The Directors of this Company have decided to recommend the under-mentioned dividends for the six months ended June 30th last:—6s. per share on the First and Second Preference shares, and 6d. per share on the Ordinary shares.

WESTMINSTER ELECTRIC SUPPLY CORPORATION (LIMITED).—An extraordinary meeting of the shareholders of this Corporation is to be held at Eccleston-place, S.W., on Wednesday next, the 24th inst., at 11 a.m., to consider a proposition to increase the capital from £300,000 to £400,000.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share	Last Dividend.	Name.	Previous Week's Price, Oct. 10.		Price Wednesday, Oct. 17.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Oct. 17. Highest	Lowest
			TELEGRAPHS.					£ s. d.		Highest	Lowest
£1,012,880	Stock	9 0	Anglo-American .... xd	39	42	38	41	4 17 7	Jan., Apr., July, Oct.	39½	38
£2,993,560	Stock	18/0	Do. Preferred .... xd	75½	76½	75	76	5 11 10	" "	75½	74½
£2,993,560	Stock	5/0	Do. Deferred	6¾	7¼	6¾	7¼	..		..	..
£184,500	100	4%	*African Direct Teleg. 4% Deb. (Reg. & Bearer)....	102	105	102	105	3 16 11	January and July ..	..	..
130,000	£10	3/0	Brazilian Submarine	12¾	13¼	12¾	13¼	4 18 1	Mar., June, Oct., Dec.	13	12¾
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1906)	110	114	110	114	4 8 8	June and December	..	–
10,000,000	$100	$1¾	Commercial Cable Capital Stock	135	145	135	145	4 17 9	Jan., Apr., July, Oct.	–	..
16,000	10	8/0	Cuba Submarine	12½	13½	12½	13½	5 18 6	February and August	..	–
6,000	10	10%	Do. Preference 10 per Cent.	19	20	19	20	5 0 0	" "	19½	..
12,931	5	1/8	Direct Spanish (£4 paid)	4½	4¾	4½	4¾	4 4 3	April and October	..	..
6,000	5	10%	Do. Preference 10 per Cent.	9½	9¾	9½	9¾	5 2 7	" "	..	–
£30,000	Stock	4½%	Do. 4½% Debentures of £50 each	105%	108%	105%	108%	..	..	..	..
60,710	20	2/0	Direct United States Cable, 1877 .... xd	8¾	9½	8½	9	5 16 8	Jan., Apr., July, Oct.	9	8{11/16}
400,000	10	2/6	Eastern .... xd	15¾	16	15¾	16	4 1 3	" "	16	15¾
70,000	10	6%	Do. 6 per Cent. Preference .... xd	16¾	17¼	16¾	17¼	3 9 7	" "	16{13/16}	16¾
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	118	121	118	121	3 6 2	May and November	120	..
£102,100	100	5%	* Do. 5 per Cent. Debentures, 1899	106	110	106	110	4 11 6	February & August	..	–
250,000	10	2/6	Eastern Extension .... xd	16	16½	16	16½	4 6 3	Jan., Apr., July, Oct.	16{5/16}	16
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	116	120	116	120	3 6 8	February & August	..	..
£62,700	100	5%	* Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900....	103	106	103	106	4 15 6	January and July	..	–
£95,100	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb., 1900..	103	106	103	106	4 15 6	" "	..	..
£300,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.) ..	104	107	104	107	3 15 4	February & August	..	..
£200,000	£25	4%	* Do. 4% Mauritius Sub. Debs.	109%	112%	109%	112%	3 12 9	May and November	..	..
180,227	10	1/3	Globe Telegraph and Trust .... xd	8¾	9½	8¾	9	4 17 3	Jan., Apr., July, Oct.	9	8{13/16}
180,042	10	6%	Do. 6 per Cent. Preference	15¾	16½	15½	16	3 15 0	" "	16	15¾
150,000	10	5/0	Great Northern	20¾	21¼	20¾	21¼	3 13 1	Jan., April, and July	20¾	..
£190,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	104	107	104	107	4 13 6	March & September	..	..
17,000	25	37/6	Indo-European	46	48	46	48	5 4 2	May and November	47½	47
37,548	10	5/0	London Platino-Brazilian	5	7	5	7	..	" "	..	..
£100,000	100	6%	* Do. 6 per Cent. Debentures	107	110	107	110	5 9 7	March & September	..	..
£100,000	£100	4%	*Pacific European Tel. 4% Guar. Debs. "Red" 1942 ..	104	107	104	107	3 15 6	..	..	..
11,839	8	4/0	Reuter's	3	5	3	5	..	April and October	..	..
3,381	£100 Cert.	35/0	*Submarine Cables Trust 6 per Cent.†	103	111	105	110	5 10 4	" "	..	..
15,609	10	5/0	West African Telegraph	3	5	3	5	..	January and July	..	..
£249,900	100	5%	* Do. 5 per Cent. Debentures	100	103	100	103	4 17 7	March & September	102½	..
30,000	10	2/0	West Coast of America	2	3	2	3	..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	101	106	101	106	7 10 11	June and December	..	..
88,321	10	9d.	West India and Panama	1⅜	1⅝	1⅜	1⅝	..	..	1½	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10¾	11¼	10¾	11¼	5 6 8	May and November	11½	10¾
4,669	10	6%	Do. 6 per Cent. 2nd Preference	9	10	9	10	6 0 0	" "	9¾	9¾
£80,000	100	5%	* Do. 5 per Cent. Debentures, 1917	108	111	108	111	4 11 1	June and December	.	..
64,242	15	7/6	Western and Brazilian	8¾	9½	8½	9	..	May and November	8½	..
33,129	7½	7/6	Do. 5 per Cent. Cumulative Preferred	6½	7	6½	7	..	..	6¾	6{9/16}
33,129	7½	4/6	Do. 5 per Cent. Deferred	2¾	3¼	2¾	3¼	..	..	..	..
£171,900	100	6%	* Do. 6 per Cent. Debs., Series "A" 1910	106	109	106	109	5 11 1	February & August	..	..
£214,800	100	6%	* Do. 6% Mort. Debs., Series "B" 1910	106	109	106	109	5 11 1	" "	..	..
$1,211,000	$1,000	7%	*Western Union 7% 1st Mort. (Building) Bonds	115	120	115	120	6 0 2	May and November	–	..
£166,900	£100	6%	* Do. 6 per Cent. Sterling Bonds	102	104	102	104	5 15 11	March & September	..	..
			TELEPHONES.								
44,000	5	10/0	Chili Telephone (fully paid)	2	3	2	3	..	..	2{5/16}	2½
224,850	10/0	2¾d.	Consolidated Telephone Const. & Maintenance ..	¼	½	¼	½	..	May and November	..	..
171,504	£1	6d.	Oriental Telephone and Electric (fully paid)	1{7/16}	1{9/16}	1{7/16}	1{9/16}	..	Yearly	..	..
484,597	5	3/4	National	4¾	5¼	4¾	5¼	4 17 7	June and December	5½	4{13/16}
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	15	15½	15	15½	3 17 5	" "	15{5/16}	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid) ..	14	15	14	15	4 0 0	" "	14¾	14½
119,234	5	3/4	Do. 5% Non-Cumulative 3rd Pref.	5¼	5¾	5¼	5¾	4 6 11	..	5¾	5{11/16}
1,000,000	Stock	4½%	* Do. Debenture Stock, 4½%	109	112	110	113	4 9 9	January and July	..	..
58,000	5	1/0	United River Plate	2	3	2	3	–	" "	..	..
£146,783	Stock	5%	Do. 5 per Cent. Debenture Stock	88	94	88	94	5 6 5	" "	..	–
			ELECTRICITY SUPPLY COMPANIES.								
40,000	£10	..	City of London Electric Lighting (fully paid)	13	14	13½	14½	..	..	13¾	..
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	14½	15	14¾	15¼	3 18 8	..	15½	15
19,000	£5	..	Electricity Supply Co. for Spain	..		..		..	–	..	..
£30,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	4½	5½	4	5	4 0 0	–	..	..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	..		..		..	–	..	..
8,322	£5	..	House-to-House Electric	..		..		..	–	..	–
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid).	..		..		–	..	..	–
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..		..		–	January and July	..	–
45,000	£5	2/6	Liverpool Electric Supply (fully paid)	6¾	7	6¾	7	–	..	..	–
111,000	5	..	London Electric Supply	¼	¾	¼	¾	–	..	..	..
49,900	£10	5/0	Metropolitan Electric Supply (fully paid)	9½	10	9½	10	2 10 0	..	9¾	9¾
£150,000	Stock	4½%	* Do. 4½% Debs. (Bonds of £10, £20, and £10) ..	111	113	113½	114½	..	June and December	..	..
6,452	£10	..	Notting Hill Electric	5½	6½	5½	6½	..	..	6½	..
19,980	£5	2/0	St. James and Pall Mall	7¼	7¾	7¼	7¾	–	..	7{5/16}	7¼
20,000	£5	7%	Do. 7 per Cent. Preference	8½	9	8½	9	3 17 9	..	8¾	8¾
59,900	5	2/0	Westminster Electric Supply (fully paid)	6¾	7½	6½	7	3 4 4	–	7{1/16}	6¾
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
90,000	3	1/6	Brush Electrical Engineering .... xd	2¾	3	2⅝	2⅞	5 4 4	..	2{13/16}	2¾
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative .. xd	2½	2¾	2½	2¾	4 7 3	..	2½	..
£125,000	Stock	4½%	* Do. 4½ per Cent. Debentures	110	113	111	114	3 19 6	March & September	112½	112
20,000	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref ..	2	2½	2	2½	–	January and July	..	..
12,139	5	..	Edison and Swan United	–		–		–	..	–	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid) ..	..		..		..	..	–	..
120,000	2	..	Electric Construction	⅜	⅝	¼	¾	..	..	½	¾
12,845	2	2/4½	Do. 7 per Cent. Cumulative Pref.	1¾	2¼	1½	2	..	–	2½	1{13/16}
91,195	2	10/0	Elmore's Patent Copper Depositing	1⅝	1⅞	1⅜	1⅝	..	–	1¾	..
20,000	5	..	Fowler-Waring Cables (fully paid)	¾	1¼	¾	1¼	..	..	..	..
50,000	10	10/0	India Rubber, Gutta Percha, &c., Works	24	25	24½	25½	4 18 0	February & August	25	24¾
£200,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	102	104	102	104	4 6 7	March & September	..	–
15,995	£10	6/4	International Okonite Ordinary	..		..		–	..	..	–
16,000	£10	..	Do. 8 per Cent. Preference	..		..		–	December and June	–	–
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid)	–	½	–	½	–	..	–	..
37,350	12	12/0	Telegraph Construction and Maintenance	41	43	41	43	4 8 9	March and July ..	42⅝	42
£150,000	100	5%	Do. 5 per Cent. Bonds	105	108	106	109	4 11 9	January and July	..	–
37,514	£5	–	Woodhouse and Rawson Ordinary (£3 15s. paid) ..	–		–		..	..	..	–
41,098	£5	–	Do. Preference (fully paid)	..		–		..	–	..	–
£63,870	10	10/0	W. T. Henley's Telegraph Works Ordinary	8	9	8	9	5 11 1	..	..	..
£30,000	10	..	Do. Preference	..		..		..	..	..	..
			RAILWAYS AND TRAMWAYS.								
£630,000	Stock	1%	City and South London Railway	36	38	36	38	1 16 2	May and November	37½	..
7,000	10	5%	Do. 5% Perpetual Preference	13	14	13	14	3 11 5	May and November	..	..
£67,130	Stock	4%	Do. 4% Perpetual Debenture	121	123	121	123	3 5 1	..	–	..
37,500	£10	1%	Liverpool Overhead Railway	7¼	8¼	7¾	8¼	1 4 3	..	..	..
6,295	10	5%	Do. 5% Preference	13	13½	13	13½	3 15 6	..	–	–
£125,000	Stock	4%	Do. 4% Debenture	111	113	111	113	3 10 10	January and July ..	–	–

* In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption. † Ex. 35s. on account of coupon October 15, 1894.

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THE ELECTRICIAN:

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NOTES.

At the meeting of the Westminster Electric Supply Corporation on Wednesday the Chairman was able to back up his request for £100,000 more capital by a very glowing picture of the lamp connection. At the beginning of this year some 132,000 8-c.p. lamps were connected to the mains of the Westminster Company; to-day that figure has been increased by 20 per cent., and applications are still coming at the same rate. It is also satisfactory to note that the desirability, not to say the necessity, of a substantial reserve fund is recognised, and that it is intended to commence betimes the tedious and, strange to say, frequently unpopular process of building up "an absolute reserve." Shareholders in electric supply companies, with the fate which has overtaken their tramway brethren in view, would do well not to put their trust in counsel's opinions, but to insist that adequate provision be made against the day of municipal purchase. Profits distributed up to the last penny may, no doubt, temporarily force up the market price of shares, and enable speculators to "unload" with advantage to their individual pockets; but moderate dividends and big reserves are the sheet anchor of electric light *investors.*

Small arc lamps, it would seem, are likely to become fashionable. We trust electric supply companies will not yield to the temptation of making their lamp connection "swell visibly" by reckoning, say a 500-c.p. arc as equivalent to 62 8-c.p. glow lamps. The watts demanded are the only reliable data to go upon.

What is *unfair* competition? We have heard so much about this strange bird of late that a satisfactory definition of it would be welcome. Such a relief, however, is not afforded us by the somewhat obscure letter signed "Consulting," which will be found in our correspondence columns this week. Letters over *noms de plume* rarely appear in our columns, as there are many objections to them; not the least of which is their tendency to mislead when *noms de plume* having no manner of connection with the writers' callings are assumed.

To define unfair competition as the poaching by manufacturers upon the preserves of contractors would at any rate be a clear enunciation of the grievance, whether the grievance itself were real or imaginary. But to lay it down as a law that makers of wires are not to be allowed to wire houses, whilst for "manufacturers of electrical sundries" to do so "is a step in the right direction," is ridiculous inconsistency. For our own part, we can see nothing "unfair" in cable-makers doing house-wiring if they choose. As to the degree of wisdom of the step, that will be determined by the rate of profit derived from the venture. As to whether it is "fair" or "unfair" that firms of manufacturers of electrical sundries should undertake wiring, we do not pretend to decide; but it is not at all clear that to do so "is a step in the right direction," for it is entering into competition with their own customers.

In the early days of the statutory electric supply business some companies made a mild attempt to "force a market" by doing a little house-wiring, but soon desisted, no doubt for excellent prudential reasons, such as the undesirability of arousing the hostility of the professional house-wirer and the difficulty of properly managing two totally different trades. Competition of this kind, had it been pushed, would, we doubt not, also have been dubbed "unfair," and would have given rise to a demonstration such as that recently directed against the Gas Light and Coke Company for trying to widen the market for gas by the sale and fixture of gas stoves at cost price. Capitalist competition of this kind is an unqualified good for the consumer, and as it neither diminishes the number of workmen in the particular trade or impairs their condition, it ought not come under the prohibition of those who consider that the ultimate end of a particular trade is to afford support to as many manual labourers as possible, regardless of all considerations.

The attempts of M. Broca to discover the law of the differential sensitiveness of the eye, while essentially a psychological problem, is of considerable practical interest to physicists in connection with the best length for a photometer bar. Inventors and advocates of different kinds of photometers are wont to claim wonderful accuracies for their instruments, expressed generally as errors of one-half or even one-fifth per cent. M. Broca shows that no such figure of merit has any meaning unless the illumination of the screens is given. The experiment with the Masson disc described in the abstract of his Paper, which we print in another column, is by no means an "extremely simple proceeding," as M. Broca states. His result, however, that for good photometric work an

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illumination of about one carcel-metre, or say one candle-foot is best, is of practical importance. A very common photometric measurement by electrical engineers is the comparison of a 16-c.p. glow lamp, with an amyl-acetate or pentane standard. Here the distance between the lamp—that is, the length of the photometer bar—will be about five times the distance of the photometer from the standard. May the bar be as short as 2ft., or is any greater accuracy to be gained by making it as long as 10ft.? To obtain an illumination of one candle-foot it is clear that the length should be about five feet; a 50-inch bar would not be far wrong. With a 10-foot bar, the illumination would be 0·16 of a candle-foot; with so feeble an illumination minute differences are not distinguishable. M. Broca finds that there is a wide range over which the sensitiveness does not differ, but he is of opinion that it begins to diminish again under higher illuminations than about one carcel-metre. We have repeated his experiment, using, instead of Indian ink spots, which are far from black when brilliantly illuminated, perforations in a white card revolving in front of a box lined with black velvet. Dazzling did not appear to disturb the sensitiveness until 10 to 15 candle-feet was reached. Experiments in daylight or in a room with unshaded lights might give different results, but they would have no practical bearing on photometry. M. Broca's experiences as to the difference between the right and left eye, show that either both eyes together, or one eye only, should be used. The habit of standing so close to an ordinary Bunsen photometer that the reflections of the right and left-hand faces of the disc are seen with the right and left eye respectively is liable to give serious errors.

The "three-voltmeter" method of measuring power in an inductive circuit is well known, but the two-voltmeter method of generating power may, perhaps, be less familiar to our readers. We have before us a circular relating to a voltmeter of American origin, in which it is asserted in prominent capital letters, that these instruments "will actually save you from five to ten times the amount of electrical energy which is required for the operation of any other type of instruments." To construct a 100-horse-power plant on this system, it is only necessary to build a voltmeter which shall waste 10 to 20 horse-power, and then to buy one of these novel voltmeters; no dynamos or steam engines are wanted, a watt saved is a watt gained. It would be a dangerous experiment to proceed to buy an electrostatic voltmeter which wastes no power; the result might be, according to this mode of reckoning, the generation of an infinite amount of electrical energy.

We have received the following communication:—

The electrolunatic presents his compliments to the Editor of *The Electrician*, and desires to known why it is that in her Order in Council of August 23, 1894, concerning electrical units and standards, Her Most Gracious Majesty spells Ohm and Volt with capitals, and ampere without a capital.

Speaking for ourselves, we can hardly consider Her Most Gracious Majesty responsible for what may be only a clerical error, a *lapsus linguæ*, or a fault on the part of the P.D. (*diabolus imprimatoris*); but in view of the circumstance that Her Majesty is in Scotland, where thistles abound, we are disposed, on the whole, to consider it a case of *Carduus nutans*.

Cable Interruption and Repair:—

	Date of Interruption.	Date of Repair.
Macao-Hong Kong ...	September 25, 1894. ...	October 19, 1894.
Zanzibar-Mombasa ...	September 4, 1894. ...	—

Telephonic Communication in South America.—Telephonic communication has just been established between Montevideo and Buenos Ayres.

Personal.—Mr. Arthur Dearlove, of Messrs. Clark, Forde and Taylor, and a valued contributor to our columns, was married yesterday at St. Mary Abbot's, Kensington.

Institution of Electrical Engineers.—The annual dinner of this institution is fixed to take place at the Freemason's Tavern, Great Queen-street, on Wednesday, November 21st.

Swiss Customs Duties on Electric Material.—It has recently been decided by the Swiss Customs Department that all globes for arc lamps and glass bulbs for incandescent lamps imported into Switzerland are to be classified under Category 215, under which the duty is 6fr. per quintal.

A Tax on Bad Car Service.—In granting the right for the construction of an electric railway in a town near Berlin, the municipality requires that a fine of £100 be paid to the city if there is any interruption in the running of the cars for which there is not sufficiently good reason.

H.M.S. "Agamemnon."—*Engineering* announces that H.M.S. "Agamemnon" is to have auxiliary circuits carried to her turrets, so that an alternative means of firing her guns by electric current can be provided in the event of the main circuit becoming disabled. The vessel is also to be fitted with a new type of electrical semaphore.

City of London Electric Lighting Company.—The City Electric Lighting Company were summoned to Southwark Police-court on Wednesday for causing a nuisance to arise by the emission of smoke from their shaft. A representative of the London County Council having stated that alterations had been made to obviate the violation of the law, the summons was withdrawn.

Electric Tramways at Cape Town.—Some time ago two proposals were submitted by different parties to the Cape Town Municipal Council: one for the construction of a line of tramway along Caledon-street, and the other for a general system of tramway lines throughout the city, both systems to be operated by electricity. The Public Works' Committee, to which the proposals were referred, have just decided to recommend their adoption.

Cost of Electric Lighting.—Prof. Kennedy recently stated that before the Edison and Swan lamp patent expired, and when current was sold at 8d. per unit, an 8-c.p. glow lamp cost almost ¼d. per hour of actual lighting, whereas at the present price of glow lamps, and taking current at 6d. per Board of Trade unit, the 8-c.p. lamp costs ⅛d. per actual hour of lighting. Prof. Kennedy estimates the average life of glow lamps at 500 to 600 hours of actual lighting.

South-West London Polytechnic Institute.—Mr. Herbert Tomlinson, F.R.S., who has been for 24 years demonstrator and lecturer on natural philosophy at King's College, London, has been appointed Principal of the South-West London Polytechnic Institute, now in course of erection in Chelsea. The Institute, which will be of the same dimensions, and be conducted on somewhat the same lines as the Battersea Polytechnic, will, it is hoped, be finished by April next.

Competitive Boiler Trials.—The *Engineer* announces that Mr. James Howden, of forced draught reputation, has challenged all makers of water-tube boilers to a 30 hours' trial, conducted by neutral experts, of the respective merits of cylindrical and water-tube boilers. The points to be determined are:—(1) Weight; (2) space occupied; (3) evaporative power; (4) economy; and (5) waste of heat. The challenge is particularly directed at the Belleville boilers. The stakes are to be the expenses and cost of the boilers.

Insurance and Fire Risks.—Two special courses of lectures have been arranged at the Manchester Technical School in connection with the Insurance Association of Manchester. These comprise six lectures on "Fire Risks of Electric Lighting," by Mr. W. Haldane Gee, B.Sc., commencing Tuesday,

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November 6th, and ending Tuesday, December 11th, and six lectures on "Chemistry in Relation to Fire Risks," by Mr. James Grant, F.I.C., commencing Tuesday, February 5, 1895, and ending Tuesday, March 12th.

Electric Traction in Belgrade.—The electric tramways in Belgrade, which have been constructed under a concession granted in August, 1891, have recently been acquired by a Belgian company, with a capital of £140,000. There are now seven different lines of tramway, on the overhead conductor system, running in the city and suburbs. The new company has, it is stated, contracted with the Compagnie Française de l'Eclairage Electrique de Belgrade for the supply of the necessary electric energy required at the rate of 15 centimes (about 1½d.) per kilometre when the number of car kilometres is below 1,000 per day, and 12 centimes (1⅕d.) when they exceed 1,000, which they are at present doing.

City and Guilds of London Institute.—The report of the Examinations Department, just issued, shows an increase in both the number of classes registered and the number of students in attendance. There were last season 853 classes registered by the Institute, viz.:—701 in technology and 152 in manual training. The total number of students in attendance was 25,718, viz.: 22,703 in technology and 3,015 in manual training. In the previous session the total number of registered classes was 734 and the attendance of students 24,374. At the examinations the total number of candidates examined was 11,631, being 1,377 in excess of the number examined last year. This is the largest increase since the foundation of the Institute.

The Hammersmith Vestry and the Electric Light.—The Electric Lighting Committee of the Hammersmith Vestry, having obtained a Provisional Order as Undertakers for the Supply of Electricity to Hammersmith, and also a complete Report on a lighting scheme, are desirous of gauging approximately the amount of support they are likely in the first instance to obtain, in order that the initial outlay on the works may be regulated accordingly, and utilised to the best advantage. To attain this laudable object the Committee have circularised probable consumers. Amongst other items of information afforded intending customers is that, from statistics compiled by Mr. W. H. Preece as to comparative cost of gas and electricity in nine chief towns of the United Kingdom, it has been ascertained that, light for light, gas rated at 3s. per thousand cubic feet is equivalent to electricity at 6d. per unit, the price at which the Vestry propose to sell.

The Lighting of Glasgow Cars.—A beginning will be made early next month with the lighting by electricity of the Glasgow Corporation tramcars. Each car is to be provided with a couple of accumulators, weighing about 40lb. apiece, placed at either end of the vehicle. There will be four lights on every car, each of 8 c.p., two being placed inside and two outside. The inside lamps are to hang from the ceiling, while the outside lights will be poised on poles above the heads of passengers. These outside lamps will be placed at the ends of the cars, and will serve the purpose of the bull's-eyes now used, as the glass facing outwards will be coloured to correspond with the name-board. The accumulators will only require to be charged once a day. The contract has been given to the Froggat Electric Lighting Company. Dynamos are being laid down at Paisley Road and at Coplawhill Stations. It is expected that by the end of the year all the cars will be fitted with the electric light.

Proposed Electric Railway to the Summit of Snowdon.—It is stated that there is now every prospect of the scheme for the construction of an electric railway to the summit of Snowdon being carried out in a very short time. There are two companies formed, and, as owner of the land, Mr. Assheton-Smith will take a leading part in the promotion of the project. The services of Mr. Duncan Fox, the engineer, have been secured, and his plans will probably be formed on the lines of those adopted for similar railways on the Continent. Unless unforeseen circumstances arise, it is, says the *Liverpool Post*, confidently anticipated that, with the advent of next season, this railway will be an accomplished fact, thus adding considerably to the importance of Llanberis as one of the starting points for Snowdon. In conjunction with this project the suggestion is made that the North Wales Narrow Gauge Railway Company should extend their line from Rhyddu to Beddgelert, so that people making the ascent of Snowdon on the Llanberis side might descend on the Beddgelert side, and so have direct communication with all places on the London and North-Western Railway. A Bill for the extension of this line has already been passed. The mountain has already been ruined by the follies of Sir E. Watkin, and a hideous railway cannot do much further harm.

Pacific Cable.—The Ottawa correspondent of *The Times*, under date October 21st, states that several weeks ago Mr. Sandford Fleming and Mr. W. H. Mercer, of the Colonial Office, left Ottawa for *Honolulu*, authorised by the Imperial Government to negotiate with the Hawaiian authorities for the purchase of Neckar Island, to be used as a landing place for the proposed Pacific cable. A San Francisco despatch says that their mission has been unsuccessful, the reciprocity treaty between the United States and Hawaii preventing the latter country from conceding any of its territory to Great Britain. Later advices state that the two Commissioners asked Hawaii for a lease of Neckar Island, and for a subsidy of £7,600 for 15 years. In return they would lay the cable and make the rate a shilling a word over the line, and a special Government and Press rate, on condition that Hawaii ceded the island to Great Britain in the event of a Hawaiian annexation to the United States. The Hawaiian Government, it is added, are willing to consider the proposal if the Commissioners accept a lower subsidy and forego the provision for the cession of Neckar Island to Great Britain in the event of annexation.

The Relative Merits of Arc-Light Machines.—A writer in *Cassier's Magazine* tells the following good story of how a dynamo salesman explained the reason for the complication in his dynamo armature winding:—

"One of the best known men in the electrical field told me recently of the manner in which he evaded a very serious question put to him in the infancy of his electrical experience, and when he did not know an armature from a bootjack. The competition this time was between the Brush arc dynamo and a Thomson-Houston. The representative of the former had advised the purchaser that the Brush machine had separate bobbins wound on the armature in such a manner that any one could be repaired in very short time by simply rewinding that particular bobbin without interfering with the other, whereas the Thomson-Houston armature was so complicated that if any wires should become defective which were several "layers" down, the whole exterior would necessarily have to be removed. When my friend who represented the Thomson-Houston Company was asked to explain this apparent defect in the construction of their armature he was nonplussed for a reply, as he had never seen both armatures together, and at that time did not know anything about the construction any way—in fact, was a greenhorn as far as detail was concerned. After hesitating a few minutes, he replied that an explanation was very easy. The Brush dynamo was expected to, and actually did, burn out very frequently, hence provision for taking care of such an abominable occurrence, while the Thomson-Houston never burnt out—in fact, owing to the design that was impossible, and, therefore, the Company had no need to arrange to take care of rewinding."

Over-Compounding Dynamos in Parallel.—In a recent issue of the *Electrical World* of New York Prof. E. P. Roberts calls attention to a case of over-compounding, where, instead of securing the regulation of voltage desired, the reverse is the case. If two or more dynamos are connected in parallel and each compounded as usual for a certain line loss, the regulation of voltage aimed at will only be attained when all of the machines are kept in circuit. For if the load becomes light and one or more be disconnected, then those still left in circuit will over-compound, not for the current on the line, but for the current in their armatures. If only one machine is left, for instance, and it is heavily loaded, the increase in voltage may be a maximum when it might happen that the load on the line is a minimum, thus subjecting lamps to an abnormal voltage. Two methods are pointed out by means of which this fault may be obviated; one consists in having a multiplicity of exterior circuits independent of each other, which seems to be impracticable; the other necessitates the use of rheostats in the shunt circuit, or, in other words, a double waste of energy, in both the series coil and the rheostat. Neither of these methods is satisfactory, and it would seem that in the case considered the best solution would consist in the employment of plain shunt dynamos if there is a large and gradual variation in load.

Novel Application of Accumulators for Traction Purposes.—There is, says the *Electrical World* of New York, a double

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track section of about a half mile of the Chicago North Side Passenger Railroad Company in the heart of the city over which the Company finds it necessary to run its cars, but on which it cannot get trolley privileges. For this purpose the Electric Storage Battery Company, Philadelphia, Pa., will furnish the road with trucks, each carrying 240 battery cells of the "chloride" type; but nothing else except a motorman and a small motor sufficient to run the truck for switching purposes, but not sufficient to run a car. When a car arrives at the end of the trolley-wire a truck will run in behind it, couple on to it, and connect its battery with the motor on the car, and the motorman on the car will operate it the same as though he had the trolley, the voltage of the current being the same. When the car reaches the end of this section of the line, the truck will be uncoupled, mechanically and electrically, switched around by its own motor, and connected to another car going back to the other end. It is expected that on this part of the line there will be 25 cars in use in the busiest part of the day, and the battery company is to furnish 40 trucks equipped with batteries, which will be charged in place on the trucks, the number relieved from duty in the slack times, with the reserve of 15, being estimated as sufficient to allow this to be done.

Obituary.—We regret to have to record the death of Mr. Edwin Clark, M.I.C.E., which occurred at Marlow on the 22nd inst. Mr. Clark was born at Marlow in 1814. At some personal labour and perseverance he went to Cambridge University, where his fondness for mathematics found vent. He became one of Robert Stephenson's chief assistants at the construction of the Conway and Britannia tubular bridges. It was while thus employed that he became, through his friend Stephenson, connected with the original Electric Telegraph Company (incorporated 1846), and which subsequently became by his exertions the "Electric and International Telegraph Company," he being the engineer for the submarine cables which were laid from Orfordness to Scheveningen, and which were the longest and at that time the lightest submarine cables in existence. It is well known to all of what must now be called an almost past generation how the work and extension of the electric telegraph prospered in his hands. He made the principal agreements with all the railway companies then in existence for providing the telegraph for their lines, which was done at a rental to the railway companies, but reserving a way leave and other advantages to the Electric Telegraph Company, which he was then serving. The Post Office authorities of the present day may not, perhaps, think well of his memory in this respect, but the railway companies will think otherwise. History will record that Edwin Clark was one of the great electric telegraph pioneers of his day, and his old assistants still take pleasure in remembering that they were associated with him.

The Heating Power of a Glow Lamp.—While an ordinary incandescent is the least likely of all illuminants to ignite inflammable materials, there are special conditions under which its heat will start combustion in highly combustible substances. The *Gas World* observes that Mascart found that a glow lamp of 32 candles set fire to cotton wool saturated with indiarubber, and packed round it, in two minutes; to black silk in six minutes; and to a double layer of cotton cloth in two minutes. The same materials not saturated with indiarubber did not take fire. Capt. Exler, of the Austrian army, now finds that a 16-candle lamp, sunk in paraffin, reaches a maximum temperature of 94°C.; one of 25 candles, 101°C. A layer of gunpowder, ecrasite, or pulverulent pyroxiline is not set on fire by this: the ecrasite melted and the gunpowder lost all its sulphur. If the substance be spread on a material, *e g*, wood, which is opaque to heat-rays, the action is more marked, when the lamp is brought very near to it: the ecrasite melts, the pyroxiline darkens, the gunpowder loses its sulphur, and the nitre melts and the wood chars. Two lamps in a cavity of wood get up a temperature of 215°C., a charring temperature; but the explosives did not go off, though they decomposed. When the cavity was filled with water it boiled in 15 minutes. The spark produced on turning off the flame only kindles these explosives when they have become very dry; but the spark produced on switching off a feeble resistance between two lamp wires can do so readily. If the lamp breaks, pyroxiline or gunpowder does not ignite, but an explosive gaseous mixture will do so.

The Past and Present of a Condenser.—Messrs. Bedell and Kinsley have recently made a study of the residual charges of condensers and their dependence upon temperature. The action of a condenser, they find, is dependent, in a marked degree, upon its previous history; so much so, in fact, that its previous charges may be of more importance in determining its action under certain circumstances than charges received later. In that case the previous absorption, after neutralising the absorption due to the final charge, may give rise to residual discharges which increase with time up to their previous initial value. Absorption gives rise to the phenomena of residual charges, and causes the condenser to depart from the exponential law in discharging through its own dielectric. The increase in apparent resistance in the condenser during discharge is associated with this effect of absorption. Previous charges modify these results, increasing or decreasing them according to whether the previous charges were in the same or opposite sense. The resistance of pure oils is constant at any one temperature, but falls off rapidly with the temperature. There are, accordingly, no absoption or residual effects in pure oils. In solid dielectrics the effects of absorption are diminished as the temperature is increased, as shown by the residual discharges and by the changes in the insulation resistance. Many of the results described are already known, but they have not before been presented together so as to show the relation between them. The fact that the previous condition of the condenser has such an influence upon its action, causes considerable embarrassment in an investigation of this sort, inasmuch as a condenser used once under certain conditions may be practically useless in the same investigation for further experiments. One of the condensers experimented upon retained its past charges after being short-circuited for a month, and it was necessary to employ another condenser which was neutral, for further experiments.

Thermo-electric Force of Electrolytes.—The *Annales de Chimie et de Physique* for September contains a Paper, by M. Henri Bagard, on the thermoelectric force between two electrolytes, and on the Thomson effect in the case of electrolytes. The Paper, says *Nature*, contains a very complete history of the work which has been done on this subject. The author uses a number of thermoelectric junctions joined in series, and measures the electromotive force developed by a given difference in temperature between the hot and cold surfaces of separation between the electrolytes by means of a capillary electrometer. This electrometer was capable of indicating an electromotive force of $\frac{1}{100000}$th of a volt. In order to check the diffusion which takes place at the common surface of the electrolytes, the author uses a porous membrane. By using membranes composed of such different substances as goldbeater's skin and vegetable parchment, it was proved that the membrane had no effect on the electromotive force, except to cause it to diminish slightly with time. Thus the results obtained with a membrane are probably identical with what would be obtained could observations be made without a membrane, and without diffusion and convection currents being set up through the surface of separation. Observations were taken both while the temperature of one junction was rising and again when cooling. The points obtained during the second of these operations often fell below the curve given by the previous set. This effect, which never amounted to a difference of $\frac{1}{10000}$th volt, the author considers to have been entirely due to diffusion. Thermoelectric couples, consisting of solutions of two different salts, and of solutions of the same salt but of different concentration, were examined, and the results obtained are shown by means of curves. In order to examine the Peltier and Thomson effects in the case of electrolytes, small bolometers were employed to measure the change in temperature. The important fact that the Peltier effect is of opposite sign on opposite sides of the neutral point was amply verified, and it appears that the change of sign takes place at the neutral point. In all cases the thermoelectric phenomena, the Peltier effect and the Thomson effect gave results in the case of electrolytes similar to those obtained with metals.

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MOTIVE POWER AND GEARING.*

BY E. TREMLETT CARTER.

(*Continued from page 595.*)

Superheating also has been adopted with a view to prevent initial condensation. With superheated steam, the fluctuations of cylinder temperature take place to the same extent, or nearly so, as with saturated steam; but the effect of introducing properly superheated steam into the cooled cylinder is to cause the steam to be reduced to a state of saturation, but without condensation. Superheating has just the same limits of value, in respect to engine speed, as the steam jacket has; and, while experiment shows that an economy of 20 per cent. or more can be effected in the case of very slow speed engines, it is improbable that there would be any economy with the high speeds commonly adopted in some types of electric light engines. Superheating has this advantage over the steam jacket that, when the degree of superheat is properly adjusted, there will be no loss of heat during the exhaust stroke; whereas, with the jacket, heat is to some extent imparted wastefully to the exhaust steam during the entire exhaust stroke.

Another important mode of reducing the evils consequent upon condensation and re-evaporation of water consists in properly draining the cylinder during exhaust. This does not directly prevent the formation of water; but, by clearing away the water immediately the release occurs, it tends to prevent the wasteful fall of cylinder temperature and the back pressure consequent upon re-evaporation in the cylinder. Mr. Bryan Donkin's researches on condensation, however, would seem to show that the steam is condensed as a fine film over the cylinder walls, and that it is improbable that any very large proportion of this water could be removed by drainage. Liquefaction by adiabatic or approximately adiabatic expansion probably leads to the formation of wetness of a different type, and of a kind which is more readily drained on release. This would appear to be supported by the fact that in some engines where the expansion is practically adiabatic, re-evaporation is found to be reduced by thorough cylinder drainage.

Influence of the Ratio of Expansion.—Thermodynamical considerations show that in order to obtain a high value for the limiting efficiency of a steam engine there must be as great as possible a difference between the temperature of admission and the temperature of rejection of the steam. This is a requirement which directly conflicts with the attempts to prevent initial condensation, in so far at any rate as only one cylinder is considered. Neglecting for the time being the losses due to condensation, we will consider the relation of the ratio of expansion to the economy of steam. Subsequently, we will see how the relation is modified by condensation, and how the conflicting effects may be reconciled.

A comparison between curves *e* and *f* in Fig. 9, will show that with steam at any given pressure a higher limiting efficiency can be obtained by exhausting it at 60°F. than at 212°F. Equation (67) proves the same, for any general case. Curve *a* in Fig. 9 shows that to obtain this fall in temperature the steam must fall in pressure, over a range which becomes greater as the initial pressure is lessened. But it is insufficient to show that the mere theoretical limit of efficiency requires this. It must be shown that, neglecting initial condensation, the actual efficiency is improved by a higher range of expansion. Let us assume adiabatic expansion in the cylinder, in order that only the intrinsic energy of the cylinder steam may be taken into account. Let it also be assumed that one pound mass of saturated steam, at an absolute pressure of P_a lb. per square foot, and having a density of Δ lb. per cubic foot, is admitted into a cylinder, and expanded to R times its initial volume. The work done during admission will be obtained by dividing P_a by Δ; and the work done during expansion may be determined by integrating the adiabatic expansion curve between the limits of initial and final volume. Thus the total work, W, done by the pound of steam will be:

$$W = \frac{P_a}{\Delta} + \int_{V_1 = \frac{1}{\Delta}}^{V_2 = \frac{R}{\Delta}} P \, . \, dV ;$$

and since, approximately,

$$P^{\frac{9}{10}} = \frac{330 \cdot 36}{V}$$

we obtain the following, by integration,

$$W = \frac{P_a}{\Delta} + k \Delta^{\frac{1}{9}} \left(1 - R^{-\frac{1}{9}} \right), \quad . \quad . \quad . \quad . \quad (86)$$

where *k* is a constant for the fixed quantities. This expression directly shows that, the other quantities remaining constant, the indicated work obtained from a pound of steam increases as the ratio of expansion in the cylinder is increased. Consequently, to obtain a low consumption of steam per I.H.P. per hour, the ratio of expansion must be high.

We have already observed in a previous article that it is useless to expand the steam down to a lower pressure than that of the exhaust. As a matter of practice, it is found that it is economical to release the steam at a slightly higher pressure than the exhaust, as the sudden drop of pressure serves to sweep a considerable quantity of the steam out of the cylinder, and avoids the work of clearing out this steam being imposed on the piston. Moreover, the sudden drop of pressure on release assists cylinder drainage, as well as indirectly reducing the percentage loss of power due to engine friction. When the expansion has been carried down to the lower limit of pressure, the ratio of expansion can only be increased by the use of still higher initial steam pressures. It is instructive to notice, by comparing equations (86) and (72), that even if the ratio of expansion is unaltered, while the pressure of steam is increased, the work done per pound of steam will increase. So that, if the ratio of expansion is increased by the practice of using higher steam pressures, there will be a double reason for an improvement being effected in the economy.

More about Condensation.—It may seem a pity that all the nice conclusions we have been able to draw from equation (86) must be upset directly we turn our attention again to the disastrous phenomenon of initial condensation. Were it not for this wasteful effect, it would be possible to go on improving the economy of the steam engine, asymptotically approaching perfection, merely by the use of higher pressure steam, less clearance and an earlier cut-off. As a matter of practice, this is quite impossible; and with every steam engine it is found that there is a limit to the range of expansion, beyond which the economy ceases to be improved, but rather is injured. The direct reason for this is that when the range of temperature of the steam in a single cylinder exceeds a certain number of degrees, depending on the speed of the engine, all known methods of coping with the initial condensation utterly fail, and the engine gives itself over to the wholesale production of water. Before that crisis is reached, the limiting ratio of economical expansion for that particular cylinder has been arrived at.

Compound Expansion.—The only remedy, if it is desired to have still higher pressures of steam and to expand it a further amount, is to use two or more cylinders, expanding the steam in stages. This is the principle of compound and multiple expansion. If steam at 150lb. pressure cannot be economically expanded down to 5lb. pressure in a single cylinder, we expand it down to only, say, 25lb. pressure in the first cylinder, and then pass this expanded steam into a second cylinder, where it is expanded again, down to 5lb. Or, if this gives too high a range of expansion in either cylinder, we may introduce an intermediate cylinder, adopting triple expansion; expanding from 150lb. to, say, 60lb. in the high-pressure cylinder, then down to, say, 20lb. in the intermediate cylinder, and finally down to 5lb. in the low-pressure cylinder. Higher pressures of steam may make it necessary to have quadruple expansion. The hotter steam never touches the cold walls of the later

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cylinders, and the colder expanded steam never touches the hot walls of the earlier cylinders. Consequently, although the finally exhausted steam may be two or three hundred degrees cooler than the initial steam, no more than a permissible amount of condensation takes place.*

It must be pointed out that the object of using compound or multiple expansion is not to obviate liquefaction of steam during expansive working, as is erroneously stated in some text-books. In the first place, as we have shown, the working liquefaction of steam is not a direct loss at all; and, in the second place, no amount of subdivision of the expansion can affect it.

Compound Engines.—Compound engines, or engines in which two stages of expansion are performed, may be classed under "Woolf" and *receiver* engines, or under *tandem* and *side-by-side* engines. The former division relates to the mode of distributing the steam; the latter, to the mode of fixing the cylinders. In the Woolf engine, in which we have the distribution first adopted in compound engines, the expanded steam from the high-pressure cylinder is passed directly to the low-pressure cylinder, expanding to fill the latter during the exhaust stroke of the former. In the receiver engine the expanded high-pressure steam is exhausted from the high-pressure cylinder into an intermediate closed vessel, or receiver, in which it remains until it is required to be passed into the low-pressure cylinder. Tandem compound engines are those in which the high and low-pressure pistons are fixed to the same piston rod, the high-pressure cylinder being bolted on to the end of the low-pressure cylinder. In the side-by-side pattern the two cylinders are separate, and the two pistons, each with its separate piston and connecting rods, actuate two cranks usually on the same crank shaft. (When the side-by-side arrangement is adopted for two cylinders not compounded, the term *twin cylinders* is sometimes used.) Most commonly, the two cylinders are placed on either side of the fly-wheel in horizontal engines, and on the same side in vertical engines.

A little consideration will enable the reader to see that with the Woolf system of steam distribution the high and low pressure pistons must commence and end their strokes simultaneously; and, if the upper half of the high pressure cylinder (assuming the cylinders to be vertical) gives steam to the upper half of the low pressure cylinder, the one piston must be making an up stroke whenever the other is on the down stroke, while if the steam passes from the upper half of the one to the lower half of the other the pistons must move in similar directions. In the former case the cranks must be at 180°. As a matter of practice, owing to the fact that clearance space and compression render it possible to throw the pistons slightly out of synchronism without serious consequences, it is sometimes the custom to have an angle of slightly less than 180° between the cranks; this arrangement enabling the dead-centres which would otherwise occur to be avoided. With the receiver engine it is possible to have the cranks set at right angles, and even to place the cranks on independent shafts running at different speeds. Cranks at 90° are most commonly adopted for horizontal engines, owing to the greater equalisation of the combined crank effort when this arrangement is adopted; but the balancing of reciprocating parts which can be obtained in vertical engines when the cranks are at 180° gives rise to this plan being used in most side-by-side vertical compound engines, except where the equalisation of crank effort is a matter of greater importance than the absence of balancing. Tandem vertical compound engines are largely used in electric power stations, and are most commonly grouped in twos or threes on the same crank shaft; the advantage of this method being that the reciprocating parts of one engine can be balanced against those of the second, or the reciprocating parts of three be balanced against one another, and an equable crank effort at the same time be obtained. Consequently, both the Woolf and receiver systems of compound distribution of steam are to be met with in electric power steam engines. We will now study these two systems a little more closely.

The Woolf Engine.—In Fig 27. a pair of indicator diagrams from the two cylinders of a Woolf engine are shown, on a system of scale drawing which will be explained in another article. The upper diagram is that taken from the high pressure cylinder; the lower is that from the low-pressure cylinder. Steam is admitted into the first cylinder at *a*, and continues to be admitted until the cut-off point *c*. At *b* the high pressure piston commences its stroke; and the little kink in the diagram at this point is due to a false jump in the indicator pencil, caused by the momentum of its rapid ascent from *a* to *b*. High-pressure expansion occurs from *c* to *d*, and at this latter point release takes place, and the steam at once rushes from the first cylinder to fill the exhaust passages between the two cylinders, as well as to fill the portion of the second cylinder which is open to it. Hence the sudden drop in pressure to *e*. The point *d* on the high-pressure diagram here corresponds to the point of admission *f* on the low-pressure diagram; this arrangement giving, as will be seen, a small pre-admission into the second cylinder. Compression in the high-pressure cylinder

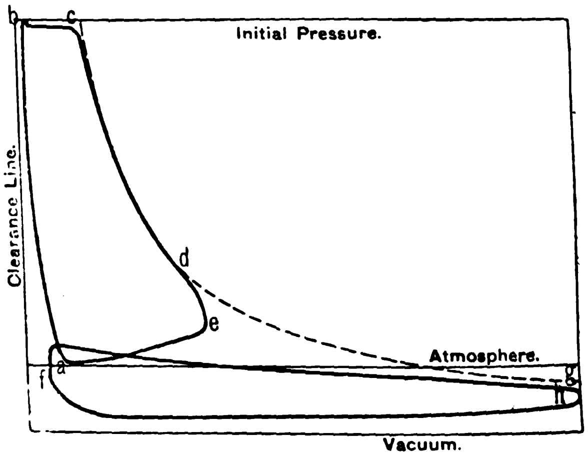

Fig. 27.

is not necessary, as it is possible to effect all the necessary economy by compression in the second cylinder, while the cushioning requisite for arresting the momentum of the piston may be produced in other ways, such as by very early admission or by means of an air cushion. Since there is a clear communication between the two cylinders all the time from *d*, past *e*, to *a*, it is evident that the expansion of the steam by its admission into the second cylinder must be accompanied by a fall of pressure, which will represent both a fall in the effective pressure on the low-pressure piston and a fall in the back pressure on the high-pressure piston. Thus, while the back pressure in the high-pressure cylinder falls from *e* to *a*, the working pressure in the low-pressure cylinder falls from the commencement of the stroke to about *g*, the point where the communication between the cylinders closes. Shortly after *g* is passed the low-pressure steam is released, and the final exhaust into the air or condenser—in the actual case under consideration, it being the condenser—takes place along the line *g h i*. At the last-named point the compression of steam into the low-pressure clearance space takes place, and continues until the point of admission *f* is again reached.

Remembering that in the diagram (Fig. 27) the two pistons are assumed to be moving in opposite directions, it will be easy to determine the values of the steam pressures in the two cylinders at any one moment. If, then, we compare the pressure in the high-pressure cylinder at any time during the exhaust, *e a*, with the pressure in the low-pressure cylinder at the same instant, we shall always find that the former has a

* It may here be observed that it is sometimes claimed that compound and multiple expansions lead to an immense saving of steam from condensation; while, on the other hand, it is often asserted that the amount of cylinder condensation in compound and multiple expansion engines is as great as in single cylinder engines, or even greater. Both statements are right, and both are wrong. For, if the range of temperature in each cylinder of a compound engine is as great as that in any given single cylinder engine, it is certain that the condensation will be as great or even greater in the former type than in the latter. On the other hand, if a compound or multiple expansion engine is worked with a *total* ratio of expansion equal to that in any given single cylinder engine, it should be found that more condensation will occur in the single cylinder than where the same expansion is sub-divided among two or more cylinders.

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higher value than the latter. As there is a clear communication between the two cylinders, this drop of pressure can only arise from wiredrawing of steam in the passages and on account of unresisted expansion into the more roomy second cylinder. It is from this cause that it happens that a lower final pressure is reached with compound expansion than with the same amount of cylinder expansion in a single cylinder, a fact which is illustrated by continuing the high-pressure expansion line in Fig. 27 in a dotted curve; when it is seen that the final pressure lies below this curve. The dotted curve must be drawn to follow the same law of expansion as that in the two cylinders.

The Receiver Engine.—A pair of indicator diagrams taken from the two cylinders of a receiver engine, and corresponding in every respect with the Woolf engine diagram in Fig. 27, is shown in Fig. 28. The chief points to be noticed relate to the periods when the high-pressure cylinder is exhausting, and when the low-pressure cylinder is making a working stroke. The relation between the two periods depends on the crank angle, *i.e.*, on the phase difference between the two strokes. In the present instance the cranks are at right angles, so that the end of the stroke of the high-pressure piston corresponds to the middle of the low-pressure stroke—a point somewhere in the low-pressure expansion period, just after the cut-off. At the commencement of the exhaust stroke in the high-pressure cylinder there is no through communication with the low-pressure cylinder; the exhaust, therefore, takes place into the receiver, the pressure in which rises, as shown by the portion of the curve *a b*. At *b*, however, the low-pressure cylinder commences to take steam, and a through communication is established, resulting in a fall in pressure in both the receiver and high-pressure cylinder, as shown by the portion of the curve *b c*. At the point *d* the low-pressure cut-off takes place, and from this point onwards the low-pressure steam expands in the second cylinder alone. The character of the diagrams is not only affected by the relative positions of the cranks; it is also influenced by the relation between the cut-offs in the two cylinders, and by the capacity of the receiver. The relation between the two points of cut-off cannot be varied arbitrarily, in any particular engine, without running the risk of injuriously upsetting the balance of the loads on the two pistons, by a reaction upon the receiver pressure. It is the usual practice to divide the normal load equally between the two pistons, and to design the valve gear so that as closely as possible there shall be an equal division of labour whatever the load may be. In some engines, however, it frequently happens that at reduced loads there is far from equality between the loads on the two pistons.

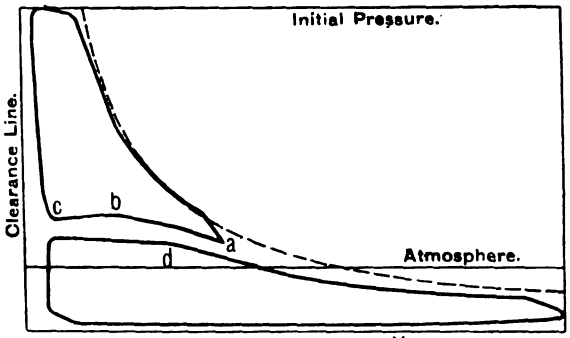

Fig. 28.

(To be continued.)

Cheap Telephones.—According to *Engineering*, in the town of Korsör, in Denmark, the inhabitants, who were dissatisfied with the rent they had to pay to the existing telephone company, which belonged to a neighbouring town, have formed a new company, with an annual rent for subscribers of 35kr., or £1. 19s., for the first year, and 30kr. (£1. 1s. 6d.) for subsequent years.

SOME NOTES ON THE GOVERNING OF STEAM ENGINES, PARTICULARLY WHEN COUPLED TO DYNAMOS.—II.*

BY G. L. ADDENBROOKE.

The article reproduced from the *Engineer*, and Mr. Mark Robinson's letter in last week's journal on practically the same subject as my first communication, are interesting as presenting the question purely from the "steam engineer's" point of view.

The *Engineer* complains that "the much-desired governor is not forthcoming because the electric light engineers have not explained fully what they want, and—which is perhaps more to the purpose—why they want it." Curiously enough that was one object I had in mind when beginning these notes, and the first article provided a qualitative reply, which it may be worth recapitulating here.

It was shown in the first place—what is not kept always in view as much as it ought to be—that the object of a central station is to supply electric current at a perfectly even pressure under all circumstances at the consumers' lamps.

Next, it was pointed out that in order to effect this the pressure on the omnibus bars at the station required to be varied according to the load, increasing as the load become heavier, and, lastly, it was noted that to produce a given voltage dynamos required to run faster at heavy loads, or to have their excitation increased. Further, it was shown that these conditions might be met in two ways, either the engines might be arranged to run always at constant speed, whatever the load, the variation in pressure being produced electrically by the use of variable resistances in the main circuits, and the exciting circuits of the dynamos, or, secondly, the requisite increase of pressure might be obtained by running the engines faster at heavy loads than at light—that is to say, by over-governing.

This is the nature of the problem with which we have to deal, the next step is to determine its magnitude. As enumerated in the first article, the following factors have to be taken into account:—

1. The increased pressure necessary in the feeders as the load increases.

2. The increased armature loss, and the increased excitation of the field magnets at heavier loads.

3. The slip or loss of pressure caused by the increased back action of the armature currents in the field magnets, and the increased self-induction, the latter meaning a higher rate of driving, though not necessarily directly loss of energy.

Let us proceed to determine roughly the magnitude of these effects in order as above.

1. *The increase of pressure required on the mains.*—This will depend on whether the system is high or low pressure. For an ordinary high-pressure system the pressure will not usually need increasing more than 5 per cent. if the standard is 2,000 volts, which is allowing an additional 1 volt, or 1 per cent., on the consumer's premises, 2 volts, or 2 per cent., in the secondary circuit from the transformer substation, and 2 per cent. in the high-pressure main.

If, however, a low-pressure three-wire system is used, the loss in the feeders may easily be 12 per cent. more at full load than in the daytime, making a 15 per cent. variation in all from dynamo to lamp.

Intermediate systems require intermediate variations; but we may fairly take it that at full load the pressure in the mains must be increased 5 per cent. in a high-pressure alternating station, or 15 per cent. in a low-pressure continuous one.

2 and 3. *The Reactions in the Generators.*—These depend somewhat on the class of generator used. As a rough approximation it may be taken that if the voltage of excitation—that is, the electric pressure across the field magnet terminals—is kept constant at all loads, the speed will have to be increased some 10 to 12 per cent. to secure equal voltage of current at full load as well as no load. This applies to alternators and shunt-wound continuous-current dynamos as used in central

* For first Article see *The Electrician*, September 14, 1894, p. 571.

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stations, intended to be worked in parallel. For compound-wound dynamos working singly this reasoning will not apply, the particular feature of their design being that they should run at a given speed and produce nearly an equal or greater voltage at high loads.

From the above considerations we deduce the facts that in an alternating station, if the excitation is constant, the speed of the alternators must be increased about 5 per cent. for the mains and 10 per cent. for internal dynamo reaction, or a total of 15 per cent. at full load, and in a continuous-current station about 15 per cent. on the mains, and 10 per cent. for the dynamos, making 25 per cent. in all.

These figures can, of course, only be considered as approximate and liable to vary with circumstances; but still they suffice to define sufficiently the order of magnitude of the effects with which we have to cope.

It is desirable at once to point out, however, that the problem is not so difficult as it would appear at the first glance, since, if the excitation is increased at the same time as the speed, the pressure will go up as some power, say, about the square of the speed. If, therefore, continuous-current dynamos are excited from the omnibus bars when the voltage of them is raised the exciting current will increase also, so that to obtain the effect of 25 per cent. increase of speed alone we have only to actually increase the rate of driving about 11 per cent. In an alternating station with the alternators and exciters coupled, where we only require an increase equivalent to 15 per cent., the rate of driving only needs an increase of 7 per cent. Supposing, then, we wished to run an alternating station entirely without electrical means of control, we should have to arrange for engines to run at a constant speed, and to be capable of varying that speed some 7 per cent. or 8 per cent. while running; or, if the stations employed low-pressure continuous currents, then, under similar circumstances, the engines would have to be capable of 11 per cent. to 12 per cent. variation while maintaining their capacity for keeping the speed constant with considerable variations in load.

The above is what may be considered as the outside limit of the problem stated purely from the "steam" engineer's point of view; and there is certainly enough in it to set inventors of governors thinking. At the same time, it is doubtful whether it will ever be practical or desirable to depend on engine regulation entirely. At present almost the converse is the case—the engines are kept as nearly as possible the same speed, and the regulation is done electrically, and chiefly in the field-magnet circuits. I am, however, one of those who hold, that the amount of regulation in central stations should be the least possible if the customers are to be well served, and, secondly, that as much as possible should be left in the hands of the men who control the engines; that is, there should not be what there is in most stations at present, a dual control, the electrical part of which is often left in the hands of learners and apprentices, who, if not incompetent, are often without a due sense of responsibility.

ELECTRIC TRACTION BY ACCUMULATORS IN MINES.

M. Joseph Libert recently contributed to the Charleroi Section of the Association des Ingénieurs sortis de l'Ecole de Liége a Paper on the use of self-contained electro-locomotives in mines, in which he describes two very interesting applications of accumulators to underground haulage, the one at the Fond-Piquette Colliery, in the Liége district, and the other at the Amercœur Colliery, in the Charleroi district.

Accumulator traction, even above ground, has not yet been very successful in England; although on the Continent, at Paris and elsewhere, it is reported that cars are being worked at a profit, and it is asserted that the problem is solved as regards surface traction. M. Libert assumes this to be so; yet there are engineers in England who have had much experience with storage traction, and who do not view the problem as completely solved even for tramcars, much less for underground haulage.

Accumulators have also been tried in England for underground work, but in a very short time the bad condition of the rails proved to be fatal to success. Indeed, to give the cells the same chance that they have on the surface it would be necessary to remake the roads entirely and relay them with much heavier and more carefully laid rails than those obtaining in the majority of pits to-day. The question of gradients, levels, and curves has further to be considered, and would necessitate much modification.

M. Libert assumes that it is generally possible to lay out the main roads in such a way that the gradient should always be with the loaded trucks, and that the resistance to the empty ones up hill should be approximately the same as to the loaded ones down hill. This we do not understand. That it is possible to make very marked improvements in the main roads we admit, of course; but quite fail to see how the general trend of the roads can be altered to suit the conditions named in more than an approximate degree; or, indeed, how it is possible, even in opening a new seam, to fulfil them unless the workings are all to the rise, which cannot be the case always. Assuming, however, that the main roads are fairly well adapted, it is obvious that the coal must be carried at a very small cost per ton per mile, and if accumulator tramways find a difficulty in paying at a penny, say, per passenger per mile, it is difficult to see how the underground locomotive can pay when the cost of haulage must be less than this figure for a ton carried per mile. M. Libert gives the cost of haulage at the Amercœur Colliery with an accumulator locomotive at 0·75d. per metrical ton-kilometre, or, say, a little more than a penny per ton mile; while the cost of horse haulage at the same pit, but under different circumstances (whether more favourable or otherwise is not stated), is estimated by him at 1·5d. per metrical ton-metre, or, say, twice as great. These figures we believe to be much in excess of the cost of haulage in English collieries with stationary engines, the cost of which is from 0·25d. to 0·5d. per ton mile.

We cannot criticise these figures as applied to the collieries in question. They may be justified under the circumstances; but we are sure that, unless the cost can be further reduced, there is no probability of the self-contained locomotive obtaining a footing for general use in the place of horses; of course, they can never compete with stationary engines or with direct-transmission locomotives where the conditions admit of their use.

The two locomotives appear to be well designed, and to embody the experience gained at various pits. The Amercœur ones have four wheels with a wheel base of about 3·75ft., the over-all dimensions being: length 13ft., width 3·9ft., and height 3·77ft. The weight, with cells, is 3 tons 2cwt. 96lb.

The driving gear consists of spur gearing in the first transmission and chain gearing in the second. There is a platform at each end.

This locomotive is designed to haul a minimum of 300 trucks per ten hours in trains of 15 trucks each, the normal speed being about five miles per hour. The line is one mile 1,520 yards in length.

The second locomotive at the Fond-Piquette Colliery has two four-wheeled bogies with short wheel bases, the wheels being apparently of the same diameter as in the first one. The over-all dimensions are: length 14·95ft., width 3·28ft., height above rails 4·34ft. There is a platform at each end. The gearing consists of a single transmission by spur gearing. The total weight is 4 tons 8cwt. 44lb. It is designed to haul 400 trucks per ten hours, each train consisting of 20 trucks, the speed being about five miles per hour, and the road about one mile in length.

This locomotive, although nearly 15ft. long, will turn round a curve of 19·6ft. radius.

The peculiarity of both of these haulage planes which renders them suitable for the use of locomotives appears to be the great length and the small tonnage carried over them in the working shift of ten hours.

The accumulators form the most interesting part of the equipment. They are of the Julien type, having plates 11·8in.

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by 7·8in. Each battery comprises 36 cells, having a storage capacity of about 49-H.P. hours, which is sufficient to give eight hours continuous working at a rate of 6 E.H.P. M. Libert estimates this as equivalent to an effective mechanical tractive power of about 4·25 H.P. Granting these figures, which appear to be reasonable, it is evident that the locomotives are of small capacity, and are only adapted for working under favourable conditions as regards rails and load. Indeed, one of the weak points with self-contained locomotives is that they have no reserve power for accidental increments of the normal load, which in all cases must inevitably affect the speed, and in some cases disastrously, with, of course, serious damage to the cells.

The method of mounting the cells in a spring carriage on the top of the bogie frames, which of course have their own springs, is excellent, and must do much towards lengthening the all-too-short life of the plates. Anxious as we are to see accumulator traction established on a sound electrical and mechanical basis, we cannot say that we have much hope that these self-contained locomotives will stand the test of mining work for long. When the problem has been successfully solved for tramcars, then we may expect to find a solution for underground haulage; but the cells will have to undergo radical alterations before even a measure of success is possible, in our judgment.

IRON WIRES UNDER ELECTRIC OSCILLATIONS.

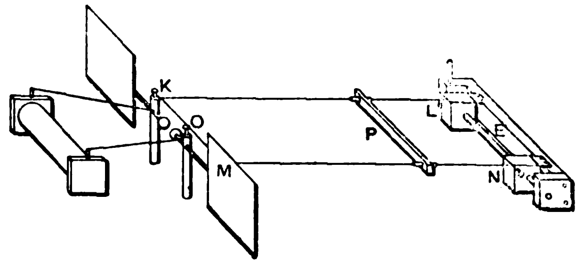
In the October number of the *American Journal of Science* a Paper from Prof. John Trowbridge appears on the change of period of electrical waves on iron wires, followed by another by Mr. Charles E. St. John on wave-lengths of electricity on iron wires. Both these Papers go to show that the question whether the magnetic properties of iron are called into play under extremely rapid alternations of the magnetising forces must be answered in the affirmative. The method of investigation employed by Prof. Trowbridge was the same as that used for the determination of the damping of electric waves on iron wires. A Leyden jar was discharged through iron and copper wires respectively, and the resulting spark, spread out by a revolving mirror, was photographed. The times of oscillation were in each case referred to a standard "time-circuit," so as to eliminate the errors due to changes in the angular velocity of the mirror. Trial circuit of the same geometrical form were arranged as follows:—A cylinder of very porous wood 11·5cm. in diameter, and 15cm. long, was boiled in paraffin, and a spiral was cut upon its surface with the turns 1cm. apart. On this cylinder and in these spirals the wires under examination were wound, thus obtaining exact geometrical similarity combined with good insulation. Several hundred determinations were made with wires of different sizes. With iron wires larger than 0·0312in. in diameter no marked change in period could be noticed. If a great number, however, of photographs were measured, an inconstancy of ratios was noticed which never appeared when the copper circuits were compared. The most marked changes in period were obtained with iron wires of 0·0312in. in diameter. With distances on the "time-circuit" between two successive serrations on the photographic record of 6·08mm. and 6·00mm. respectively; the distance for the iron wire was 3·7mm., and for the copper wire 3·4mm. A large number of similar results show that the wave-lengths sent out by a vibrator on iron wires differ in length from those transmitted along copper wires of the same geometrical form.

Mr. C. E. St. John, working in the Jefferson Physical Laboratory, arrived at the same result by an entirely different method.

A Lecher wire combination was deprived of the secondary discs near the vibrator plates, which complicate the simple Hertzian wave system. In order to be able to adjust the length of the wires at will, the author finally adopted the arrangement shown in the diagram.

L K M N is a copper or iron wire with free ends at L and N. These ends were inserted in small copper boxes 10cm. square and 4cm. thick, mounted upon the wooden bar E by insulating supports. Within the boxes were wooden bobbins fixed on a hard rubber axle, and each capable of holding 10m. of the largest wire experimented upon. The bar E was fastened to a wooden support resting upon a car which ran on a wooden track extending the entire length of the room. A specially-designed interruptor for the induction coil was driven by a small electric motor, and made about 25 breaks per second. The plates of the Hertz vibrator were 40cm. square and fixed at 61cm. apart.

The induction coil was 53cm. long, 19cm. in diameter, and was excited by the current from five storage cells. A sparking distance of about 6mm. was most effective in producing oscillations in the secondary circuit, which was arranged to give maximum resonance. For each observation, the interruptor was set in action, the circuit was closed through the induction coil, and an observation was taken of the first swing of the needle connected with the bolometer, whose terminals are shown at P. The bolometer was that described by Paalzow and Rubens, in which the heat caused by oscillating currents alters the resistance in one arm of a Wheatstone Bridge and disturbs its balance. The terminals consist of two capillary



glass tubes set in a frame of wood, which slide over the wires to be explored, and around each tube is wrapped by a single turn one of the wires leading to the bolometer. A series of maxima and minima were thus obtained from which the wave length could be determined. Such observed half wave lengths were the following:—

Copper, diameter	0·1201 cm.	255·6 cm.
Iron, „	0·1186 cm.	251·6 cm.
Copper, diameter	0·07836 cm.	251·6 cm.
Iron, „	0·07850 cm.	246·8 cm.

The capacity per unit length being the same for wires of the same diameter, the shortening of the wave length when iron displaced copper must be caused by an increased self-induction due to the magnetic properties of the iron. This implies that the magnetisation of iron can be reversed 115 million times per second. This reduces the "time lag" of magnetisation to very narrow limits, if forces of such duration can magnetise the iron.

Mr. St. John thus sums up his conclusions:—

1. The self-induction of iron circuits under very rapid electric oscillations (115×10^6 reversals per second) is greater than that of similar copper circuits. The change in self-induction varies from 3·4 to 4·3 per cent. in the present investigation, and increases with decreasing diameters.

2. The increase in self-induction produces greater damping and a shortening of the wave length of 1·5 to 2 per cent.

3. The permeability μ of annealed iron wires under this rate of alternation is about 385.

4. For oscillations of the same period, the wave length along parallel copper wires varies directly with the diameter of the wires. Range of wires used 0·03915cm. to 0·1201cm. The maximum decrease observed is 5 per cent.

Franklin Institute Awards.—The Committee on Science and the Arts of the Franklin Institute have just announced the awards of the John Scott Legacy Premium and Medal to Clement Payen for his inventions in connection with the chloride electrical storage battery, and to Alexander Jay Wurts for improvements in lightning arresters.

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The Electrician.

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SPECIAL NOTICE.

The present number of "THE ELECTRICIAN" completes Vol. XXXIII. With next week's Number will be issued (Gratis) the Index to the Volume.

ACCUMULATORS.

While steady progress has been made during the last thirteen or fourteen years in the construction of dynamos, motors, lamps, and the minor accessories of electrical work, the accumulator, though somewhat improved, remains in an undeveloped stage. Success has been achieved chiefly in that type of accumulator which is used for supply stations, and even here it is a long way behind the dynamo as an economical, durable and efficient item of plant. In first cost, accumulators are a serious burden to a station; taking the normal rate of discharge, the cost is about four to six times that of a dynamo of the same output. The durability has been considerably improved; but there seems to be some doubt about the constancy of the storage capacity. The efficiency is lower than that of an inferior dynamo or motor, and there is no improvement with larger sizes. But, for all this, we believe that many of the promises made for secondary batteries may yet be fulfilled, and that improvements will be made, probably in special directions for special purposes. The slowness of this development in the past has no doubt been due to the fact that an experiment with an accumulator is a matter of months. An improvement in dynamo construction can be tested as soon as it has been made, and the result can be worked out within a few minutes of the test. A number of modifications and further tests of a machine may, perhaps, be carried out and completed in the same day; but with a battery a year or eighteen months of regular work must elapse before a definite opinion can be formed of its merits.

In dynamo design there are two distinct elements, the electrical and the mechanical. There has been an immense amount of discussion about the former, and a great neglect of the latter. Many dynamos have been built which have run for years without trouble, simply because they have been built by mechanical engineers. Others, giving perhaps a larger output for their weight and a higher efficiency, are continually breaking down because they have been designed by electricians. In the construction of accumulators similarly, there is the chemical and the mechanical element. Much attention has been given to an explanation of the chemical action, but there has not been much fertility of invention in this direction. The chloride and the alkaline batteries are the only two noteworthy departures from the lead peroxide original. The success of several types of battery is due to their mechanical construction. The retention of the paste, the prevention

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of buckling, the use of separators, and the arrangement of joints and connections have contributed much more to success than theoretical investigations of the reactions which go on, or which ought to go on, within the cell.

The accumulator came to us from the Continent, and it is there that it has been most successful. The Tudor, Julien, and Laurent-Cély or chloride battery are used to a very large extent by our neighbours, and the last of these has been recently introduced in this country. The patent monopoly may have had something to do with the lack of progress in England; but next year will see the expiry of the earlier patents, and we shall then see whether the pasted plate receives attention from manufacturers who have hitherto used modifications of the Planté battery.

Next to supply work, traction seems to be the most important use to which accumulators may be applied. The problem at first seemed so easy, but it was attacked by men who knew little about mechanical construction and nothing about tramways. Even the late Mr. Reckenzaun, one of the few competent men who seriously concerned themselves with it, cannot be said to have seen success, though he may have contributed largely to a success which will one day be made. The Julien battery seems to have the best result up to the present, and in another column we print an article on electric traction in mines, where this battery has been used. The difficulties of electric traction are merely mechanical. Given a decent motor, and putting aside for the moment the question of corrosion of earth returns, a mechanical engineer will make an electric railway or tramway succeed if the conditions of success are present. It is doubtful if overhead wires will be popular in this country, and it is certain that the high speeds used in America will never be tolerated here. If electric traction is to become common on tramways, it is probable that accumulators will be used. Because success has been achieved in Paris and elsewhere, we cannot assume that the same system is applicable to our roads; but a service which suits the requirements and the pocket of a Frenchman is more likely to suit an Englishman than the systems described by Mr. Wilkinson in the Paper which is concluded in our present issue.

REVIEWS.

Les Oscillations Electriques. By H. Poincaré. (Paris: George Carré.)

The above work consists of an exposition of Maxwell's electromagnetic theory, with special reference to the researches on electric oscillations carried out by Professor Hertz and his followers. It is a reproduction, with additions, of the lectures given by the author to his students during the session 1892-3. The rapidity with which these lectures have been worked up and published is characteristically French. We have not heard of any English professor who publishes his lectures year after year as M. Poincaré seems to do. Those who have kept themselves in touch with the literature to which the researches of the late Professor Hertz has given rise, will remember the two highly valuable works on electricity and optics which Professor Poincaré published in 1890 and in 1891. The first of these volumes dealt with Maxwell's theory, and the electromagnetic theory of light; and the second with the analogous theory of the late Prof. von Helmholtz, and also with the experiments of Hertz on oscillations. The present volume, like the others, extends to 300 pages or more; but, although travelling over much the same ground as the other two, it is by no means a repetition of their contents. In fact, even the fundamental equations are considerably altered owing to the adoption of a different system of notation. In the former volume Maxwell's symbols were adhered to with almost the same strict fidelity as is to be found in Professor J. J. Thomson's recently published sequel to Maxwell's work. In the present book, however, Prof. Poincaré has endeavoured to modify the equations, so as to make the connection between the symbols and experimental quantities more apparent than is the case when one tries to apply Maxwell's equations directly to explain Hertz's results. It is interesting to note that the author has found it best to reproduce Hertz's notation. The chief difference between this and Maxwell's consists in the introduction of a quantity, A, into the equations. This quantity is ultimately shown to have a definite connection with the velocity of undulatory electromagnetic disturbances in air, and has thus a distinct physical meaning. One of the advantages of introducing it into the equations is that it enables the symbols for specific inductive capacity (electric or magnetic), to be regarded merely as numbers. In Maxwell's theory, as explained in his book, the symbols κ and μ for these quantities cannot be regarded as mere numbers, because they express the ratio between the induction and the inducing force; that is, between the flux (electric or magnetic), and the corresponding force producing it. Maxwell's book was, however, not concerned much with the explanation of oscillation phenomena, the existence of which had not at that time been experimentally established; and, when only a steady electric, or a steady magnetic, state is under consideration, only one of the symbols μ or κ enters the equations. When this is the case it is possible, by arbitrarily altering the dimensions of the quantities involved in the equations, to look upon either μ or κ (but not both) as a mere number, expressing the ratio of the inductivity of the medium, to that of air. This ratio is, of course, unity in the majority of cases, where the medium considered is air itself; and Maxwell accordingly omits the inductivity symbol altogether in many of his equations. This is most confusing to the student who endeavours to apply the theory to the phenomena of oscillations, for it is necessarily some time before he can distinguish the cases where the omissions have been made, from those in which the inductivity symbols do not naturally occur. It is a difficulty which appears to be of very little moment to the merely mathematical reader; but to the physicist it is an all important matter. This source of confusion is entirely avoided in the present book.

To properly appreciate this work the reader must be well up in the mathematical theory of electricity. Poynting's theorem about the transfer of energy in the electromagnetic field occurs in the very first chapter; and the second chapter, after briefly describing the work on electric oscillations done previous to that of Hertz, is soon devoted to the mathematical discussion of the exciters and resonators used by that scientist and his followers. Although Hertz found it comparatively easy by his method to establish the existence of electric undulations, and to show that they were the same in general characteristics as light waves, it did not prove a simple matter to show that the velocity of these two kinds of disturbance was the same. An error in calculating the capacity of his apparatus misled Hertz to a conclusion which he was very loth to accept; viz., that the velocity of light was different from that of the electromagnetic waves. The most careful experimenting only seemed to confirm this view, although it was in direct opposition to the conclusions of Maxwell's theory. It was not until Prof. Poincaré pointed out how the error in calculation arose that the seeming contradiction was explained. The critical examination to which the author of this work subjects the theory of the capacity and self-induction of apparatus such as that used in these experiments, is specially worthy of attention. Hertz stated explicitly that the theory he gave was only a preliminary one; and, indeed, the slightest consideration shows that when electrical disturbances are occurring at the rate of 100,000,000 per second our ordinary notions of capacity and self-induction must be greatly modified. That this is the case is shown by an elaborate investigation of the apparatus used by M. Blondlot. The third chapter is mainly concerned with the mathematics of Hertzian oscillations; but it also contains some valuable observations in reference to the decrement of the oscillations of a Hertz exciter. The vexed question of multiple resonance is next discussed at length, and the experiments of Sarasin and de la Rive, Blondlot, Perot, Bjerknes Jones and Rubens,

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whose researches bear on this matter, are described. The new phenomena discovered by Messrs. Sarasin and de la Rive are shown by these experiments to be due to the oscillation of the vibrator subsiding more rapidly than those of the receiver. The study of the decrement of the oscillator is important, not only because the damping affects the character of the resonance, but also because it determines the sharpness of the resonance effect.

The results obtained by Hertz in many of his earlier experiments were complicated by reflections occurring on the walls, &c., of the rooms in which the observations were made; and, although Hertz was the first to demonstrate the existence of these reflections, he did not foresee their influence on the tests in question till after the majority of his experiments were made. The actual results obtained were always faithfully recorded, and tended to confirm the erroneous conclusion that the velocity of the waves when traversing air was not the same, as when moving along metallic conductors. The proper interpretation of some of these experimental results is still problematical. Prof. J. J. Thomson has shown in his recent work how the apparent difference in the velocities can be accounted for by side reflections, and Prof. Poincaré, in the fifth chapter of his book, devotes a good deal of attention to these obscure points, and refers to experiments by more recent workers. Another chapter is added, describing the various experiments which have been made on the propagation of electric waves in dielectrics other than air. The various methods of determining specific inductive capacity by means of electric oscillations, such as those used by Rubens, Arons, J. J. Thomson, Lecher, Blondlot, &c., are described and criticised from the theoretical point of view; and the results which these experimenters found are compared with those which have been obtained by older static methods. The book concludes with a critical discussion of Hertz's celebrated memoir on the fundamental equations of the electrodynamics of moving bodies.

The eminence of the author of this work renders superfluous any testimony to its ability. The student will find here the most complete account yet published of the experimental work, on electric waves, to which Hertz's researches have given rise; and the description is, moreover, accompanied by a fuller theoretical criticism than is to be found in any other book with which we are acquainted. The book should certainly be included in the library of every specialist on the subject.

Dynamo Attendants and their Dynamos. By A. E. Gibbings. (London: S. Rentell. 1894.)

The author of this little book commences by lamenting that "the men who look after the dynamos of a private electric lighting plant are so seldom well acquainted with the rudimentary principles of the machines in their charge," has discovered that the fault is due to the absence of suitable literature, and proceeds to supply the want. It may be doubted if the generality of dynamo attendants, even in private dynamo rooms, do require the kind of information provided by Mr. Gibbings; but there are plenty of amateurs who may find it interesting and instructive reading of its kind. A dynamo attendant who needs to be told, for example, that "The spindle goes right through the bearings, commutator, armature and pulley, and should run perfectly true and be a good fit," ought to vacate his post on the instant. On the other hand, it probably will be news to most dynamo attendants that in suddenly altering the resistance of a shunt machine "there is a danger of short-circuiting the dynamo, causing too much current to go around the shunt and fuse it." It is not very consoling to be told that sparking due to overloading "may partly be due to earth contacts in the external circuit; and if so, will very likely take some time to discover;" and how does the dynamo attendant like being told that the speed indicator "is to form a check on the watchfulness of the dynamo attendant," and "should be fastened with a padlock so that no tampering" can take place? In coupling machines in series or parallel, "the dynamo attendant may assume the methods to be analogous to those he would adopt when connecting up a primary battery"; but he must not be over sure of this, as he must "take into consideration the different forms of winding," and "it must be ascertained beyond doubt that the increased current which will traverse the circuit will not cause serious damage." With such vague phrases does the author supply the place of definite information and direction; and in this inane and insipid style he offers to his readers a combination of platitudes and error.

The Practical Designing of Structural Ironwork. By Henry Adams. (London: E. and F. N. Spon. 1894.)

This is a truly admirable work. We do not remember to have met with a clearer, more concise and practical treatise on structural ironwork design. Not alone is the information eminently practical and to the point, devoid of irrelevant theory and useless padding, but the author's method of arranging it is the best possible way of conveying the instruction which is intended. We think that this method might with advantage be adopted by writers upon other technical and engineering topics. Mr. Adams plan is to select a series of actual problems, arranging them in progressive order, and then, while working these out numerically, to intersperse the solution with such remarks and generalisations and practical hints as would be likely to be of use to the reader in the practical working out of similar problems. First, we have a problem involving the design of a "small cast-iron girder," then a "flitched beam," then some observations on riveting; and so on, through "cast-iron columns" and "story posts," to such more complicated structures as a "lattice girder bridge" and a "wrought-iron roof truss." The author evidently is thoroughly proficient in his subject and, what is equally to the purpose, he understands how to impart his knowledge to his readers. Bridge and roof design are not subjects which are closely affiliated to electrical engineering; but to anyone who may desire to obtain information on these subjects we could not recommend a more useful, or a more readable work than that one before us in which Mr. Adams adds another to his already lengthy list of practical engineering treatises.

Electric Lighting Plants: their Cost and Operation. By W. J. Buckley. (Chicago: W. Johnston Printing Company. 1894.)

This little book claims to consist of "data compiled from station reports of electric lighting plants employing overhead circuits, with suggestions pertaining to the information usually desired by the non-technical purchaser"; or, in other words, its purpose is "to give to intending purchasers of lighting plants such details as may aid them in forming a fair estimate of the cost of construction and operation of their proposed station." It will be seen, then, that the writer starts with a definite and laudable object in view; but it cannot be said that he quite achieves its end. Only American practice is considered; but even from an American point of view the scope is narrow. For the writer, after telling us that he is "neither electrician, engineer nor expert, but a salesman," goes on to confess that "in a noble effort to deserve his salary" he has refrained from mentioning other lighting apparatus but that made by the Company whose salesman he is. As an instructive spectacle of frankness and modesty, all this may be very well; but it is hardly calculated to inspire confidence in the reader. However, the writer is not as bad as he paints himself, and his book contains a great deal of useful information of a general character, including a number of tables and curves showing the weight, size, cost, efficiency, &c., of engines, dynamos, transformers, shafting, belting, &c., and it suffers only in "errors of omission" from having been restricted to the wares of only one electrical company.

"A Dictionary of Electrical Words, Terms, and Phrases." By E. J. Houston. Third edition. (New York: The W. J. Johnston Company. London: "The Electrician" Printing and Publishing Company.)

The rapid circulation of this compilation has necessitated the issue of a third edition in an unrevised form, but with copious additions in the form of an appendix. Our opinions of this work are expressed in our review of the second edition, which will be found on page 510 of Vol. XXIX. We regret that as the defects, which were there pointed out, still exist, we are unable to alter our opinion of the main body of the work. With regard to the appendix, this is both extensive and exten-

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sively cross-referenced, perhaps too extensively, indeed. What progress the profession must have made (at any rate, in the coining of words), if we may judge by the 105 pages of appendix. It is true that we have heard of "Spark, Electric," before, and are surprised at its absence from former editions. But the words "trega," "magnetine," "magnetician," "electrologist," &c., are new to us, and they doubtless mark important advances in the science. The first-named is "a prefix proposed by Houston and Kennelly for a million million or 10^{12}." The appendix, however, notwithstanding that it contains many definitions which might safely have been dispensed with, is on the whole a very useful addition to the work.

Tables and Formulas for Electric Street Railway Engineers. By E. A. MERRILL. (New York: The W. J. Johnston Company, Limited. 1894.)

In so far as this consists almost entirely of tables, without any compressed text-book stuff, this is almost an ideal pocket-book. But for the fact that the electrical and mechanical data are in American units and gauges, and are, therefore, only readily useful in America, the ideal would, perhaps, have been attained. The book is small and light, and strongly bound; the print is clear, the matter is well arranged, and consists almost exclusively of tables and formulæ; there are no useless and inartistic pictures, so absurdly out of place in a pocket-book of this kind; and there is no theorising. Everything is short, terse, and to the point; and little, if anything, legitimately connected with street railway work has been overlooked. There is a great deal in the book which might prove useful to an English tramway engineer.

Construction des Lignes Electriques Aeriennes. By A. BOUSSAC and E. MASSIN. (Paris: Gauthier Villars et Fils.)

Shortly before his death in January, 1893, M. Boussac, Professor of Construction at the École Professionnelle supérieure des Postes et Télégraphes, decided to publish his course of lectures there in book form. The present volume comprises such lectures, nineteen in number, as were in manuscript or in type at the time of M. Boussac's death, together with six more completing the course, from the pen of M. Massin. This work is a clear and methodical, though a somewhat too mathematical, exposition of the leading principles of overhead telegraph line construction. It should form an excellent supplement to the elaborate telegraphic treatise by M. Thomas, recently reviewed in these columns, in which the chapter devoted to line construction was perhaps unduly brief.

NOTES ON ELECTRIC TRAMWAYS IN THE UNITED STATES AND CANADA.*

BY H. D. WILKINSON.

(Concluded from page 729.)

I found, on the other hand, that some of the more recently-planned power stations were equipped with direct-coupled plant; and the tendency of advanced practice in America, if one may take the plant at the World's Fair as an indication, was certainly towards direct driving. The General Electric Company, who completely equipped the very successful elevated electric railroad of three miles in extent through the Exposition grounds, used for the most part generators coupled both to horizontal and vertical engines, while the Westinghouse Electric Company supplied power to the moving sidewalk from a large dynamo taking the place of a flywheel between the high and low-pressure sides of a cross-compound horizontal engine. This Company also exhibited a 160-H.P. generator direct-coupled to a Westinghouse high-speed engine, such as regularly used in their power stations.

I also saw well-arranged direct-driven sets in the power-houses at Milwaukee and Cleveland. At the former place there was a very large Edison plant, with boilers on an upper floor and engines below. The engines were of 600 H.P., vertical, triple-expansion, condensing, each driving two 200-kilowatt generators. At Cleveland the power-house of the Cleveland City Railway Company contained four vertical triple-expansion condensing engines, by the Globe Manufacturing Company, of Cleveland, of 560 H.P., three driving two 190-kilowatt four-pole generators each, and one driving one six-pole generator, the maximum output of the station being 2,800 amperes at 500 volts. These engines were fitted with Joy's valve gear, controlled by a small centrifugal governor through the medium of a hydraulic valve.

Dynamos were very carefully insulated from earth, in some cases by half an inch of sulphur under the rails, and in all cases by wood under the bed-plate, and where direct-coupled the coupling was insulated. This precaution is necessary where overhead wires are used, on account of lightning, to prevent a side flash between coils and framework. When a flash does pass by the machine, the damage is caused by the current of the machine following up the flash. The "magnetic blow-out" and "air-blast" arresters are being supplanted by Wurts' water tank arrester, in which there is no spark gap. The well-known action of lightning in choosing to flash from coils to frame instead of through magnet and armature coils to earth, on account of self-induction in the latter, is utilised in preventing its reaching the machine at all. Coils are placed in the line circuit—a sufficient number being in multiple to carry the current—and from these at intervals connections are tapped to carbon rods dipping into water in a tank. Lightning is checked by the induction of the coils, and discharges by the rods and water to earth. By the use of running water the normal loss from generators is reduced to a very small amount; and by using a small branch from the city water mains, with overflow pipe for this purpose, the additional advantage is gained of a good earth.

I found that a good deal of power was tapped off the 500-volt tramway circuits for supplying private motors. On the Cleveland Electric Railway Company's system there was 350 H.P. taken off for this purpose, the motors varying in size from one-eighth to 25 H.P. The tariff charged was 20s. per month per horse-power

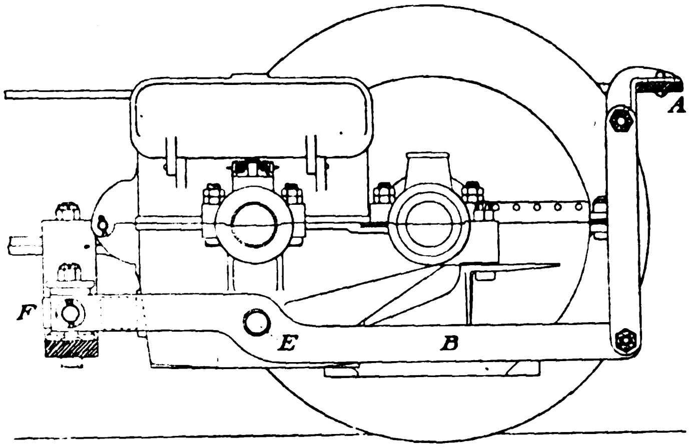

FIG. 19.—Side Suspension of Motor.

for a 3 H.P. and over, or at the rate of 4d. per horse-power hour, the horse-power being averaged by a portable meter kept on the circuit for a given time.

Improvements have been made in the design of street car motors, their attachment to car trucks, and in decreasing their weight for a given output. Through the courtesy of the General Electric Company I am able to give a few particulars of their latest type of 25-H.P. motor, known as the "G.E. 800 motor." This name is stated to be given to it on account of the drawbar pull exerted by the motor being 800lb. on ordinary street tracks, with 33in. car wheels, the usual single reduction gear, and rated current. The dead weight has been reduced to 1,450lb., or 730lb. below the former standard type of the same power, viz., the W.P. 50 (waterproof motor). Next to reducing the weight of the motor *per se* is the requirement of reducing dead weight on the axles and distributing it over the car. By the usual end suspension about half the weight is carried by the axle, and half by a cross-bar resting on springs; but by a new arrangement with side-bar suspension (Fig. 19), the whole of the weight is taken off the axle. The side-bar B takes the weight of the motor at the trunnion E, and is itself supported by link bars bolted to the frame at the back A and by six springs in front at F, four of which take the weight, and two resist upward pressure. The wear and tear of the track is by these devices considerably reduced, and the running of the cars improved. The motor is enclosed in a cast-iron frame, in two parts hinged together, the same forming the field. There are two field coils, one in the upper and the other in the lower portion of the field; and, as these are wound to give similar poles, two additional consequent poles are formed between them, making a four-pole machine. The armature is cross-connected, so that only one pair of brushes is used; and these, with the upper field coil and armature leads, are fixed inside the upper half-frame, and swing back

* This Paper will be discussed early in the course of the next session of the Institution of Electrical Engineers.

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with it. The iron of the field is, of course, to earth, and therefore special care is necessary to insulate the field coils; but the chance of a fault is minimised by coupling the coils to the earth return, in which case they can only vary by a few volts from the potential of the frame itself. The axle gear, which runs in an oil chamber, is arranged for a speed reduction of 4·78.

The latest type of Westinghouse motor for street cars is built in a cast-iron horizontal frame, on which are hinged the upper and lower field magnets, so that the armature can be got at from above or below. There are four field poles, with as many coils. The armatures are drum-wound, each coil being wound on a former of the size of a quarter the circumference of the core, then taped, and slipped into its place between the teeth of the core. The wires composing the coil are laid so as to form a flat strip, which goes in edgewise between the teeth and lies flat at the ends of the drum, so economising space. The whole is then covered with waterproof material.

There are various types of "controllers," or combination switches, for putting the two motors on a car in series and parallel. The switch handle has from five to ten notches, giving different grades of speed. The first, or starting, position puts the motors in series through resistances; the succeeding steps reduce the resistances, shunt one motor out of circuit, and finally put both in parallel. There is also a side lever operating a cylinder of contacts for reversing the motors. I tried the experiment on one of these controllers of making the motors act as an electrical brake. Getting them first up to full speed, the controller was put back to starting position, current switched off, motors reversed, and then put in parallel again. The slight difference in excitation between the motors then caused one to act as a generator and drive the other, making a very powerful and quick-acting brake. A single switch might be employed which would effect these changes, and so prove an important aid to the mechanical brake in an emergency.

In Philadelphia I found very few streets with overhead wires, and learnt that an active policy had been pursued by the City Electrical Bureau towards the placing of all electric wires underground. One overhead trolley line was in operation, but the feeder cables were all in underground cement-lined conduits. Mr. D. R. Walker, chief of the Electrial Bureau, informed me that he, in company with the Director of the Department of Public Safety, had examined into the systems of electric traction in other cities, with the view of employing the most suitable for the city of Philadelphia. He referred me to his report, which summed up as follows:—

"The overhead system, or electric propulsion of street cars is, in my opinion, better fitted for small towns or villages, or to connect the same, or for the suburbs of a city such as our own; but when it comes to introduce electricity as a motive power in the heart of a large city, the circuits conveying the power for the same can, and should, be placed beneath the surface of the street. It has been effectually proven a success in Chicago, and is now being introduced to a large extent in Washington, D.C.; and any new privileges asked for in this direction should be granted only on condition that all the wires used for such a purpose should be placed underground. The only difference between the overhead and underground systems is in the matter of cost, which is but a secondary question when the safety and comfort of our people, and maintaining the beauties of our thoroughfares, are concerned. Again, a more reliable service can be maintained underground than overhead, as it would be free from interruptions caused by fire, falling of wires, or the action of the elements. The franchises so granted are immensely valuable, and while they are being issued the interests of the city should be taken into consideration, and provision made underground for its electrical systems and for the lighting of its highways."

I may mention incidentally that the city authorities use, or own and rent to private companies, about 25 miles out of the 150 miles of underground conduit laid. I refer here to conduits constructed for the reception of electric cables and feeders, not for tram-car propulsion. The wires owned by the city are for telegraph and telephonic communication from the City Hall to fire and police stations and street call boxes, of which there is a most complete system, and for the electric lighting of the streets. The city contracts with lighting companies to supply lamps and current only, posts and cables being erected and laid by the city. I was very much impressed with this imposing and beautiful city, and with the system of control exercised in the interest of the citizens over all electrical undertakings by the Electrical Bureau.

Of the 12,000 miles of tramway in the United States and Canada, about 7,200 miles are operated by electricity, and 3,500 miles by horses. In conclusion, I need only remark how well adapted electric traction is to the wants of the people. Following the ordinary highways, where business is done and people congregate and travel to and fro, tramways afford at once a means of locomotion that is readiest to hand with least trouble to the traveller. For short distances, people will not go out of their way to get on the railway, or climb steep staircases to elevated roads, provided that the street tram-cars travel at a reasonable speed, with minimum delay. For the latter desideratum a modification of the American practice in cities of not stopping between "blocks" might be adopted, while for a reasonable speed we must look to other means of propulsion than horses. The cable system is very suitable in certain localities, such, for instance, as on straight and hilly roads; but the wear and tear of cable is enormous on curves. Steam is unsightly and obnoxious. Electricity affords at once rapid and noiseless travel, quick control, with small wear and tear, and the current can simultaneously be utilised for heating and lighting the cars. As a means of travel, I have not experienced in the States anything so pleasant as their well-lighted and fast-moving electric street cars; and I cherish the hope that ere long this public boon may be extensively put into action along the streets and lanes of our own country.

THEORETICAL AND EXPERIMENTAL INVESTIGATIONS ON THE VISUAL SENSATIONS AND ON PHOTOMETRY.*

BY ANDRÉ BROCA.

In their photometric investigations, first Bouguer and afterwards Masson were struck by the fact that the eye perceives a difference between two luminous fields when this difference has a certain value dependent upon the luminous intensity originally common to the two fields. It was this remark that formed the starting point of Weber's and of Fechner's attempts to find a relation between the magnitude of the visual sensation and that of the excitation. Fechner's law was at first accepted in a general way; but to-day there seems to be reaction, and many individuals appear to hold the belief that it is impossible that a function connecting sensation with excitation should exist.

The retina is a machine which transforms the undulatory energy, when its wave-length is comprised between certain limits, into another form, the nature of which is quite unknown, and which physiologists call *nervous influx*. This is propagated by a conductor, the optic nerve, and impresses itself upon the cerebral surface at a clearly defined spot, the occipital lobe. Is it possible to disentangle from the midst of these complex phenomena a law connecting the sensation with the objective cause? Certainly not, unless we carefully define the condition of the organs at the moment of the impression, for the effect of the impression evidently depends on the degree of fatigue of the various organs, and this latter itself depends upon two causes: the impressions previously received, and the state of the circulation which allows of the reconstitution of the organs. But, owing to the constant change of the organism and its reconstitution by means of the materials brought to it by the blood, the state of the visual organs under the influence of a definite excitation tends to a definite limit.

But what is the nature of the connecting function? Fechner gave a first approximation, taking his stand on the Bouguer-Masson law and the following hypothesis: When the eye distinguishes two fields it is because the increased sensation due to the difference of illumination has attained a constant value.

The first thing to do is to verify Fechner's hypothesis, and this is what I have done, relying on certain anatomical data and some experiments indicating the part played by each of the two eyes in binocular vision. I hope to show that the sensations due to the two eyes are added.

The organ of vision may, in fact, be compared to an installation for the transmission of energy to a distance. The undulatory energy actuates a generating apparatus, the retina; this transmits *viâ* the optic nerve the energy in a form quite unknown, but called *nervous influx*. This is received by a well-defined portion of the receiving machine, the brain, and the brain under the influence of this impulse gives rise to the psychical act of perception. There are, therefore, two generating and two receiving machines. The relative values of each of these cannot be known *a priori*, and we know that, at any rate in the case of the cerebral lobes, the operations need not be the same. The two receiving apparatus which ultimately produce the sensation are probably of unequal efficiency; consequently, we cannot conclude from the fact that because two eyes are concerned the two sensations are added, except upon one condition—namely, that the nervous influx produced by each of the two eyes is equally divided between the two receivers; that is to say, between the two cerebral hemispheres. This, in fact, is what actually takes place in the case of the fibres issuing from what the anatomists call the yellow patch. Numerous experiments prove that a crossing-over effect occurs for the bundle of nerves issuing from the patch, at a spot called the *chiasma of the optic nerves*. We may, therefore, say that the sensations of the

* Abstract from the *Journal de Physique*, May, 1894.

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two eyes should be added. If, therefore, for example, the right eye makes use of $1/\alpha$ of the luminous energy emitted by unit surface, whilst the left eye utilises $1/\beta$, the two eyes together will utilise $1/\alpha + 1/\beta$. Direct experiment verifies this qualitatively. Unfortunately, measurement is impossible, and we must content ourselves with subjective estimates.

Look with one eye at a uniform well illuminated white surface, and interpose an opaque screen held at arm's length, so as to conceal a portion of the illuminated surface. The screen being sufficiently far off we may regard the surface as one divided into two uniform fields, one bright the other dark, the zone over which the screen impedes the complete utilisation of the pupil being very small. It is confounded, indeed, with the shady zone due to diffraction. If at this moment the other eye is opened, one sees very clearly a very great difference in intensity between the field seen with both eyes and that seen with a single eye. This observation is occasionally delicate, for, in fact, observers who have one eye decidedly inferior to the other easily miss the sensation.

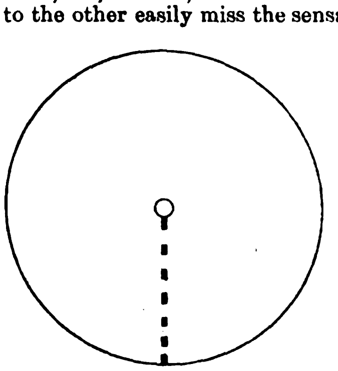

FIG. 1.

I made some measurements of this difference by means of a slightly modified Rumford photometer. I placed behind the photometer a screen having a hollow for the nose, and separating the two luminous fields. Placing the forehead and the nose behind this screen, the left eye only sees the left field of the photometer, and the right eye only the right side. The illuminated fields stand out against a dark background. In this way I obtained the following result: The right-hand field being illuminated to the extent of 0·4 carcel-metre, the left gave the same impression for an illumination of 1 carcel-metre. Therefore, for equal illuminations my left eye gives me an impression $2\frac{1}{2}$ times feebler than my right.

These experiments, it seems to me, establish the law I enunciated; that is to say, that the sensations of the two eyes are added.

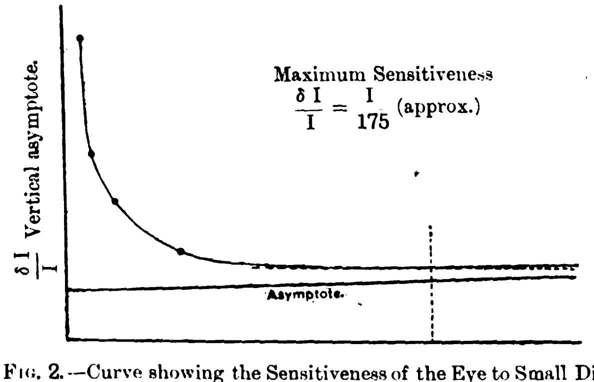

FIG. 2.—Curve showing the Sensitiveness of the Eye to Small Differences of Illumination as a Function of the Illumination. (Gas Lighting.)

I supplemented this experiment by another with the Masson rotating disc with black dots (Fig. 1). I looked at such a disc, and noted the last rings visible with both eyes and with each separately. The motion of the disc was derived from a small dynamo, and was very rapid and very regular. The result was as follows: If with the right eye I saw ring n, and with the left eye ring p, with both eyes I saw rings $n + p$, whatever the values of n and p, which varied with the illumination. The deviations from this were always very small and variable. This fact was verified by two other observers. The intensity of luminous sensation is evidently from this experiment greater with two eyes than with one, and it also shows that the increased sensation which gives rise to the perception is the same in the two cases. These experiments thus give considerable support to Fechner's law.

It remains for me to investigate the differential sensitiveness of the eye as a function of the intensity, and to deduce the law connecting the sensation with the excitation. Bouguer, in studying the degree of accuracy of his photometer, and Masson, employing the rotating disc just described, enunciated the following law: The ratio of the smallest perceptible difference to the total intensity is a constant. Helmholtz had already shown, but without any actual measurements, that the differential sensitiveness passed through a maximum. I undertook similar experiments, supplemented by photometric measurements. The source of light was a standard gas lamp, the value of which was frequently checked by means of a modified previously standardised Mascart photometer. The illumination of the disc was then calculated by the law of inverse squares. The gas lamp was nearly equal to one carcel. The results were as follows:—

Distance of the lamp (metres).	Illumination of the disc (carcel-metre).	Ring perceived.	$\frac{\delta I}{I}$
1	1	7	$\frac{1}{173}$
2	$\frac{1}{4}$	6	$\frac{1}{147}$
3	$\frac{1}{9}$	4—5 } Doubtful.	$\frac{1}{94}$
4	$\frac{1}{16}$	3—4 } Doubtful.	$\frac{1}{72}$
5	$\frac{1}{25}$	2—3 } Doubtful.	$\frac{1}{44}$

Putting these results into the shape of a curve (Fig. 2), the values of I being abscissæ and those of $\delta I/I$ ordinates, I get a branch of an hyberbola having the axis of y as asymptote; this is obvious, since when I approaches zero, δI approaches the minimum perceptible difference, which is not nothing. It must be clearly understood that this curve only applies to my eyes, and to the light from a gas lamp. Everyone must plot his own curve for himself, an extremely simple proceeding. The practical outcome of all this is that if we desire to do good photometric work, we must work with an illumination of about 1 carcel-metre, the observer being about 30cm. from the fields under observation.

But this is not the only consequence concerning practical photometry arising from my experiments. Every photometer includes a diffusing surface divided into two fields, each illuminated by one only of the two sources of light to be compared. The *ensemble* of these two fields is observed either monocularly or binocularly, according to the type of photometer, but the condition which it is always sought to realise is a perfect symmetry of the beams in regard to the normal to the diffusing surface.

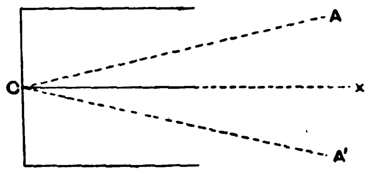

FIG. 3.

The necessity for this symmetry is well known to all who give their attention to photometry. The diffusing surfaces are not perfect, in short, and do not diffuse light equally in all directions. Nothing can be settled about the equal brightness of two fields which are not lighted by beams of the same angle of incidence. An experiment which it is easy to make shows this. Imagine an observer to be agreed as to the equality of the illumination of two illuminated surfaces when he is in a given position. However slightly the observer moves his head, the equality will apparently disappear; from this fact arise most of the errors of photometry. Two measurements are comparable only when they relate to the same position of the eyes as regards the photometer. In my opinion, therefore, every binocular vision photometer at present in use should be fitted with an apparatus intended to keep the observer's head in a fixed position. Such an addition is, moreover, by no means difficult to improvise for ordinary Foucault or Rumford photometers or others on the same principle. It is owing to this defect that binocular vision photometers have almost been abandoned in favour of photometers of the eye-piece type. A similar device is necessary for a photometer on the system pointed out by M. Cornu. I have frequently used a photometer made on this plan (Mascart pattern, large size). I began by having enormous errors, and I found that these errors were diminished when I took every possible care to fix the position of my eye. I then placed a fine wire a little behind the point of observation, and by bringing it always carefully into the same position relative to the separation between the two fields I obtained perfectly concordant results. Finally, in view of the experiments described we should, I think, increase the sensitiveness of the apparatus by adding a double *camera lucida* enabling us to work binocularly and thus to use our visual mechanism in the best conditions. Let us take a Foucault binocular vision photometer, in which the sources of light are movable along two straight lines the bisectrix of which is normal to the diffusing surface (Fig. 3). Let the head of the observer be placed symmetrically

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with regard to this bisectrix. The arrangement seems symmetrical. So far as apparatus is concerned it is so, physically it is not; for the two eyes of the observer are often very unequal, as I have previously shown, and in accordance with the unequal diffusion in different directions the left eye plays the principal part in the perception of the right field and *vice versâ*. If my explanation is correct, the difference will be greater the greater the angle A C. Experiment verifies this. With an angle of 10° there was an error of 30 per cent., with an angle of 20° about 50 per cent. How is this persistent error to be eliminated? By working with a fixed auxiliary source of light, at A, for instance, and by bringing the two fields to equality, first with the standard and then with the source of light to be measured, both being placed on the line A′C. By placing the standard first along A and then along A′, and the source to be compared first along A′ and then along A, the need for an auxiliary light is obviated.

To sum up, the conditions to be fulfilled by an accurate photometer are as follows:—

(1) It should be adapted for binocular vision.

(2) It should be arranged so that the observer's eyes should always be in a clearly defined position.

(3) It should be arranged to be worked with the sources of light changed over, when a double measurement is impossible.

The first two conditions are easily realised in instruments without eye-pieces. In eye-piece instruments it is only necessary to arrange a fine wire beyond the point of observation, and parallel to the line separating the two fields, and to place beyond the eye-piece a double *camera lucida* permitting binocular vision.

ON THE DEGREE OF INCANDESCENCE OF LAMPS.*

BY A. CROVA.

The determination of the degree of incandescence of lamps can be accurately carried out with a spectro-photometer; but, practically, it can be done sufficiently accurately in the manner proposed by me to the 1889 Congress of Electricians, and recommended by that body.† The luminous intensity in terms of the carcel is determined by interposing a trough containing a mixture of chloride of nickel and perchloride of iron having such proportions‡ that it transmits a certain amount of the radiation comprised between 630*d* and 534, with a well-marked maximum at 582.

A second determination is effected by placing a red glass in front of the eye, the glass being such that it only transmits the radiation comprised between the red end of the spectrum and the vicinity of the D band. The first determination gives the value of the source of light under consideration in carcels; the ratio of the first to the second gives the degree of incandescence. I have shown§ that if we compare two lights of different colour their total intensities are in the same ratio as their intensities measured in the portion of the spectrum of wave-length 582. It is thus both very convenient and very accurate to make photometric measurements with the aid of the 582 trough. When any two sources of light have to be compared they are not, as a matter of fact, usually of identical colour; the 582 solution makes them so, and thus renders the measurement more accurate. The light of a carcel at one metre is too intense, and the interposition of the trough reduces it to such a degree that the smallest difference between the two illuminations on the photometer screen is brought out clearly.‖

As the use of electric lamps and high-power burners is becoming more and more general my method may be employed to discover without much trouble the best working conditions. A few examples will demonstrate the utility of these determinations.

In the case of an arc lamp the degree of incandescence varied from 1·5 to 1·7, the electrical energy consumed being respectively 1,509 and 1,660 watts. For a 16-c.p. glow lamp, this figure varied from 1·05 to 1·23 according as the lamp was more or less overrun. In the case of a Bourbouze lamp with platinum mantle the degree of incandescence was less than unity for small power, but increased with the consumption of gas and compressed air, reaching unity with a proper supply, that being the figure of the carcel.

An investigation of the Auer burner gave some interesting results. The candle-power, degree of incandescence, and gas consumption of the Auer burner tested by me, gave the following figures, which are the mean of a number of determinations:—

Luminous intensities (carcels)*	4·42	5·23	5·35
Degree of incandescence	1·30	1·41	1·47
Gas consumption per hour (litres)*	93	105	102
Consumption per carcel per hour	21	20	19

It will be seen that the candle-power increases with the degree of incandescence, which is in conformity with the principles of radiation by incandescent bodies. If the gas consumption per hour is increased the degree of incandescence, low at the commencement, increases continuously, as also the candle-power, up to a certain limit, beyond which more and more of the gas is uselessly burnt without helping to heat the mantle of refractory earth which forms the wick of this burner. It is, therefore, advantageous to push the Auer burner to that degree of incandescence beyond which it cannot go, whatever may be the gas consumption. Similar tests may be made with various kinds of high-power burners, and accurate data may be obtained as to the best conditions of working.

The case is quite different for gas burnt in an ordinary Bengel burner. In the Auer burner and others of the same kind the quantity of refractory matter is constant, and the maximum effect corresponds to the highest temperature which this matter can attain in a Bunsen flame. In the Bengel burner, on the other hand, a portion of the gas is burnt externally and internally in so far as the cylindrical mass of gas that escapes by the ring of holes is concerned; this consumption of gas causes no deposit of carbon and produces a bluish flame, which is quite negligible from the photometric point of view. The high temperature produced by this non-luminous combustion incandesces the carbon molecules dissociated from the hydrocarbons contained in the mass of gas comprised between the two surfaces of combustion, which surfaces are the true source of light as was shown by the photographic investigation carried out by me.† The quantity of incandescent carbon that emits the light is only a fraction of the total carbon contained in the gas under combustion, and this fraction is all the smaller the lower the flame; if the flame is made small enough all the gas burns blue and there is no useful light. As the gas consumption of the burner increases the relative quantity of dissociated carbon increases; the degree of incandescence diminishes slightly, and the luminous output increases rapidly to a maximum corresponding to the moment at which the flame becomes smoky. A similar result is reached with the Carcel standard, the consumption of which is varied by raising the wick more or less. With a Bengel burner I obtained the following results:—

Luminous intensities.	Gas consumption. Litres per hour.	Gas consumption. Litres per hour per carcel.
0·2	56	280
0·4	78	195
0·6	95	158
0·8	108	135
1·0	120	120
1·2	131‡	109

It follows from these considerations:—

1. That in a hydro-carbon burner by increasing the hourly consumption of combustible the luminous output increases, though the degree of incandescence slightly diminishes, until the output reaches a maximum which should not be exceeded.

2. That in lamps in which the incandesced refractory substance has a fixed value independent of the consumption of combustible, the maximum effect corresponds to the minimum amount of combustible necessary to reach the maximum degree of incandescence.

* 1 carcel = 10 candles (approx.); 1 litre = $\frac{1}{28}$th cubic feet (approx.) litres per hour per carcel ÷ 230 = cubic feet per hour per candle. [Ed. *E.*]

† "Photometric Investigation of Certain Sources of Light," *Comptes Rendus*, Vol. LXVI., p. 1343.

‡ Above 131 litres per hour the flame became smoky.

* *Comptes Rendus*, Vol. CXIX., No. 16, p. 627, October 15th.

† *Proceedings* of the 1889 International Congress of Electricians, p. 210, where the composition of the 582 solution will be found.

‡ Palaz: "Traité de Photométrie Industrielle," p. 82. Sublimated anhydrous perchloride of iron 22·321 grammes, crystallised chloride of nickel 27·191 grammes; this must be dissolved in distilled water, and the volume of the solution brought up to 100 cubic centimetres at 15°C. [Ed. *E.*].

§ "Phometric Comparisons of Differently-Tinted Lights," *Comptes Rendus*, Vol. XCIII., p. 512.

‖ M. Pellin has constructed a slide-bar to my specification, which can be adapted to any photometer, and by means of which these determinations are very easily carried out.

A NEW WIRE GAUGE.

In these days of general and electrical progress in metal working the gauging of wires has become of much importance, and the necessity of some substitute for the clumsy slot gauge hitherto in general use has become obvious. The latter form of gauge simply shows if a wire conforms to some one or other number of a certain gauge such as the standard or Birmingham wire gauge, but gives no other information. Such gauges are seldom, if ever, quite reliable, especially in regard to the smaller sizes. To obtain the actual size of a wire recourse must be made to a micrometer gauge.

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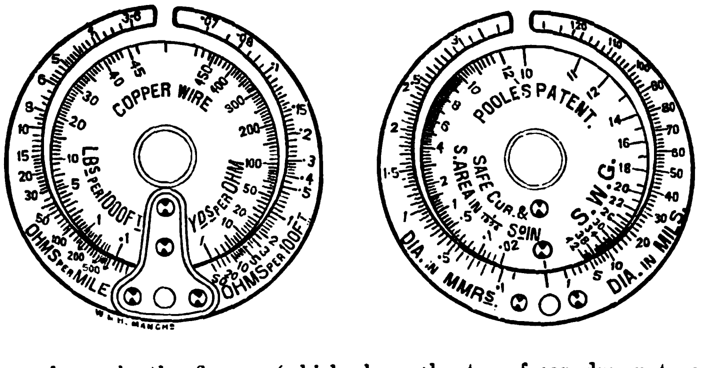
A wire-gauge has been designed by Mr. Poole, of the New Telephone Company, Manchester, to give in one small handy and compact instrument various information in regard to copper wires, such information being given at a glance without calculation or recourse to vernier scales, which seem to be most puzzling to most people. The wire to be measured is passed through the opening in the outer ring (which itself gauges to No. 10 standard wire gauge)



as shown in the figures (which show the two faces drawn to a scale of two-thirds full size) and drawn along one of the slots until stopped, the sizes being then shown at the points of contact of the wire with the sides of the slot which may be taken as opposite the centre of the wire. The various particulars as detailed on the instrument can thus be found at once.

ELECTRIC LIGHTING OF RAILWAY CARRIAGES.*

According to the experience of the Allgemeine Elektricitäts-Gesellschaft of Berlin, the simplest solution of the problem of the electric illumination of passenger carriages on railways is to be found in accumulators pure and simple. We give in the following lines the main features of a system of train lighting by electricity, as recommended by the Allgemeine Elektricitäs-Gesellschaft, chiefly on the basis of their experience on the Dortmund-Gronau-Enschede line. It is one of the Government railways of Prussia, about 60 miles long, leading from the very busy Dortmund district across the sparsely populated and quiet plains of north-west Westphalia, to the little town of Enschede, in the kingdom of the Netherlands, a few miles beyond the frontier. The plant has been running for more than a year. The cells employed are a special type of the accumulators of the "Accumulatoren-Fabrik Hagen," expressly made for the Berlin Company. A battery capable of feeding five 5-candle lamps for 40 hours would weigh 467lb., if discharged at 15 volts; if 22·5 volts are desired, the weight rises to 516lb.; if 30 volts, 591lb. The capacity should leave a reserve of about 10 per cent. or more. As a rule, discharge at 22 5 volts, requiring 12 cells, will answer best. A battery of this voltage, capable of feeding five 16-candle lamps for 8, 12, or 16 hours, would weigh 443lb., 516lb., and 562lb. respectively. If two lamps are desired for each compartment, two batteries with one lamp in each circuit would prevent a total extinction of the light if the battery should give out. Two 8 or 10-candle lamps replacing one of the 16-candle lamps just spoken of would require batteries weighing 754lb. and 886lb. respectively for 12 and 16 hours' service. The cells are put in cases not too heavy to be managed by one man, and these cases placed under the cars, like the ordinary gas reservoirs. As regards comparative weights, we are assured that the gas plant for five jets for 40 hours, would weigh about 1,000lb., whilst the equivalent electric plant, with a battery of 12 cells, would not weigh more than 640lb. Sometimes the cells are placed under the seats. The connections consist both of contact springs and of flexible cords. The discharged cells are exchanged and recharged in the lighting station. Where this is not feasible, the charging may be done on trucks on some siding, or with the cells in position, in which case the train has for hours to remain on that siding. This latter arrangement has not much to recommend it. A hint given in the pamphlet that the somewhat impoverished cells taken out of a first-class carriage might still do for a third or fourth class compartment, would hardly be welcomed in this country. For the German railways, the company reckon as minimum illumination admissible: one lamp of 16 candles for the first class, one of 10 candles for the second and third classes, and two lamps of 6 candles for the fourth class. That would enable the first-class traveller to read comfortably on any seat, and those in the second and third classes on four of the 10 seats; but two lamps of 8 or 10 candles would be more convenient for the first two classes, and proportionately better light for the other two classes as well. The lamps used on one line should, as much as possible, be of the same kind. The lamps of higher candle-power being more economical as regards current consumption, a good light can be given. Every battery needs a switch; the switches should be accessible to the guard only. It has not been found profitable to allow passengers to turn the light on and off as they like, although a good deal of light might occasionally be saved if the passengers were considerate. The Company do not want the passengers to touch anything but the screens. The state of the battery is indicated by voltmeters or by Aubert's hour-counters. The latter are very simple, but as they only show for how many hours the battery has been discharging, they can be used only with constant and uninterrupted supply. The leads are put under wood or encased in gas-piping; on the engine the wires are lead cables placed in gas pipes. Ample space is left everywhere between the two wires of each circuit. When desired, cistern, boiler, engine, dynamo, and cells are supplied, or a petroleum motor instead of the steam plant. These motors cannot be guaranteed free of smell. On lines where trains run backward and forward without being uncoupled, the whole accumulator plant may well be placed on a special truck. This system is in use on some of the Danish isles and on the west coast of Sweden. About cost, the pamphlet—besides offering estimates—does not say anything beyond stating that the electric lighting of the Dortmund-Enschede line does not cause any higher expense than the illumination by gas would cause, although the plant is neither large nor perfect as regards full utilisation of the machinery. On this line the ordinary officials look after the accumulators.

* From *Engineering*.

A HYDROSTATIC ELECTROMETER.

A new absolute electrometer, due to Signor G. Guglielmo, is described in the current number of the *Zeitschrift für Instrumentenkunde*. It consists essentially of a flat dish filled with a conducting liquid and communicating with a burette. The flat rim of the dish is provided with three insulating feet, upon which rests a metallic disc with a truly plane under surface. When electrified, this disc attracts the liquid and raises its level, and to restore it to its former level it is necessary to withdraw some of the liquid from the burette. The readjustment is controlled by a pointer which is mounted in the flat dish and touches the surface of the liquid from below. The amount of liquid withdrawn is weighed or measured, and this gives the difference of level, and hence the electric pressure. The apparatus is improved by having two flat dishes communicating with each other and with the burette, and by surrounding the second one with a circular tank serving as a "guard ring" and provided with its own burette. Signor Guglielmo recommends aqueous saline solutions or acidulated water as liquids, since mercury is too little sensitive. In another form of the apparatus, the saline solution is contained in a flat dish, and a short piece of wide glass tubing is immersed in it so as not to touch the bottom. A layer of insulating liquid of approximately the same density as water is poured over the glass tube, which is provided with a guard ring, and surmounted with the disc to be electrified. When that is done, the solution rises in the tube and falls outside it, the rise being the greater the less the difference of density between the two liquids.

CORRESPONDENCE.

PROLONGING THE LIFE OF ARC LAMP CARBONS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The "curious device due to Herr Francis Jehl," described on page 718 of your current issue, appears to be a mere modification of the Hazeltine "tip," patented in America and in this country a little more than four years ago; and it differs from the latter merely in mechanical details.

Werdermann was, so far as I know, the first to point out the advantages of shielding the hot ends of the carbon rods from contact with the air; and for this purpose he coated his carbons with fire-clay, lime, glass, and other materials. See his British Patent, No. 4,805 of 1876.—Yours, &c.,

Norfolk House, Norfolk-street, Strand, London, W.C., October 23rd. — J. G. LORRAIN.

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CONTRACTORS *versus* MANUFACTURERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Now that the electrical industry is so rapidly establishing itself in nearly every provincial town, one who has had considerable knowledge of the ups and downs of a contractor's life notes, with mingled feelings of amusement and annoyance, so-called installation branches being opened by all sorts and conditions of electrical engineers and manufacturers; but surely for a firm of cable manufacturers to take up wiring work must ultimately prove a fatal step as regards the interests of the shareholders of any such concern. There are firms whose names it is needless to mention, and there are others whose names would be conspicuous by their absence were I to trouble you with a list. Surely, when one takes into consideration the fact than in an ordinary installation of any size the value of the cables and wires alone is generally about one-third of the total cost, it must be apparent to those who understand the business that it is a most unfair and foolish step for any cable manufacturer to take up to any extent ordinary wiring work. I have a glaring instance brought to my notice of orders during the last 12 months of some thousands of pounds in value having passed by a firm of considerable repute in cable manufacturing solely on the ground of this suicidal policy which they appear to have adopted, and although there are numbers of other manufacturers of electrical apparatus who do installation work, yet at the same time a contractor knows that it is as a rule the cables which make up, as I before stated, about one-third the total cost of the job.

Now, with regard to manufacturers of electrical sundries, who are also in a number of cases contractors, this appears to me to be a decided step in the right direction, as it is on the accessories to a very great extent that the success of electric lighting depends. A manufacturer of electrical sundries who has installation work of his own can design and construct an article which he, from his own personal experience and that of his staff around him, knows to be thoroughly suitable and efficient; and when that article is produced it is to the benefit of the trade that he places it before them. There are a very large number of accessory manufacturers who supply goods, which, when bought by the unwary and installed on some unlucky client's premises, are found to be absolutely unsuitable for the work for which they are intended to be used, and, furthermore, in design are proved to be very faulty. Such goods are not supplied by the manufacturing contractor, and it is, therefore, as I have previously stated, no doubt a step in the right direction to see some of the largest firms busily developing the electrical accessories department. I might mention that the cost of sundries on an average installation amounts only to about one-eighth of the total. Thus it will be seen that the cable manufacturing contractor gets by far the largest chance of profit out of his contractor.—Yours, &c.,

CONSULTING.

Thermocouples with Liquids.—In *Wiedemann's Annalen*, No. 11, Herr August Hagenbach gives his results obtained with thermocouples consisting of a metallic wire whose terminals were inserted into a hot and a cold portion respectively of a saline solution. The combinations employed were zinc with its chloride and sulphate, copper and cadmium with their respective sulphates, and platinum with zinc, cobalt, copper and cadmium sulphates, copper and cadmium chlorides, and chrome alum. Of these combinations the most powerful was that of platinum with a 5·6 per cent. solution of cupric chloride. With one terminal at 20°C. and the other at 80°C., the E.M.F. developed was 0·146 volts, but it was less with either a higher or a lower percentage of the salt. On the whole, the behaviour of salts of the same acids was similar. In the combinations of the metals with their own salts, the E.M.F's developed increase more rapidly than the difference of temperature, the deviation being more marked with the more dilute solutions. Of the two modifications of chrome alum the green variety shows a decided superiority to the voilet variety.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

NEW BOOKS AND EDITIONS.

The 1894 Edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK contains 1,000 closely-printed pages, and several new and useful features have been added. The price of this edition of the Directory and Handbook is now 5s. post free; abroad 5s. 6d. *The 1895 edition is in active preparation.*

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free.

"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell, with this title, will be ready in a few days. It will contain the latest information respecting the application of electric energy to mining purposes, in which the author has hac much experience. The book is well printed, on good paper, and will contain nearly 250 illustrations, a large proportion of which have been specially made for the book. The price is 10s. 6d., post free 11s. (abroad 11s. 6d.). Orders can now be sent in.

"THE WORK OF HERTZ."—The lecture delivered by Dr. O. J. Lodge at the Royal Institution on June 1st is reprinted with corrections and additions, and many original illustrations, price 2s. 6d. net.

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. (abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application to the Publisher.

"ELECTROMAGNETIC THEORY," by Oliver Heaviside, is now ready, price 12s. 6d. (abroad 13s.). Prospectus on application.

"THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application to the Publisher.

"DRUM ARMATURES AND COMMUTATORS."—This book, written by Mr. F. Marten Weymouth, is also ready; price 7s. 6d (abroad 8s.). Prospectus on application.

TENDERS INVITED.—The Corporation of Sunderland invite tenders for wiring the Town Hall for the electric light, including the supply and fixing of cables, casings, switch and fuse boards, lamps, &c. Specifications, schedules, and general conditions may be obtained from the borough electrical engineer, and tenders must be delivered not later than 5 p.m. on Thursday, November 8th. Further particulars appear in our advertisement columns.

——— The Postmaster-General invites tenders for the supply of red fir telegraph poles, and for creosoting the same. Forms of tender, containing all particulars, can be had on application to Mr. Charles E. Stuart, Controller of Stores, Telegraph-street, London, E.C. Tenders have to be in by noon on Wednesday, the 31st inst.

TENDERS ACCEPTED.—The tender of Messrs. Willans and Robinson (Limited) has been accepted for two additional dynamos required for the electric lighting station at Whitehaven, the amount being £1,479.

——— The following were the tenders recently received by the Cardiff Corporation for wiring the Town Hall and Market Hall. As announced in our issue of September 28th, Messrs. Fergusson and Co. were the successful tenderers:—

	Town Hall.			Market.		
Knapman, Hodder and Co.	£994	18	6	£740	7	6
Sidney F. Walker and Co.	705	0	0	610	0	0
J. B. Saunders and Co.	678	0	0	483	0	0
W. and T. Robinson (Limited)	636	10	0	480	17	0
F. W. Ball and Co.	553	5	7	507	18	9
Fowler, Lancaster and Co. (Limited)	493	15	0	232	10	0
Clay Bros. and Co.	318	0	0	245	0	0
Maunsell, Mercier and Co.	264	0	0	198	0	0
Fergusson and Co. (accepted)	338	0	0	185	0	0

——— At Tuesday's meeting of the London County Council a report was received from the Main Drainage Committee that the Naval Construction and Armaments Company (Limited), the builders of the new sludge vessel, had asked to be allowed to sublet the installation of electric light on the vessel to Messrs. Paterson and Cooper. The Committee saw no objection to this, and accordingly recommended that the Naval Construction and Armaments Company (Limited) be allowed to sublet to Messrs. Paterson and Cooper the installation of the electric light on the new new sludge vessel, and that the conditions of the Council's standing orders with respect to sub-contractors be in this instance dispensed with. The recommendation was approved by the Council.

APPOINTMENT VACANT.—An advertiser invites applications for the post of assistant electrical engineer for a low-tension central station. The post is in connection with a municipal electric light supply station.

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APPOINTMENT.—The Town Council of Taunton have appointed Dr. J. A. Fleming consulting electrical engineer for the year ending September 1, 1895, at a fee of 25 guineas, with a fee of 10 guineas per visit to Taunton and travelling expenses.

———— Mr. Charles Turner, A.M.I.E.E., who is acting as resident engineer in charge of the work for the lighting of the parishes of St. Luke's and Clerkenwell, commences his duties under the Salford Corporation next week, at a salary of £250 per annum. Mr. Turner was previously with the Woking Electric Supply Company.

FORTHCOMING SALES BY AUCTION.—Messrs. Fuller, Horsey, Sons and Cassell announce in our advertisement columns that the modern electric lighting plant which has been previously offered for sale as a whole is now to be disposed of in lots under the hammer. The plant is quite as good as new, having only been used for a short period, and is only now to be disposed of because the owners require the space, and are taking current from the City of London Company's mains. The plant comprises 2 loco-type boilers, 3 Armington-Sims engines, 3 Elwell-Parker dynamos, 52 E.P.S. cells, and a number of measuring instruments, switchboard, and other apparatus. The sale takes place on Wednesday, November 28th, at one o'clock. Orders to view the plant at Billiter-buildings, Billiter-street, E.C., together with catalogues, may be obtained of the auctioneers, 11, Billiter-square, E.C., or of Mr. H. Cuthbert Hall, 46, Queen Victoria-street, London.

———— Messrs. Wheatley Kirk, Price and Goulty announce the sale by auction of an extensive assortment of machine tools, engineers' plant, loose tools, stores, &c., at the Union Foundry, Leeds. The auctioneers especially call the attention of machinery buyers to this important sale. Messrs. Shepherd, Hill and Co., the proprietors of Union Foundry, have earned a world-wide reputation for excellency in workmanship and design of their machine tools. The same firm of auctioneers hold a sale at Ditchingham, Norfolk, of silk-weaving, &c., plant, formerly in use by the celebrated old Norwich firm of Grout and Co. This sale takes place on Thursday next. The above sales by Messrs. Wheatley Kirk, Price and Goulty are in addition to the sale of engines, dynamos, cable, copper tubing, &c., which is to be disposed of at the Deptford Central Lighting Station, London, S.E., and of which a preliminary announcement appears in our advertisement pages.

RECENT SALES.—Messrs. Wheatley Kirk, Price and Goulty last week disposed of engineering plant, tools, &c., at Messrs. W. H. Allen and Co.'s York-street Works, Lambeth. A good company of buyers assembled from the provinces, and prices for machine tools ruled fairly high, some lots securing considerable competition.

BANKRUPTCY.—Under a receiving order granted against William David Gooch, electrical engineer, accounts have been furnished showing liabilities £4,365, with assets of uncertain value. The debtor states that for many years he was engaged as consulting engineer and otherwise to various undertakings at home and abroad. From about 1885 to 1888 he carried on business on his own account at 2, Victoria-mansions, Westminster, during which time the bulk of his present indebtedness was incurred in connection with speculative electrical contracts, &c. For about 12 months he was a partner in the firm of Lidstone and Co., of 2, Victoria-mansions, Westminster, engineers and patentees, but the partnership was dissolved in 1888. Since then he has had occasional engagements as consulting and electrical engineer, and for the last five months has been in the employ of an electric welding company, his fees or salary therefrom averaging about £6 per week. The debtor attributes his insolvency to losses in 1885-88 in connection with speculative electrical contracts and industrial patents in which he was interested, and partly to law costs, including, particularly, the liability to the petitioning creditors. The Official Receiver (Mr. H. Brougham) states that the debtor makes no proposal and has been adjudged bankrupt.

———— The first meeting of creditors of W. H. Akester, whose bankruptcy we noted last week, is to be held at the Bankruptcy Court, Carey-street, W.C., on November 2nd, at 11, and the public examination will be held at the same place on November 21st, at 11.

———— The discharge of F. Silvester, who traded as F. Silvester and Co., ironfounders, of Newcastle-under-Lyme, and who became a bankrupt last year, has been suspended for two years.

———— Under the failure of Messrs. Young and Buss, trading as wholesale ironmongers at Blandford-street, Baker-street, accounts have been furnished showing total liabilities £13,180, of which £7,249 is unsecured, and assets £4,483. The business is stated to have been founded fifty years ago by Mr. John Young, sen., who retired from the firm in the year 1882. Mr. H. W. Figg is trustee of the estate, with a committee of inspection.

———— At the Halifax Bankruptcy Court on Tuesday a receiving order was made in the affairs of Frederick Leopold Wovilliard-Rigg and Harry Ernest Scarborough, trading as Messrs. Wovilliard, Scarborough and Co., electrical and mechanical engineers, Wade-street, Halifax. The liabilities are stated to be about £500, and the assets £300.

LIQUIDATIONS.—A petition has been presented by the Bedford Engineering Company (Limited) for the winding up of J. G. Statter and Co. (Limited), and is down for hearing at the Royal Courts of Justice, Strand, W.C., on October 31st.

———— Mr. G. Sneath has presented a petition for the winding up of Dalziel's News Agency of America (Limited), which is set for hearing at the Royal Courts of Justice, Strand, W.C., on October 31st.

———— In the list of creditors of Barnard, Bishop and Barnards (Limited), Norwich, now being wound up, five German firms figure for a total of close upon £4,300, the remaining 40 British creditors claiming between them a total of £2,450.

RECEIVER APPOINTED.—Mr. Justice Stirling on Wednesday heard a motion asking, on behalf of the holders of a series of debentures, for the appointment of a receiver and manager of the British Electric Light Company (Limited). Counsel stated that under the terms of the debentures, if the principal money was not paid on July 31, 1894, the whole of the Company's undertaking and property should become specifically fixed and charged therefor, and that principal and interest should forthwith become payable. Payment of the principal had been demanded and had not been made, and the interest had been in arrear for a year. The Company did not appear, and his Lordship said there would be the usual order.

AGENCY.—Mr. G. Straus, of Queen Victoria-street, London, has been appointed sole agent for Great Britain and the Colonies of L. Barrière, of Paris, for metal screws, terminals, metal turning, &c.

BUSINESS CHANGES.—Owing to ill health, Mr. W. E. Hayne has been compelled to retire from practical work, and has disposed of his Brighton business to Mr. T. King, of Maidstone, who has appointed Mr. C. Rawlings as manager. Mr. Hayne has commenced practice as a consulting engineer at Ebor House, Bexhill-on-Sea.

DISSOLUTIONS OF PARTNERSHIP.—Messrs. Percy and Walter Andreae, carrying on business as electrical engineers at 85, London-wall, E.C., and at 179, Victoria-street, Westminster, S.W., and elsewhere, have dissolved partnership.

———— Mr. E. Smith has retired from the firm of the Electric Shot Firing Company, and the business will in future be carried on by the remaining partners, Messrs. T., W. A., and S. R. Malson.

REPORT.—Messrs. B. Verity and Sons request us to state that they are exceedingly busy, and have been obliged to put down additional machinery in order to cope with the pressure of orders.

THE "MELDRUM" FORCED DRAUGHT.—We hear that the Lancashire boilers for the new Bolton electric supply station are being fitted with the "Meldrum" forced draught apparatus. This system of steam-blast draught has been tried and found successful at several electric supply stations in London and elsewhere; and it has, we believe, proved a valuable feature in the boiler plant at times when it has been necessary to get steam up quickly, or to steam harder than the usual rate. Another feature of the "Meldrum" system is the readiness with which it can be adapted to the combustion of dust fuel and dry refuse, which it is difficult or impossible to burn in an ordinary furnace with natural draught. The ready control which can be exercised by the stokers over the draught, with the "Meldrum" apparatus, is of great service in regulating the variations in the productions of steam, especially where the load on the boilers is liable to sudden and frequent change.

RAMSAY'S ANTI-GROOVING GEAR FOR COMMUTATORS.—Several more or less successful attempts have been made at various times to devise a mounting for the dynamo brush-holder which will obviate the grooving due to the brushes on the commutators. The latest idea is that of Mr. Alex. Ramsay, who proposes to mount the brush-holders and rocker on a sleeve placed on an extension of the dynamo spindle, the sleeve having a screw thread cut on it to enable the position of the brush-holders to be varied longitudinally. When not required to shift along the screw sleeve, the rocker is held in a fixed position by a set screw which locks the rocker in any desired position. We believe the arrangement has quite recently been patented by Mr. Ramsay.

AUTOMATIC RECORDING INSTRUMENTS.—Mr. L. Casella writes to inform us that he has been appointed agent in Great Britain, the Colonies, and America, for Richard Frères' automatic recording instruments, concerning which an illustrated and descriptive catalogue is now ready.

ARC LAMP COMPETITION.—We have received the following communication from Messrs. Crompton and Co. (Limited):—"In these days, when the question of improved arc lighting is now so promi-

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nently before the public, it may interest your readers to know that we have been successful, with our new simplified Crompton-Pochin type of lamp, in obtaining the order for the street lighting of Edinburgh. Although a large number of makes of lamps were tendered for, only three were selected for trial, and of these our lamp was judged best suited for the purposes of the Corporation. The conditions of the competition were not limited to the comparative excellences of the lamps; but the question of the economical use of carbons was also taken into consideration. We believe this is the first time that a tender has been so carefully adjudicated on, so that the results in this case are especially gratifying to ourselves."

Plume Shades.—Messrs. Charles Ingle and Co. have now ready a price list of selections of plume shades designed by Miss Beatrice Devonport, samples of which were recently illustrated and described in *The Electrician.* It is difficult for ordinary wood or process block illustrations to do justice to these artistic arrangements of feathers, and we fear the illustrations given in the list are not calculated to attract notice, but so many elegant designs are possible with the material used that the shades will doubtless continue to have a large sale. They are supplied in a number of tints and colours, and combinations can be repeated for subsequent orders.

Screws and Terminals.—The Automatic Standard Screw Company, Halifax, send us a copy of their general stock list of screws, pins, terminals, &c., specially prepared for telegraph, electrical, and optical work, for which the Company have received several special awards. The Company keep large stocks of taps and dies, including the Whitworth, B.A., the Sellers', the common V thread, and others, and are prepared to execute orders for any pitch or diameter of screws. The list can be obtained by the trade on application.

Adelaide (South Australia).—The Corporation have been considering the question of the electric lighting of the city, and, it being understood that they were proposing to spend some £50,000 in laying down a central station plant, a deputation of citizens waited upon the Town Council on August 6th to lay before them reasons why this expenditure should not be proceeded with. It was urged that as the Gas Company had offered to reduce the price of gas, it was not advisable to incur such an outlay of capital for a possible saving of a few hundred pounds a year. The deputation were informed that the Electric Lighting Committee would reconsider the whole question. It is understood that the South Australian Hydraulic Power Company have submitted to the Committee a proposal to light the streets of the city by the electric current, giving a total light equal to 250,000 candle-power, against the 12,577 now derived for the public gas lamps, at the price now paid for gas, for a term of 21 years; the Corporation to have the option of purchasing the undertaking at the expiration of that time. The Company would also pay the Corporation a percentage on the net profit derived from private lighting. The Company say that they would be able to supply electrical energy at a cheap rate, and they could have their plant ready by the time of the expiry of the present gas contract.

Birmingham.—On Tuesday the Market Hall was lighted by electricity for the first time, the ceremony of switching on the current being performed by Mr. Councillor Parkes. The installation consists of 42 arc lamps with a total of about 50,000 candle-power, and the light is well distributed over the hall. The current is taken from the mains of the Birmingham Electric Supply Company, and will cost £507, and £25 for carbons per annum, against £522 previously paid for gas-lighting, the quality of which had been matter for complaint for some time.

Bootle.—The Town Council have resolved to apply for a Provisional Order.

Cartmel (Lancs.).—A public meeting was held at Cartmel last week to consider the advisability of laying an electric railway through the Cartmel Valley. Mr. John Hesketh, of Blackpool, was amongst the speakers, and it was pointed out that the railway would be of great service to the farmers and the inhabitants generally, and that the large waterfalls in the district could be utilised very cheaply and effectively for driving the dynamos, the current from which would also be available for electric lighting. The meeting, which was favourable to the ideas, was ultimately adjourned *sine die*, and in the meantime Mr. Ramsbotham, the convener, will endeavour to formulate a scheme for the carrying-out of the undertaking.

Chapel Lighting.—The first public building in Cheltenham to be wired for the supply of the electric current from the Corporation mains is Salem Chapel, the installation in which will be equivalent to 270 8-c.p. lamps.

Coventry.—The Town Council have decided upon 6d. per unit as the charge for the electric current.

City of London.—The Commissioners of Sewers have referred to the Streets Committee the question of the advisability of including Finsbury-circus among the main streets for electric lighting purposes.

Ealing.—The Surveyor reported at the meeting of the Local Board last week that application had already been made for 2,500 private lamps, half the number estimated for.

Hanley.—At the meeting of the Town Council, on Tuesday, it was reported by the Electric Lighting Sub-Committee that the applications for the electric current from private consumers had been so numerous that, if the markets were electrically lighted, all the available energy would be taken up. They therefore recommended the tenders for an additional engine and alternator to be obtained, and that the electrical engineer be requested to submit at an early meeting a scheme for the extension of the plant and mains for supplying the electrical energy likely to be required within the area of supply, that part of the scheme relating to the compulsory area being submitted for first consideration. The sub-committee also recommended that the town-clerk be requested to write to the Brush Electrical Engineering Company, requiring them to forthwith put the electric lighting plant and machinery into proper working order to the satisfaction of the borough surveyor in accordance with the terms of their contract. In moving the confirmation of these minutes, Alderman Shirley said the extent to which electrical energy had been applied for was simply phenomenal. All the power they were at present able to supply had been asked for, and the committee were, therefore, compelled to take steps with a view of providing additional plant and increased energy. The Board of Trade required them to retain surplus energy to the extent of 20 per cent., so that it was compulsory for them to provide extra power if they wished to meet the demands upon them. Mr. A. Wood, in seconding the motion, said it would have been better if the committee had got the existing plant out of the hands of the contractors before taking steps to provide additional plant; but, seeing that they had not sufficient power to light their markets now the wiring was complete, the committee thought it desirable to proceed with obtaining further machinery without delay. The motion was then agreed to.

Hillgrove (New South Wales).—An electric plant has been supplied to this town by the Crompton Electric Supply Company of Australia. The dynamos are driven by turbines, the water-power of the Gara Falls, situated about six miles away, being utilised. At present current is only to be supplied for the electric lighting of the public streets; but the Company hopes shortly to be in a position to supply it for both private lighting and power purposes. It is expected, when the latter is available, that the low-grade mines in the district may be worked profitably.

Islington (London, N.).—The work in connection with the laying of the mains for the electric light was commenced on Wednesday.

Leeds.—The temporary electric lighting of the grounds and picture gallery at Temple Newsam during the recent visit of the Duke and Duchess of York was placed in the hands of Messrs. Maunsell Mercier and Co., of Manchester.

Liverpool.—The City Council are to be asked at their meeting to-day to open up negotiations with the Liverpool Electric Supply Company (Limited) for the purchase of their undertaking.

Loans to Young Tradesmen.—There is a City of London charity known as Wilson's Loan Charity, which grants to young tradesmen under the age of forty years carrying on business in the City of London, or within five miles, and who have been in business one and not more than three years, and have succeeded to an extent to justify it, the loan at 2 per cent. interest per annum of from £100 to £300 for a period of five years. Three unquestionable sureties are required for £100, and four for larger amounts. Personal application has to be made to the Clerk of the Trust, Chamber of London, Guildhall, E.C.

Luton.—The Highways and Lighting Committee having reported favourably to the last meeting of the Town Council on the proposal to apply for a Provisional Order, a special meeting of the Council is to be held to decide the question.

Madras.—The Government has sanctioned an estimate of Rs.17,230 for lighting the Arkonam railway station and yard by the electric current.

Mill Lighting.—The Seebpore and Howrah mills, Calcutta, are to be electrically lighted. The installation in each case will consist of 1,300 8-c.p. incandescents, current being generated by three E.C.C. dynamos, each coupled direct with a steam engine. The tweed factories of Messrs. Gibson and Longair, Selkirk, and of Messrs. Dalziel, of Walkerburn, are also being fitted up for the electric light.

Monmouth.—The Town Council in committee have reduced the number of proposed sites for the works required for the combined drainage and electric lighting scheme to two—the Osbaston farm

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and Brooksholme. The engineers state that they will be able to complete the works in about a year from the time of commencement, which will be undertaken immediately the sanction of the Local Government Board has been obtained.

PADDINGTON (LONDON, W.)—The Guardians have decided to light their infirmary by electricity.

ST. LUKE'S (LONDON, E.C.).—The work of laying the mains for the parish electric light supply was commenced on Wednesday.

TECHNOLOGICAL EXAMINATIONS.—The following list of prize-winners is extracted from the Report of the Examinations Department of the City and Guilds of London Institute, just issued :—

Electric Light and Power Distri ution.

Eborall, Alfred Cecil, 3rd Ordinary, £1 (Goldsmiths) and Bronze Medal, Finsbury College, London.
Ferris, Thomas Howard, 1st Honours (Sec. II.), £3 (Goldsmith's) and Silver Medal, Merchant Venturers' Technical College, Bristol.
Hawkins, Walter, 1st H. (Sec. III.), £3 (Goldsmiths) and S. M., Finsbury College, London.
Lewis, Philip Marpole, 2nd H. (Sec. I.), £3 (Goldsmiths) and B. M., Finsbury College, London.
Pinkerton, Andrew, 2nd H. (Sec. II.), £3 (Goldsmiths) and B. M., City and Guilds Institute, Examinations Department, London.
Sheardown, Percy S., 2nd O., £2 (Goldsmiths) and B. M., Finsbury College, London.
Shepherd, George M., 1st O., £2 (Goldsmiths) and S. M., Goldsmith's Institute, London.
Weymouth, George Andrew Philip. 2nd H. (Sec. III.), £3 (Goldsmiths) and B. M., Municipal Technical College, Derby.

Electro-Metallurgy.

Freeman, Frederick James, 1st O., £2 (Armourers and Brasiers) and S. M., Municipal Technical School, Birmingham.
Harris, Edward Victor, 3rd O., B. M., Municipal Technical School, Birmingham.
Weightman, Alfred Thomas, 1st H., £3 (Armourers and Brasiers) and S. M., City and Guilds Institute, Examinations Department, London.
Wilson, John H., 2nd O., £2 (Armourers and Brasiers) and B. M., Municipal Technical School, Manchester.

Mechanical Engineering.

Amor, Edward Robert, 4th O., £1 (Skinners) and B. M., Technical Schools, Devonport.
Berry, Frederick, 3rd H., £2 (Skinners) and B. M., Municipal Technical School, Manchester.
Cairns, Charlie Waldie, 2nd O., £2 (Skinners) and B. M., School of Science and Art, Newcastle-on-Tyne.
Honiball, Charles Roland, 2nd H., £3 (Skinners) and B. M., School of Science, Liverpool.
Jopling, Frederick William, 3rd O., £1 10s. (Skinners) and B. M., School of Science and Art, Newcastle-on-Tyne.
Parker, John, 5th O., 10s. (Skinners) and B. M., Woolwich Polytechnic, London.
Tod, James Niebuhr, 1ft O., £2 (Skinners) and S. M., Heriot-Watt College, Edinburgh.

Telegraphy.

Booth, Augustus C., 1st H., £3 (Pewterers) and S. M., Telegraphists' School of Science, G.P.O., London.
Frazer, William Ross, 2nd H., £3 (Pewterers) and B. M., Technical and Art School, Inverness.

Telegraphy and Telephony.

Eborall, Alfred Cecil, 1st O., £2 (Pewterers) and S. M., Finsbury College, London.
Mackenzie, John Donald, 2nd O., £2 (Pewterers) and B. M., Glasgow and West of Scotland Technical College, Glasgow.
Smith, David, 3rd O., £1 (Pewterers) and B. M., Robert Gordon's College, Aberdeen.

Telephony.

Frazer, James, 1st H. £3 (Pewterer's Company), and S. M., Robert Gordon's College, Aberdeen.
Whillis, Charles, 2nd H., £3 (Pewterers) and B. M., Telegraph School, Newcastle-on-Tyne.

Typography.

Jones, William Charles, 1st O., £2 (Cordwainers) and S. M. (*Electrician* Office Apprentice, 5th year), Borough-road Polytechnic, London.

THE RATING OF ELECTRIC LIGHTING COMPANIES.—The Birmingham Electric Supply Company (Limited) on Monday appealed at the Birmingham Quarter Sessions against a poor-rate assessed on March 30th last by the Churchwardens and Overseers of the poor for the parish of Birmingham. Counsel for the Company said that it was first rated in 1892 at £825 gross and £700 net. In 1893 a simple principle of doubling was applied, and the gross was raised to £1,650 and the net to £1,400. In the present year the overseers had not doubled the amount; but they suggested adding 50 per cent. on, and raising the gross to £2,475, and the net to £2,100. The case was a very important one to the Company. Up to the present no effort had been made to rate an electric company on a really scientific basis, and it was obvious in this case that the overseers of Birmingham had not rated upon any ordinary principle which should apply generally to the rating of companies. They had applied a rough and ready principle of taking 15 per cent. off the gross to arrive at the net, but this was not a principle which should apply to this Company, which was more like gas or railway companies than anything else. It was maintained that the total rateable figure, on the most liberal way of regarding it from the Overseers' point of view, amounted to a sum of £1,400. Expert evidence was then given. Counsel having addressed the Recorder on behalf of the Overseers, submitting that the assessment made by them was perfectly justifiable, the Recorder before adjourning the hearing of the case, said that he had formed opinions, to which, however, he did not bind himself, and which were subject to what was to be said on both sides. He had come to no conclusion in regard to the accumulators which had formed one of the principal points of dispute. Of the other disputed items he should strike out the tenants' income-tax, and also the contracting account. He did not think he could allow anything for the compulsory termination of concession. Of course these decisions were not final.——On Tuesday morning it was announced that the Overseers and the Company had come to terms, and the appeal was withdrawn. The terms of settlement were not made public.

WALTHAMSTOW (ESSEX).—The Local Board have decided to apply for a P rovisional Order.

WHITEHAVEN.—Mr. Rienzi Walton held an inquiry at the Town Hall, on behalf of the Local Government Board, in reference to an application by the Whitehaven trustees for sanction to borrow an additional sum of £6,304 for electric lighting works. Mr. Brodie, the surveyor and engineer to the trustees, made a detailed statement supporting the application, and there was no opposition.

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

October 12, 1894.

19,423. J. H. DUNN. London. Improvements in the construction of retorts or furnaces for the production of gases by the use of electricity.

19,443. P. T. LETCHFORD. London. Improvements in the electrical production of musical notes.

19,444. G. G. STOUT. London. Improvements in electric arc lamps.

October 13, 1894.

19,481. J. W. EWART. London. An apparatus for heating water by electricity.

19,508. C. P. C. CUMMINS and J. L. GOLDING. London. Improvements in cut-outs for use in electric circuits.

19,517. R. WENDER. London. An improved apparatus for indicating the lamp-hours of electric lamps.*

October 15, 1894.

19,560. F. H. ROYCE. Manchester. Improvements in the means of transmitting power of gas engines, steam engines, and the like, for driving dynamos and other apparatus.

19,585. P. A. MOUGIN. London. Improvements in electric arc lamps.

October 16, 1894.

19,603. C. L. CLARKE and W. P. THEERMANN. Manchester. Improvements in ceiling roses, cut-outs, and such like, for electrical purposes.

19,605. B. ANDREWS. London. Improvements in electrical conductors and joints therefor.

19,668. A. F. B. GOMESS. London. Improvements in carbons or electrodes used in arc lamps for electric lighting.

19,681. W. MILLER. London. Improvements in coin-freed telephonic apparatus.

19,702. G. E. HEYL. London. Improvements in accumulators.

19,710. J. A. TIMMIS. London. Improvements in dynamo-electric machines and motors.

October 17, 1894.

19,733. W. HEARN and C. R. GATEHOUSE. London. An electric clock.

19,742. W. P. THEERMAN. Manchester. Improvements in electrical switches.*

19,764. J. HOPKINSON. London. Charging electric accumulators.

October 18, 1894.

19,807. H. OPPENHEIMER. London. Improvements in and connected with electric door contact.

19,842. L. H. CLINE. Wallsend-on-Tyne. Improved electric storage fuse distribution box, also relating to single and double-pole fuses or cut-outs.

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19,868. W. A. Thoms and W. H. Burgum. London. An improvement in electro-deposition of an alloy of zinc and cadmium.

19,889. C. T. Praed and P. R. Allen. London. Improvements in electric arc lamps.

October 19, 1894.

19,924. J. W. Hoyland and W. H. Sturge. Birmingham. Improvements in the combination of electric light with metallic bedsteads.

19,934. G. Hubner. London. New or improved process for producing a porous mass specially suitable as a filling material for electric accumulators and a new or improved accumulator adapted for the use of such filling material.*

19,966. H. Birnbaum. London. Improvements in means or apparatus relating to the supply of electrical energy to portable electric lighting apparatus.

SPECIFICATIONS PUBLISHED.

Note.—All Specifications can now be obtained at the uniform price of 8d. each.

1893.

15,971. Anders and Kottgen. Electro-magnetic motor.
18,150. Doubleday (Sussmann). Secondary battery lamp for mines, &c.
21,435. Schindler. Electric heating bodies, &c.
21,966. Beal. Electrical drop indicator.
22,515. Darrah and Metcalfe. Clips for electric conductor casings.
22,960. Wilkinson and Penson. Controlling electrical devices.
23,239. Lewis. Arc lamps.
23,308. Hutin and Leblanc. Continuous current dynamos.

1894.

4,849. Day and Allmark. Supporting and protecting electrical conductors.
9,974. Thompson (Coffin). Heating metals electrically.
14,634. Buell. Galvanic battery.
16,400. Newton and others. Generating and applying electricity to the body.

COMPANIES' MEETINGS AND REPORTS.

Brazilian Submarine Telegraph Company (Limited).

The forty-second ordinary general meeting of the shareholders of this Company was held on Wednesday, at Winchester House, under the presidency of Sir John Pender, G.C.M.G., M.P.

The SECRETARY (Mr. Richard Collett) read the notice convening the meeting, and the report of the Directors was taken as read.

The CHAIRMAN: The receipts for the half-year ended June 30, 1894, were £94,679; for the previous half-year they were £96,262, showing a small decrease of £1,583. The receipts from messages show a decrease of £1,393, and those from miscellaneous receipts, from interest, rents, and transfer fees, show a decrease of £190, resulting in a net decrease, as before stated, of £1,583. The decrease in the interest results, of course, from the fact that the rates allowed by the banks on deposit accounts have during this year been so very low. That we can all understand. With respect to the small decrease in message receipts, I may say that, having regard to the further fall in the value of the Brazilian currency, the loss would have been larger but for the fact that we carried some 40,000 words more than in the previous half-year. This shows a satisfactory growth of traffic with South America, and that notwithstanding there are competing lines which succeed more or less in obtaining part of the traffic, yet the work performed by the Company continues to grow. The sending of news telegrams for publication in the daily Press is increasing, and the companies interested are desirous of affording the necessary facilities whereby this traffic may be fostered. The messages are in plain language, and although carried at low rates, deserve special attention and encouragement. As compared with the corresponding half-year in 1893, the income from messages shows a decrease of £12,181; but this is fully accounted for when we consider the different values of the Brazilian currency collected in the respective half-years. In the June half of 1893 the average rate per milreis was 12½d., and in the half year under review 9½d. While speaking of exchange I may as well treat it up to date. During the current half-year the rate has reached 12½d. and is now 11½d. This welcome improvement is due, I believe, to the much more settled state of political affairs in Brazil and to the blessing of a splendid coffee crop. We must hope the improvement will continue; if it does our business and that of other companies who have, like ourselves, embarked large sums of capital in Brazil will benefit thereby. Leaving the credit side of the revenue account and taking the expenditure, we find that the total for the June half-year was £20,269, and for the previous one £24,284, being a decrease of £4,015. This decrease is practically due to our having been fortunately free from any interruptions of our cables and the consequent expense of repairs. Our freedom from interruption, I am pleased to say, has continued to the present time. Analysing the items of expenditure, I find that the general expenses of the London offices were £2,998 for the period under review, as compared with £2,761 for the previous half-year, or an increase of £237, of which £103 appears under the head of salaries, owing to a re-arrangement of salaries, which I explained fully at a previous meeting; £90 is for travelling expenses to the Continent, incurred in protecting the interests of the Company; £50 in office and general expenses, and £99 for advertising and maps for our customers. On the other hand, there is a decrease of £112 in respect of furniture and office fittings, the expenditure on this head in the six months to December, 1893, being of quite an exceptional character. The working expenses at stations are practically alike, being £13,026 for the last half-year and £13,064 for the previous one. This shows a decrease of £38. This small sum is the difference between a number of increases and a number of decreases in the various heads which appear as working expenses at stations. I can give them in detail if the shareholders wish it; but I think I have given you as much detail as will interest you. In the remaining items of expenditure there are decreases under the following heads: Special legal expenses, £148; staff assurance, superannuation, and pension funds, £87; extensions at St. Vincent, £730; repair of cables, £4,950, and increases in the following: Insurance for spare cable, £13; legal, actuarial, and other expenses of instituting the pension and superannuation funds, £230 (this is an exceptional expenditure, and will not occur again); and expenses of special mission to Brazil (£1,458, to this matter I shall refer again a little later on). That, I think covers the items in the revenue account, the final comparison, being that the result of the working for the June half-year is £2,432 better than that of the previous one, that sum being the difference between the decrease in the expenditure, £4,015, and the decrease in the income, £1,583. An interim dividend at the usual rate of 1½ per cent. has been paid in respect of the March quarter, and £42,501 remains to be dealt with. Of this the Directors have transferred £15,000 to the reserve fund, and now recommend the declaration of a final dividend of 3s. per share, together with a bonus of 1s. per share, making a total dividend of 6½ per cent. for the year. This distribution is the same as that made for the last two years. The balance then remaining to the revenue account, £1,501, is carried forward. Now, gentlemen, I think that is a very satisfactory statement to put before you. Every department of trade, every interest connected with foreign countries, has been more or less suffering. We, however, continue to pay you to-day what we have been paying you, and I think we have to congratulate ourselves that we are able to make such a statement as this. The reserve fund amounts to £692,269. The contributions from revenue account during the last 18 months have only amounted to £42,000, but with the interest on investments the fund stands at a satisfactory figure; but a large and growing reserve is absolutely necessary. There are two cables to be maintained and, sooner or later, renewed; and repairs are likely to come heavier as cables age. One is over 20 years old, and the other 10. Having built up a good reserve, the Directors are enabled to declare the usual dividend and bonus, although the profits are much less than those of a few years back. Gentlemen, I have to throw a little cold water on the statement put before you; but in making my remarks as to our smaller income now, my object is to show you that, notwithstanding this small decrease, we are maintaining our dividend as well as increasing our reserve fund, if not as largely as I should desire to do. Having regard to the wear and tear of the shore ends at the various places where our cables land, and to be prepared with sufficient cable for the repairs and renewals which must be undertaken from time to time, your Directors have had 90 miles of cable manufactured during the half-year, costing about £16,000. The Pacific and European Telegraph Company, as you know, is one of our "feeders" now, and I am glad to say that it is working thoroughly well. The traffic is growing, and I think that it will continue to do so in view of the fact that we are giving a very excellent service. We are not disposed to boast unduly. We think that "slow and sure" is the better policy, but I think you will be satisfied when I tell you that since we have established the line we have already doubled the traffic, and I trust it will continue to grow in the same proportion in the future. You are also aware that we have got £40,613 in the balance-sheet as paid on account of 5,556 shares of £10 each in the Azores Company. I am not yet in a position to make definite remarks on this matter, but I am in a position to say that the Eastern Company have secured a concession from the German Government which will not only give us special advantages in obtaining and carrying the German traffic to and from America, but also over what I call our Eastern system as well; and the Eastern Company not only have this for 40 years, but they have accompanying it—which is always a very satisfactory thing in the beginning of a company—a subsidy from the German Government. By-and-by you will hear something more of this; but meantime I am very pleased to say that the Eastern Company have got this subsidy. They have got the control, it is in friendly hands, and will be used in a just and fair spirit. You will have observed that the statements which I have put before you have been very carefully prepared. We want you to know all that we think you are entitled to know, because the more confidence that can exist between the shareholders and the Directors, the more prosperous and more successful the concern will be. That is our policy; it has been my policy in connection with submarine telegraphy ever since I have had anything to do with it. I have found it successful, and I am too old to change now. I mentioned last time that we were sending out a commissioner or agent to Brazil. We sent out a gentleman to come to an understanding with the Brazilian Government with respect to our cable, the concession in connection with which was for twenty years and was about to expire. They thought it had expired, but we think differently. As, however, I have to be very careful in every word I utter at the present time, I have put my words and thoughts on paper, so that you will know precisely the opinions we have formed, and will be able to judge how far they are correct or not. At our last meeting I told you that the exclusive privilege under our concession granted by the Brazilian Government would shortly expire, and that it was our intention to send out an agent with a view to obtaining from the Government satisfactory arrangements for the future. Under the concession the Brazilian Government undertook not to concede the establishment of another cable between Brazil and Europe or Brazil and Portuguese possessions for 20 years; and the cables and landlines and their working were not subject to any contri-

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bution or special tax. The Brazilian Government declare the privileges under the concession expired in August, 1892, and from January 1st last imposed a tax upon the traffic passing by the Company's cables. Your Directors were advised upon these points, and to safeguard the interests of the Company, they protested against the decision of the Government, but with a view of coming to a friendly and satisfactory arrangement and understanding with the authorities in Brazil, they decided to send out a special representative to Rio Janeiro. This gentleman was instructed to negotiate with the Government for arrangements under which the interests of Brazil and of the submarine cable companies would be consolidated and protected. The time of the visit was unfortunately inopportune, as, consequent upon the civil disturbances which had only been suppressed a short time before, the Minister to whose department the business belonged was fully occupied with more pressing affairs, and did not afford our agent the opportunity of bringing forward his business. Your Directors confidently hope that at an early date, when Brazil has settled down to a state of peacefulness and prosperity, the negotiations may be resumed with advantage to all concerned. It is not your Company alone that is interested in maintaining friendly and equitable arrangements with the Brazilian authorities. Our partners—or, rather, our allies in the "pool," the Western and Brazilian Company—are, I may say, equally concerned. One company cannot be affected by the imposition of taxes on its traffic without the other participating in the charge. Your Directors have, therefore, a responsibility imposed upon them of safe-guarding interests beyond those of their own shareholders, and this is a duty they desire to perform to the satisfaction of all. Speaking of the Western and Brazilian Company, I cannot help thinking that two companies so closely allied by a joint-purse agreement having some forty years to run, each company continuing and completing the service of the other, should be more closely allied than they are. With the present separate directorates and establishments, differences of opinion and policy must from time to time arise. With a closer alliance by fusion the differences would be prevented, and many important economies effected. Personally, I feel strongly that it would be in the interests of both bodies of shareholders if their separate companies were made one. This is an important matter, and I think the sooner it is dealt with the better for all concerned. That has been my idea for many years, and it is my idea to-day, but you know the difficulties in bringing about even friendly alliances between two boards. This, however, is an important question. I know there are reasons on the part of the Western and Brazilian Company which keep them back for the moment, but, at the same time, I know that both the president and the managing director of that company have held the same opinion that I hold to-day. I hope, therefore, that the time is not far distant when this question will be dealt with in such a spirit of fairness that the shareholders in the respective companies will see that it is to their interest to support any movement made in that direction. I have now, gentlemen, in a very calm, and, I hope, very clear way, given you a considerable amount of information as to the working of this concern in the last six months. We can go on very well even if no arrangement is come to, but if we can go on better with an arrangement, why should not that arrangement be made? I beg to thank you for the attentive way in which you have listened to the remarks which I have addressed to you to-day, and I now beg to move—

"That the report of the Directors and the accounts to June 30, 1894, now submitted, be approved and adopted, and that a dividend be now declared of 3s. per share, making, with the interim dividends already paid, a total dividend of 6 per cent. for the year, and also a bonus of 1s. per share, making in the aggregate a distribution of 6½ per cent. in respect of the profits for the year ended June 30, 1894, the said dividend and bonus to be respectively free of income-tax."

The Hon. W. ST. JOHN BRODRICK, M.P., briefly seconded the resolution.

The CHAIRMAN then expressed his readiness to answer any questions which the shareholders might desire to ask; but no one rising to address the meeting, he put the motion in the usual manner, and declared it carried unanimously.

Mr. FREDERICK YOULE next proposed the re-election of Sir John Pender as a Director of the Company. The shareholders, he remarked, knew Sir John Pender so well that they would be only too glad to continue his services as Chairman of the Company.

Lord SACKVILLE A. CECIL seconded the resolution, which was carried unanimously.

The CHAIRMAN, in acknowledging his re-election, expressed his satisfaction at retaining the shareholders' confidence. They might rest assured that he should endeavour by his work to deserve its continuance. He then proposed the re-election of the Hon. W. St. John Brodrick as a Director of the Company.

Mr. J. DENISON PENDER seconded the motion, which was unanimously agreed to.

Mr. GEORGE C. SCRUTTON afterwards proposed the re-election for the ensuing year of the auditors, Messrs. Deloitte, Dever, Griffiths and Co., and Messrs. Gane, Jackson and Jefferys, at a remuneration of £50 for each firm.

Mr. EDWARD PINNOCK seconded the motion, which was unanimously adopted.

The CHAIRMAN then intimated that that terminated the business, and he expressed a hope that they would meet many times again in as auspicious and satisfactory circumstances as on the present occasion.

On the motion of Mr. SCRUTTON, seconded by Mr. JOHN NEWTON, a cordial vote of thanks was passed to the Chairman and Directors.

The CHAIRMAN: On behalf of my colleagues and myself, I beg to thank you. While I like now and again to have a little exchange of opinions at these meetings, you probably could not have paid us a greater compliment than you have done to-day, by accepting all that we have put before you without even a remark or objection of any kind. We shall endeavour in the future to maintain this close communion, which it is so desirable should be observed between shareholders and directors, and I hope that it will be attended with the same success in the future as it has in the past.

The proceedings then terminated.

Westminster Electric Supply Corporation (Limited).

An extraordinary general meeting of the shareholders of this Corporation was held on Wednesday at the office, Eccleston-place, Belgravia, S.W., for the purpose of considering a resolution to increase the capital. Lord Suffield (Chairman) presided.

The SECRETARY (Mr. Frank Iago) read the notice calling the meeting.

The CHAIRMAN said: I have not a great deal to say on this occasion, but I may take the opportunity, first of all, of informing you that the prospects of the Corporation are very brilliant. We have passed through a great deal of difficulty, as many of you are aware, and it is now apparent that we have succeeded in our efforts. With regard to the raising of the proposed further capital I may explain that the Directors have no intention of applying any portion of it towards additional buildings. That is not at all requisite, nor do we apprehend such will be the case for a very long time, and perhaps never. But, in consequence of the very considerable increase which has taken place in our business, it is only natural that we should require extra plant, extra meters, and extensions of our mains, and of course there are also other large expenses which we must meet. Therefore, gentlemen, it is with great confidence I shall ask you directly to agree to the increase of our capital by £100,000. It is not proposed to issue the whole of this new capital nor any large part of it at once; but we must have capital, and we shall issue it according to our requirements. With the view of informing you what strides are being made in our business, I may just give you a few statistics. On December 31, 1893, the lamps on circuit numbered 131,565, of eight candle-power; now they have reached the total of 158,000. About 9,000 more are waiting to be connected, and applications are still being received at the same rate. I think you will admit that as the business grows in this enormous ratio it is necessary we should have more plant. I may say that we propose to give the existing shareholders the opportunity of taking up the new shares, supposing, of course, that you agree to the proposed increase of capital. When this is done the Board will consider the amount it is at present advisable to issue, and then communicate with the shareholders as to the terms and invite subscriptions from them. I now beg to move—

"That the capital of this Corporation be increased from £300,000 to £400,000."

Mr. E. BOULNOIS, M.P., seconded the resolution.

Mr. A. TOOTH inquired if it were proposed to cover any new ground?

The CHAIRMAN: No, we do not propose to go over any new ground. That is to say, it is not intended to go to Parliament for powers to go outside our present area.

Mr. TOOTH asked if the £100,000 would be issued in shares or debentures, and at what price.

The CHAIRMAN: It will be issued in shares, and the price will be determined upon later. We are not yet in a position to know exactly how much we shall require; but at the confirmatory meeting, which will be held in about a fortnight, we shall be able to give that information.

Mr. KEENLYSIDE inquired whether, supposing they decided upon asking for £50,000 of capital, 50,000 fully-paid shares would be issued, or whether 100,000 partly-paid shares would be offered for subscription?

The CHAIRMAN: Whatever proportion of shares is issued will be fully paid.

A SHAREHOLDER asked if that would not make a difference to their Stock Exchange quotation.

The CHAIRMAN: We have the best authority for stating that the gentlemen of the Stock Exchange do not object.

A SHAREHOLDER ventured to hope that the Board would see their way to issue the shares at par.

The CHAIRMAN: I am sure I need not say, without pledging myself or the Board in any way, that seeing the increase which has taken place in our business, you may look forward to a better dividend than you have had; but with regard to the issue of the shares at par, I want to say that we are hoping to create an absolute reserve fund. You are aware we have our depreciation fund, and certain other funds already: but we are desirous of having an absolute reserve, and I think it will be more prudent if a small premium is made with which to form the nucleus of such a reserve fund.

The resolution was then unanimously agreed to.

A vote of thanks to the Chairman terminated the proceedings.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The Directors of this Company have decided, after placing £2,000 to the reserve fund and £5,000 to the debenture redemption fund, and subject to audit, to recommend at the forthcoming meeting a dividend at the rate of £2 per cent. per annum, free of income tax, for the six months ended June 30th last, carrying forward £5,630. This dividend will be payable: 3s. per share to the ordinary shares, and 3s. per share to the preferred ordinary shares. The transfer books will be closed from November 6th to 16th inclusive.

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Venezuela Telephone and Electrical Appliances Company (Limited).

The ordinary general meeting of this Company was held on Tuesday at the offices, 37, Lombard-street, under the presidency of Sir Douglas Fox.

The SECRETARY (Mr. J. Simpson) read the notice convening the meeting, and the report of the Directors was taken as read.

The CHAIRMAN: Gentlemen, it becomes my duty to again address a few words to you with respect to the progress of this Company. This is our fourth annual meeting, and I am glad to feel that it is unmistakably the most satisfactory report we have been able to present to you since the initiation of the Company. You have only got to look at the second paragraph to see at once the cause of our progress being satisfactory. Our profit during the year has amounted to £7,415, as against £4,143 last year, and the sum actually earned during the year—striking out all question of balances—amounts to £2,735, showing that we are now established upon a firm, and I trust it will prove to be a regular, basis of fair income, enabling us to make a proper return not only to our debenture-holders, but also to our shareholders. I am glad to tell you that we have to-day the great advantage of the presence here of our much esteemed manager, Mr. Wallis. He has come home for a little well-earned rest, and we have taken the opportunity of asking him to attend here and say a few words. I do not propose, therefore, to trouble you by duplicating the remarks which he will make with reference to the actual working details in Venezuela; but it is only fair to him to point out that since he has taken charge of the management of the Company, there has been a substantial reduction in the operating expenses there. We find that while the business has increased from £18,444 last year to £21,284 this year, the operating expenses are actually less; and I believe that with the efforts which Mr. Wallis is still making, we may hope for, at any rate, a moderate decrease in the working expenses in the future. This year they work out at 56 per cent. of the gross receipts, against 60 per cent. last year. I should like to point out one other matter in the accounts. You will observe that our capital is represented by £70,000 in shares, £70,000 of First Mortgage Debentures, and £12,900 of Second Mortgage Debentures, making a total of £152,900; and if you turn to the other side of the account you will observe that this exactly represents at par the amount expended—that is to say, the cost of the property, the stores and materials at Caracas, and the cost of issuing the two sets of debentures. Those four items together amount to £152,000, and, therefore, the expenditure is now represented exactly by the par value—the nominal value—of our securities. I am quite sure that we are very much indebted for the good results we have obtained to the arrangements made by our friend Mr. Philipps, when he went to Venezuela. He has been there twice, but his second visit was especially fruitful of good results, and he then laid down with Mr. Wallis a plan of operations, which has been very loyally carried out by Mr. Wallis and our excellent staff under him. I think we have reason to congratulate ourselves as to the way in which the business of the Company has been carried on during the year under review. We are glad to believe that our shareholders across the water, who are very considerable in number, take an active interest in our work, and I believe they are represented here by a gentleman from Holland, whom we very heartily welcome. We believe that his presence here will encourage us all in the endeavour to do what we can to serve the interests both of the Dutch and the English shareholders, which, after all, are identical. I do not think I need take up your time any longer; but before I move the resolution which I shall propose I will ask Mr. Wallis to say a few words.

The GENERAL MANAGER (Mr. Edgar A. Wallis) said that he need not touch on the financial result of the year's working; but he thought a few local facts and features connected with their enterprise in Venezuela might be of interest to them. The number of subscribers connected at June 30, 1894, at Caracas was 1,593, being a gain during the year of 195; at La Guaira the number was 221, being an increase of 7; at Valencia the number was 278, being an improvement of 21, and at Puerto Cabello the number was 125, or an increase of 16. The total increase in the number of subscribers on June 30th last was, therefore, 239, compared with the number at June 30, 1893. During the 12 months they had carried out and paid for a considerable amount of work in order to accommodate their new subscribers. All their four offices were now fitted with multiple switch-boards, which were the most perfect yet introduced, and had been adopted in all the most important telephone systems in the world. The improvements and alterations in their La Guaira exchange had enabled him to carry out, with only comparatively little opposition, the change they had had for some time in view; namely, the enhancement of rates in that district from 14 to 18 bolivars per month, an increase which began to take effect in December, 1893. In the La Guaira district they had also carried out considerable improvements in line construction, improvements making towards directness of route and economy of distance. The repairs to their Puerto Cabello and Valencia trunk line, necessitated by the damage and destruction which occurred during the revolution, had been concluded, the cost being charged to revenue, and this line was now in excellent working order. The secretary informed him that a question was recently asked about the repairs and renovations of telephones, and it might not be out of place for him to state that each telephone as it was changed or withdrawn was put into the shop, which it afterwards left practically as good as new, the renovations being paid for entirely out of revenue. The Company had some two miles of subways in Caracas, with 21 manholes and cables laid to accommodate at present 2,250 subscribers. These subways, which were fitted with extra pipes sufficient to enable them to duplicate all existing cables should they find it necessary at some future date to do so, were laid down at considerable expense to the Company about two or three years ago, in order to introduce their wires into their central office, their iron poles in its vicinity being already overburdened. All lines now entered the office by subways. For the rest, their system of line construction was aerial, their wires being run upon iron poles and wooden cross arms. He estimated roughly that they must have about 3,000 miles of iron wire so strung in the Republic. Their offices were open night and day, and the average number of local connections effected every 24 hours in their Caracas Exchange was between 10,000 and 11,000—figures which he thought, from his knowledge of the telephone business, he might say were unique in proportion to the population. He thought there was no town where the telephone had come to be looked upon so much in the light of a household necessity as it had in Caracas. In conclusion, he would like to say that while they had not, of course, escaped the friction and difficulties incidental to a telephone business, the steady growth of the Company's business had hardly even been checked by temporary fluctuations in commercial prosperity, but had moved always steadily in one direction. He thought he might say that the steady and continual increase in demand for telephones satisfactorily proved that the very cheap and effective service rendered by the Company had not been without its reward in the cordial appreciation of the Government and the public of Venezuela. Unless any unforeseen circumstances occurred, he thought and hoped that the Company would enjoy in 1894-95 as prosperous a year as it had done in 1893-94.

The CHAIRMAN said he thought they would consider Mr. Wallis's statement very satisfactory. He then moved the adoption of the report and accounts.

Mr. J. W. PHILIPPS seconded the motion, which was carried unanimously.

Resolutions were afterwards passed declaring a dividend on the share capital at the rate of 4 per cent. per annum, and re-electing the retiring Director, Sir Douglas Fox, and the retiring auditors, Messrs. Price, Waterhouse and Co.

On the motion of the CHAIRMAN, seconded by Mr. L. FRANKEN, a vote of thanks was passed to Mr. Wallis and the staff in Venezuela for their care of the interests of the Company.

The GENERAL MANAGER having briefly acknowledged the compliment,

Mr. FRANKEN referred to the presence at the meeting of Mr. Van Es, the principal partner and manager of the Commandetaire Bank Van Es and Co., of the Hague, Holland, who had a large interest in the Company's shares and bonds, and who had attended the meeting in order to give the support of the Dutch certificate holders to the Board and the manager in Venezuela. They were very satisfied with the progress which the Company had made, and he was desired by Mr. Van Es to express the hope that the working of the Company in the future would be as efficient as it had been in the past, and to state that the Dutch proprietors would be perfectly willing to render the Company any assistance that might be required. It was the intention of Mr. Van Es to submit to the Directors a project by which the charges might be reduced to a certain extent, and the bonds be regularly redeemed, so that the debt of the Company would go down as the earnings increased.

The CHAIRMAN stated that any proposition coming from Mr. Van Es would be considered by the Directors.

Mr. FRANKEN then proposed a vote of thanks on the part of the Dutch certificate holders to the Directors and Mr. Wallis.

The motion was seconded, and carried unanimously.

The CHAIRMAN: On behalf of my colleagues and myself I beg to thank the Dutch and English shareholders, and to assure them that we shall do the best we can to promote the welfare of the Company. We are all interested in it, and in trying to serve the shareholders we are, therefore, serving ourselves as well.

The proceedings then terminated.

Eastern Extension, Australasia and China Telegraph Company (Limited).

The following is the report of the Directors for the half-year ended June 30th last, to be submitted to the forty-second ordinary general meeting, to be held at Winchester House, E.C., on Wednesday next, at 2 p.m.:—

The gross receipts for the half-year ended June 30, 1894, including Government subsidies, have amounted to £247,681. 2s. 4d., against £257,986. 13s. 5d. for the corresponding half-year of 1893. The working expenses, including £21,295. 16s. 5d. for cost of repairs to cables and expenses of ships, absorb £80,295. 3s. 10d., against £78,229. 19s. 3d. for the corresponding period of 1893, leaving a balance of £167,385. 18s. 6d. From this is deducted £3,940. 2s. 7d. for income tax, £32,488. 13s. 9d. for interest on debentures, debenture stock, contribution to sinking fund and revaluation of currency balances, leaving £130,957. 2s. 2d. as the net profit for the half-year. Two quarterly interim dividends of $1\frac{1}{4}$ per cent. each, amounting to £62,500, have been paid for the half-year under review, leaving £68,457. 2s. 2d. to be carried forward.

The loss resulting from the third year of working, ended April 30th last, under the Australian Tariff Guarantee arrangement, amounted to £12,384, half of which was borne by the guaranteeing Governments, and the other half by the associated Cable Companies in terms of the agreement.

The laying of the Company's alternative cable between Singapore and Hongkong *viâ* Labuan was successfully completed by the Telegraph Construction and Maintenance Company, and the line opened for traffic on May 5th last. It has already been found a most valuable addition to the Company's system. A short length of cable has also been laid between Labuan and Borneo so as to give direct telegraphic communication with

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Saudakan, the headquarters of the British North Borneo Company, when the land line which is in course of construction by that Company across North Borneo is completed.

Numerous cable repairs have been carried out during the half-year under review, but owing to the system being duplicated the traffic has not been affected.

Monte Video Telephone Company (Limited).

The following is the report of the Directors, to be presented to the shareholders at the annual general meeting, to be held at the offices, 96, Gresham House, Old Broad-street, E.C., on Wednesday next, the 31st inst., at noon:—

The statement of accounts for the year ended 31st July last shows a net profit of £6,902 15s. 11d. After making provision for all working expenses in Monte Video and London, depreciation of stock of materials in Monte Video, and writing off the final amount of preliminary expenses, there remains an available balance, including the amount of £775 2s. 9d. brought forward from last year, of £7,677 18s. 8d. It is with satisfaction that attention is drawn to the result of the year's working of the Company's business. The amount of subscriptions shows an increase compared with last year of £460, while the capital expenditure during the year was £875 6s. 3d., as against £1,637 4s. for the previous year. The entire property has been maintained in efficient repair at the cost of revenue. After careful consideration of the whole position of the Company, the Directors recommend the payment of a dividend of 4 per cent. on the Preference Share Capital, absorbing £5,600, which, after placing £1,000 to Reserve Account, and £500 to reserve for bad and doubtful debts, leaves the sum of £577 18s. 8d. to be carried forward to next year.

It will be observed that the position of the Company is improving, and keeping pace with the general prosperity evidenced in industrial and financial circles throughout Uruguay.

Mr. Herbert Ward retires from the Board, and being eligible offers himself for re-election; as also do the auditors, Messrs. Gérard Van de Linde and Son.

NEW COMPANIES, STATUTORY RETURNS, &c.

HALL ELECTRICAL COMPANY (LIMITED).—This Company was registered on October 16th, with a capital of £4,000, in £1 shares, to acquire as a going concern the business of electrical engineers and contractors carried on by A. Hall and Co., at Liverpool, and to carry on the business of electrical engineers and contractors in all or any of its branches. The subscribers (with one share each) are—Loftus J. Barnacle, Herbert H. Hall, Edward J. Bayley, Leslie Wilde, William Paul, Henry Jones, and John D. Malley. The first Directors are—Loftus J. Barnacle, Herbert H. Hall, and Charles E. Keizer.

LONDON WIRE NETTING COMPANY (LIMITED).—This Company was registered on October 16th, with a capital of £2,500, in £1 shares, to acquire the business of manufacturers and galvanisers of and dealers in wire netting and wire drawers carried on by Walter P. Grafton and Richard O. Williams at Millwall.

RICHARDS'S MACHINE TOOL COMPANY (LIMITED).—This Company was registered on October 16th, with a capital of £2,000, in £1 shares, to acquire the business of a machine tool engineer carried on by George Richards.

J. SUMNER (LIMITED).—This Company was registered on October 18th, with a capital of £3,000, in £10 shares, to acquire the business of an engineer, ironfounder, and machinist carried on by James Sumner at Leyland.

WIGSTON ELECTRICAL AND ENGINEERING COMPANY (LIMITED).—This Company was registered on October 23rd, with a capital of £25,000, in 2,000 Ordinary and 500 £6 per Cent. Cumulative Preferred shares of £10 each, to carry on the business of electrical and mechanical engineers, manufacturers of and dealers in electric, galvanic, magnetic, telegraphic, telephonic, and other appliances and apparatus for surgical, curative, restorative, domestic, and other purposes, and of steam, hydraulic, pneumatic, and other engines, machines, appliances, and apparatus, wholesale and retail ironmongers, electric bell manufacturers and fitters, electro-platers, cycle manufacturers, boiler makers, iron and brass founders, ornamental ironworkers, &c., and to carry on the business of an electric light supply company. The first Directors are—John T. Biggs, Orson Wright, and Thomas C. King.

ELECTRIC CONSTRUCTION COMPANY (LIMITED).—The annual return of this Company, made up to September 27th, was recently filed, when 120,000 Ordinary and 12,995 Preference shares were taken up and issued as fully paid out of a nominal capital of £400,000, divided into 150,000 Ordinary and 50,000 £7 per cent. cumulative Preference shares, all of £2 each.

ELECTRIC EXPLOITATION COMPANY (LIMITED).—The statutory return of this Company, made up to May 8th, has been recently filed. The Company has a nominal capital of £25,000 in £1 shares, of which 20,367 have been taken up. Of these 20,000 have been issued as fully paid to Max Sussmann, of Neuruppin, Prussia, or his nominees, in consideration for the transference to the Company of certain patents relating to improvements in the manufacture of secondary battery plates, portable secondary battery lamps for use in mines, and dry electrolyte for secondary batteries. Upon the remaining 367 shares the full amount has been called, resulting in the payment of £360, and leaving £7 unpaid.

ELECTROPHONE (LIMITED).—An agreement, made July 30th (and recently filed) between the vendors and the Company, states that whereas by a previous agreement the vendors decided to sell to the Company the business carried on by them under the style or firm of the "Electrophone Syndicate" for £15,000, payable by instalments in cash and the allotment of fully-paid shares, it is therefore agreed that 500 shares of £5 each shall be allotted as fully paid to Harold S. J. Booth or his nominees as part payment of such sum of £15,000.

ENGLISH ELECTRIC CARBON COMPANY (LIMITED).—The first annual return of this Company, made up to July 13th, has only just been filed. 789 shares have been taken up out of a capital of £10,000, in £10 shares, and the full amount per share has been called. The calls paid amount to £7,840, leaving £50 in arrears.

HALIFAX AND BERMUDAS CABLE COMPANY (LIMITED).—The annual return of this Company, made up to October 3rd, has been filed. The whole nominal capital of £50,000, in £5 shares, has been taken up, and all considered as fully paid.

"HARP" ARC LAMP SYNDICATE (LIMITED).—The statutory return of this Company, made up to September 24th, was recently filed, when 1,000 shares were subscribed for out of a capital of £5,000 in £1 shares. Resulting from a call of £1 per share £993 has been received, leaving £7 still to be paid.

HEMMING AND COMPANY (LIMITED).—An agreement, dated May 14, 1894, but only recently filed, made between T. L. Hemming and Company (Limited), Thomas L. Hemming, and Stephen Wright, provides for the sale to the new Company of the business of mechanical, chemical, electrical, and general engineers, electricians, &c., carried on by the vendors, for the sum of £5,600, payable £600 in cash and £5,000 by the allotment of fully-paid shares. Thomas L. Hemming agrees to stay in the service of the new Company on the same terms as he served the old. An agreement, dated June 15th (filed at the same time), with the new concern as the fourth party, adopts all the provisions of the preliminary agreement and discharges Stephen Wright from all liability under such contract.

D. HULETT AND CO. (LIMITED).—The annual return of this Company, made up to September 4th, has been filed. Out of a nominal capital of £35,000, divided into 6,900 Ordinary shares of £5 each, and 100 Founders' shares of similar value, 5,900 of the former and all the latter have been taken up, and, with the exception of 1,900 Ordinary shares, issued as fully paid. Upon these shares the full amount has been called, resulting in the total payment of £9,500.

CITY NOTES.

BIRMINGHAM CENTRAL TRAMWAY COMPANY.—A special meeting of this Company was held on Wednesday to discuss a proposition from the Directors to reduce the capital from £388,000 to £194,000, in consequence of the heavy burden of unremunerative expenditure in the early years of the Company. A fortnight ago an unsuccessful attempt was made to pass the resolution; but on Wednesday the Directors were provided with proxies representing the necessary three-fourths of the Company's capital, and, the opposition being withdrawn, the proposal was carried.

CITY AND SOUTH LONDON RAILWAY.—The traffic returns of this Company for the week ended October 21st were £932, as against £810 in the corresponding period of 1893, being an increase of £122. The total receipts for the half-year amount to £13,863, as against £12,956 for the corresponding period of 1893, an increase of £907.

EASTERN TELEGRAPH COMPANY (LIMITED).—This Company announce the payment by warrants on the 1st November of interest for the half-year ending October 31st, on their Four per cent. Mortgage Debenture Stock. The transfer books will be closed from the 27th October to the 1st November, both days inclusive.

EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY (LIMITED).—This Company notify that on Monday, November 19th, at noon, at the Company's offices at Winchester House, Old Broad-street, E.C., 362 Five per Cent. Mortgage Debentures will be drawn for payment on January 1, 1895. Notice will be given by advertisement of the numbers of the debentures drawn. The Company also announce the payment by warrants on November 1, 1894, of interest on their Four per Cent. Mauritius Subsidy Debentures. The transfer books will be closed from October 27th to November 1st, both days inclusive.

ELECTRICAL COMPANIES' SHARES.—At the Auction Mart on Wednesday some Electrical Power Storage Company's £5 (£3 paid) shares changed hands at 2⅜ and 2¼, and £5 founders' shares at 2¼, while £10 "A" shares (£9 paid) of the Exchange Telegraph Company realised 5¾ and 6.

INDO-EUROPEAN TELEGRAPH COMPANY (LIMITED).—The Directors of this Company have declared an interim dividend for the half-year ended June 30th last, at the rate of 5 per cent. per annum, free of income tax, which is payable on and after November 1st. Coupons held in this country must be deposited at the bankers', Messrs. Barclay and Co., 54, Lombard-street, E.C., three clear days for verification.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended October 19th (after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited) were £3,215.

WESTERN UNION TELEGRAPH COMPANY.—The report for the fiscal year ending June 30, 1894, shows a decrease for the year in gross revenues, as compared with the year preceding, of 3,125,787dols. Expenses of operation and maintenance were reduced 1,422,235dols., leaving net profits lower by 1,703,733dols. than in 1893. The Company earned in the fiscal year a small surplus over all charges, including dividends at the old rate.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Oct. 17.		Price Wednesday, Oct. 24.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Oct. 24.	
			TELEGRAPHS.					£ s. d.		Highest	Lowest
£1,012,880	Stock	9 0	Anglo-American .... xd	38	41	38	41	4 17 7	Jan., Apr., July, Oct.	38	
£2,993,500	Stock	13 0	Do. Preferred	75	76	74½	75½	5 12 7	" "	75¾	74¾
£2,993,500	Stock	5/0	Do. Deferred	6¾	7¼	6¾	7¼	..	..		
£184,500	100	4%	*African Direct Teleg. 4% Deb. (Reg. & Bearer)....	102	105	102	105	3 16 11	January and July	..	..
130,000	£10	8/0	Brazilian Submarine	12¾	13¼	12¾	13¼	4 18 1	Mar., June, Oct., Dec.	13¼	12¾
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1906)	110	114	110	114	4 8 8	June and December	..	–
10,000,000	$100	$1¾	Commercial Cable Capital Stock	135	145	135	145	4 17 9	Jan., Apr., July, Oct.	142	..
16,000	10	8/0	Cuba Submarine	12¾	13½	12¾	13½	5 18 6	February and August	13	12¾
6,000	10	10%	Do. Preference 10 per Cent.	19	20	19	20	5 0 0	" "	..	..
12,931	5	1/8	Direct Spanish (£4 paid)	4¼	4¾	4¼	4¾	4 4 3	April and October	..	..
6,000	5	10%	Do. Preference 10 per Cent.	9¼	9¾	9¼	9¾	5 2 7	" "	9¾	–
£30,000	Stock	4½%	Do. 4½% Debentures of £50 each	105%	108%	105%	108%	..	..	..	..
60,710	20	2/0	Direct United States Cable, 1877	8½	9	8½	9	5 16 8	Jan., Apr., July, Oct.	..	..
400,000	10	2/6	Eastern	15¾	16	15¾	16	4 1 3	" "	16	15¾
70,000	10	6%	Do. 6 per Cent. Preference	16¾	17¼	16¾	17¼	3 9 7	" "	16¾	16¾
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	118	121	118	121	3 6 2	May and November	119	..
£102,100	100	5%	* Do. 5 per Cent. Debentures, 1899	106	110	106	110	4 11 6	February & August	..	..
250,000	10	2/6	Eastern Extension	16	16½	16	16½	4 6 3	Jan., Apr., July, Oct.	16⅛	16
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	116	120	116	120	3 6 8	February & August	..	..
£62,700	100	5%	* Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103	106	103	106	4 15 6	January and July	..	..
£95,100	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb., 1900..	103	106	103	106	4 15 6	" "	..	..
£300,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.) ..	104	107	104	107	3 15 4	February & August		..
£200,000	£25	4%	* Do. 4% Mauritius Sub. Debs. (regd.)	109%	112%	109%	112%	3 12 9	May and November	111	..
180,227	10	1/3	Globe Telegraph and Trust	8¾	9	8¾	9¼	4 13 2	Jan., Apr., July, Oct.	9	8¾
180,042	10	6%	Do. 6 per Cent. Preference	15½	16	15¾	16¼	3 13 10	" "	16⅛	15¾
150,000	10	5 0	Great Northern	20½	21½	20½	21½	3 19 1	Jan., April, and July	21¼	20¾
£190,000	100	5%	Do. 5 per Cent. Debentures, 1883 issue	104	107	105	108	4 12 7	March & September	..	..
17,000	25	37/6	Indo-European	46	48	46	48	5 4 2	May and November	47½	..
37,548	10	5/0	London Platino-Brazilian	5	7	5	7	..	" "		..
£100,000	100	6%	* Do. 6 per Cent Debentures	107	110	107	110	5 9 7	March & September	..	..
£100,000	£100	4%	*Pacific European Tel. 4% Guar. Debs. "Red" 1942 ..	104	107	104	107	3 15 6		..	..
11,839	8	4/0	Reuter's	3	5	3	5	..	April and October	..	..
3,381	£100 Cert.	35/0	*Submarine Cables Trust 6 per Cent.	105	110	105	110	5 10 4	" "	..	..
15,609	10	5/0	West African Telegraph	3	5	3	5	..	January and July	..	..
£249,900	100	5%	* Do. 5 per Cent. Debentures (red.)	100	103	100	103	4 17 7	March & September	101	..
30,000	10	2/0	West Coast of America	2	3	1½	2½	..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	101	106	101	106	7 10 11	June and December	..	..
88,321	10	9d.	West India and Panama	1¼	1¾	1¼	1¾	..		1⅛	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10¾	11¼	10¾	11¼	5 6 8	May and November	11¼	11
4,669	10	6%	Do. 6 per Cent. 2nd Preference	9	10	9	10	6 0 0	" "	..	..
£80,000	100	5%	* Do. 5 per Cent. Debentures, 1917 (red.)	108	111	108	111	4 11 1	June and December	..	..
64,242	15	7/6	Western and Brazilian	8½	9	8½	9	..	May and November	8¾	8½
33,129	7½	7/6	Do. 5 per Cent. Cumulative Preferred	6½	7	6½	7	..	..	6¾	..
33,129	7½	4/6	Do. 5 per Cent. Deferred	2¾	3¼	2¾	3¼	..	..	..	..
£171,900	100	6%	* Do. 6 per Cent. Debs., Series "A" 1910	106	109	106	109	5 11 1	February & August	..	..
£214,800	100	6%	* Do. 6% Mort. Debs., Series "B" 1910	106	109	106	109	5 11 1	" "	..	..
$1,211,000	$1,000	7%	*Western Union 7% 1st Mort. (Building) Bonds	115	120	115	120	6 0 2	May and November	–	..
£166,900	£100	6%	* Do. 6 per Cent. Sterling Bonds (red.)	102	104	102	104	5 15 11	March & September	..	..
			TELEPHONES.								
44,000	5	10/0	Chili Telephone (fully paid)	2	3	2	3	..	..	..	..
224,850	10/0	2½d.	Consolidated Telephone Const. & Maintenance .	¼	½	¼	½	..	May and November	..	..
171,504	£1	6d.	Oriental Telephone and Electric (fully paid)	7/16	9/16	7/16	9/16	..	Yearly		..
484,597	5	3/4	National	4⅞	5⅛	4⅞	5⅛	4 17 7	June and December	5⅛	5
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	15	15½	15	16	3 15 0	" "	15½	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid) .	14	15	14	15	4 0 0	" "	14¾	–
119,234	5	3/4	Do. 5% Non-Cumulative 3rd Pref.	5½	5¾	5½	5¾	4 6 11		5¾	..
1,000,000	Stock	4½%	* Do. Debenture Stock, 4½% (red.)	110	113	110	113	4 9 9	January and July	..	..
58,000	5	1/0	United River Plate	2	3	2	3		" "	..	..
£146,733	Stock	5%	Do. 5 per Cent. Debenture Stock (red.)	88	94	88	94	5 6 5	" "	..	–
			ELECTRICITY SUPPLY COMPANIES.								
40,000	£10	..	City of London Electric Lighting (fully paid)	13½	14½	13	14	..	..	.	..
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	14¾	15¾	14½	15	4 0 0		..	..
£100,000	Stock	5/0	Do. 5% Debenture Stock (red.)	..		131	133	3 15 2	June and December	–	..
19,900	£5	..	Electricity Supply Co. for Spain	..		..			–	..	..
£30,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	4	5	4½	5½	3 12 9	–	..	..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	..		..		..	..	..	..
8,322	£5	..	House-to-House Electric	..		..		–	–	..	–
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid).	..		..		–	..	..	–
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..		..		–	January and July .	..	–
45,000	£5	2/6	Liverpool Electric Supply (fully paid)	6¾	7	6⅞	6⅞	–	–	..	–
111,000	5	..	London Electric Supply	½	⅝	½	⅝	..	..	..	–
49,900	£10	5/0	Metropolitan Electric Supply (fully paid)	9½	10	9½	9¾	2 11 3	..	9¾	
£150,000	Stock	4½%	* Do. 4½% Debs. (Bonds of £10, £20, and £40) .	113½	114½	113½	114½	3 18 7	June and December	..	..
6,452	£10	..	Notting Hill Electric	5½	6½	5½	6½		..	..	..
19,980	£5	2 0	St. James and Pall Mall	7¼	7¾	7½	8	–	..	..	..
20,000	£5	7%	Do. 7 per Cent. Preference	8½	9	8¾	9¼	3 15 8	–	..	..
59,900	5	2/0	Westminster Electric Supply (fully paid)	6½	7	6½	7	3 4 4	–	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
90,000	3	1/6	Brush Electrical Engineering	2¾	2¾	2¼	2¾	5 9 3			
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	2½	2¾	2½	2¾	4 7 3	..	..	..
£125,000	Stock	4½%	* Do. 4½ per Cent. Debentures	111	114	111	114	3 19 6	March & September	..	..
20,000	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref ..	2	2½	2	2½		January and July	..	..
12,139	5	..	Edison and Swan United	–		–		.	..	–	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid) ..	..		..			..	–	..
120,000	2	..	Electric Construction	½	¾	½	¾	..	–	..	..
12,845	2	2/82	Do. 7 per Cent Cumulative Pref.	1¼	2	1¼	2	..	–	..	..
91,195	2	10/0	Elmore's Patent Copper Depositing	¾	1¼	1¾	1¾	–	–	..	
20,000	5	.	Fowler-Waring Cables (fully paid)	½	1½	½	1½	.	..		..
50,000	10	10/0	India Rubber, Gutta Percha, &c., Works	24½	25½	24½	25½	4 18 0	February & August	25¼	24¾
£200,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	102	104	102	104	4 6 7	March & September	..	–
15,995	£10	6/4	International Okonite Ordinary	..		..		..	–	..	..
16,000	£10	..	Do. 8 per Cent. Preference	.		..		–	December and June	–	–
20,000	9		Manchester Edison-Swan "A" (£1 5s. paid)	–	½	–	½	..	..	..	..
37,350	12	12/0	Telegraph Construction and Maintenance	41	43	41	43	4 3 9	March and July	42½	42
£150,000	100	5%	Do. 5 per Cent. Bonds	106	109	106	109	4 11 9	January and July	108	–
37,514	£5	–	Woodhouse and Rawson Ordinary (£3 15s. paid)..	..		–		..	..	..	–
41,098	£5		Do. Preference (fully paid)			.		..	–	..	–
£63,870	10	10/0	W. T. Henley's Telegraph Works Ordinary	8	9	8	9	5 11 1	..	..	..
£30,000	10	..	Do. Preference	..		..		..	..	..	..
			RAILWAYS AND TRAMWAYS.								
£680,000	Stock	1%	City and South London Railway	36	38	36	38	1 16 2	May and November	..	..
7,000	10	5%	Do. 5% Perpetual Preference	13	14	13	14	3 11 5	..	..	..
£67,130	Stock	4%	Do. 4% Perpetual Debenture	121	123	121	123	3 5 1	May and November	..	..
37,500	£10	1%	Liverpool Overhead Railway	7½	8¼	7½	8¼	1 4 3	..	–	..
6,295	10	5%	Do. 5% Preference	13	13¼	13	13¼	3 15 6	..	–	–
£125,000	Stock	4%	Do. 4% Debenture	111	113	112	114	3 10 2	January and July ..	–	..

* In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption.

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